65 NUMERICAL ANALYSIS

MR2918625 65-06

★**Recent advances in scientific computing and matrix analysis.**
Proceedings of the International Workshop held at the University of Macau, Macau, December 28–30, 2009.
Edited by Xiao-Qing Jin, Hai-Wei Sun and Seak-Weng Vong.
International Press, *Somerville*, *MA*; *Higher Education Press*, *Beijing*, 2011.
xii+126 *pp.* *ISBN* 978-1-57146-202-2

Contents: Zheng-jian Bai and Xiao-qing Jin [Xiao Qing Jin[1]], A note on the Ulm-like method for inverse eigenvalue problems (1–7) MR2908437; Che-man Cheng [Che-Man Cheng], Kin-sio Fong [Kin-Sio Fong] and Io-kei Lok [Io-Kei Lok], Another proof for commutators with maximal Frobenius norm (9–14) MR2908438; Wai-ki Ching [Wai-Ki Ching] and Dong-mei Zhu [Dong Mei Zhu[1]], On high-dimensional Markov chain models for categorical data sequences with applications (15–34) MR2908439; Yan-nei Law [Yan Nei Law], Hwee-kuan Lee [Hwee Kuan Lee], Chao-qiang Liu [Chaoqiang Liu] and Andy M. Yip, An additive variational model for image segmentation (35–48) MR2908440; Hai-yong Liao [Haiyong Liao] and Michael K. Ng, Total variation image restoration with automatic selection of regularization parameters (49–59) MR2908441; Franklin T. Luk and San-zheng Qiao [San Zheng Qiao], Matrices and the LLL algorithm (61–69) MR2908442; Mila Nikolova, Michael K. Ng and Chi-pan Tam [Chi-Pan Tam], A fast nonconvex nonsmooth minimization method for image restoration and reconstruction (71–83) MR2908443; Gang Wu [Gang Wu[1]], Eigenvalues of certain augmented complex stochastic matrices with applications to PageRank (85–92) MR2908444; Yan Xuan and Fu-rong Lin, Clenshaw-Curtis-rational quadrature rule for Wiener-Hopf equations of the second kind (93–110) MR2908445; Man-chung Yeung [Man-Chung Yeung], On the solution of singular systems by Krylov subspace methods (111–116) MR2908446; Qi-fang Yu, San-zheng Qiao [San Zheng Qiao] and Yi-min Wei, A comparative study of the LLL algorithm (117–126) MR2908447.

{The papers are being reviewed individually.}

65C Probabilistic methods, simulation and stochastic differential equations

MR2871782 65C05 11B39 65D30

Bilyk, Dmitriy (1-SC; Columbia, SC)**;**
Temlyakov, V. N. [Temlyakov, Vladimir N.] (1-SC; Columbia, SC)**;**
Yu, Rui [Yu, Rui[1]] (1-SC; Columbia, SC)

Fibonacci sets and symmetrization in discrepancy theory. (English summary)
J. Complexity **28** (2012), *no.* 1, 18–36.

Summary: "We study the Fibonacci sets from the point of view of their quality with respect to discrepancy and numerical integration. Let $\{b_n\}_{n=0}^{\infty}$ be the sequence of Fibonacci numbers. The b_n-point Fibonacci set $\mathcal{F}_n \subset [0,1]^2$ is defined as $\mathcal{F}_n := \{(\mu/b_n, \{\mu b_{n-1}/b_n\})\}_{\mu=1}^{b_n}$, where $\{x\}$ is the fractional part of a number $x \in \mathbb{R}$. It is known that cubature formulas based on the Fibonacci set $\mathcal{F}_n$ give optimal rate of error of numerical integration for certain classes of functions with mixed smoothness.

"We give a Fourier analytic proof of the fact that the symmetrized Fibonacci set $\mathcal{F}'_n = \mathcal{F}_n \cup \{(p_1, 1-p_2) : (p_q, p_2) \in \mathcal{F}_n\}$ has asymptotically minimal L_2 discrepancy. This approach also yields an exact formula for this quantity, which allows us to evaluate the constant in the discrepancy estimates. Numerical computations indicate that these sets

have the smallest currently known L_2 discrepancy among two-dimensional point sets.

"We also introduce *quartered* L_p discrepancy, which is a modification of the L_p discrepancy symmetrized with respect to the center of the unit square. We prove that the Fibonacci set $\mathcal{F}_n$ has minimal in the sense of order quartered L_p discrepancy for all $p \in (1, \infty)$. This in turn implies that certain two-fold symmetrizations of the Fibonacci set $\mathcal{F}_n$ are optimal with respect to the standard L_p discrepancy."

MR2871781 65C05 46E22 65D30

Gnewuch, Michael (D-KIEL-II; Kiel)

Weighted geometric discrepancies and numerical integration on reproducing kernel Hilbert spaces. (English summary)

J. Complexity **28** (2012), *no.* 1, 2–17.

Summary: "We extend the notion of L_2-B-discrepancy introduced in [E. Novak and H. Woźniakowski, in *Analytic number theory*, 359–388, Cambridge Univ. Press, Cambridge, 2009; MR2508657 (2010d:11088)] to what we shall call weighted geometric L_2-discrepancy. This extension enables us to consider weights in order to moderate the importance of different groups of variables, as well as to consider volume measures different from the Lebesgue measure and classes of test sets different from measurable subsets of Euclidean spaces.

"We relate the weighted geometric L_2-discrepancy to numerical integration defined over weighted reproducing kernel Hilbert spaces and settle in this way an open problem posed by Novak and Woźniakowski.

"Furthermore, we prove an upper bound for the numerical integration error for cubature formulas that use admissible sample points. The set of admissible sample points may actually be a subset of the integration domain of measure zero. We illustrate that particularly in infinite-dimensional numerical integration it is crucial to distinguish between the whole integration domain and the set of those sample points that actually can be used by the algorithms."

MR2822407 65C05 60G70 62G20 62G32 90B25

Guyader, Arnaud (F-RENN2-NDM; Rennes)**;**
Hengartner, Nicholas [Hengartner, Nicolas W.] (1-LANL-IF; Los Alamos, NM)**;**
Matzner-Løber, Eric [Matzner-Løber, Éric] (F-RENN2-NDM; Rennes)

Simulation and estimation of extreme quantiles and extreme probabilities. (English summary)

Appl. Math. Optim. **64** (2011), *no.* 2, 171–196.

The paper presents an efficient algorithm for estimating (i) a tail probability given a quantile, or (ii) a quantile given a tail probability. The algorithm improves the multilevel splitting methods known in the literature. By means of Poisson process tools the exact distribution of the estimated probabilities and quantiles are established.

Bernd Heidergott

MR2788863 65C05

Lee, Jeong Eun (5-QUT-SM; Brisbane)**;**
McVinish, Ross [McVinish, Röss] (5-QLD; Brisbane)**;**
Mengersen, Kerrie [Mengersen, Kerrie L.] (5-QUT-SM; Brisbane)

Population Monte Carlo algorithm in high dimensions. (English summary)

Methodol. Comput. Appl. Probab. **13** (2011), *no.* 2, 369–389.

Summary: "The population Monte Carlo algorithm is an iterative importance sampling scheme for solving static problems. We examine the population Monte Carlo algorithm in a simplified setting, a single step of the general algorithm, and study a fundamental

problem that occurs in applying importance sampling to high-dimensional problem. The precision of the computed estimate from the simplified setting is measured by the asymptotic variance of estimate under conditions on the importance function. We demonstrate the exponential growth of the asymptotic variance with the dimension and show that the optimal covariance matrix for the importance function can be estimated in special cases."

MR2839113 65C05 93D09

Nurges, Ülo (ES-TALL; Tallinn)

Discussion on: "On the generation of random stable polynomials" [MR2839112].

Eur. J. Control **17** (2011), *no.* 2, 160–161.

This paper presents a discussion of [P. S. Shcherbakov and F. Dabbene, Eur. J. Control **17** (2011), no. 2, 145–159; MR2839112] on the generation of stable random polynomials. Two issues regarding the paper are raised. The first concerns the terminology assigned to a set of parameters appearing in a particular method (based on the Schur-Cohn stability test, and called Levinson-Durbin (LD) parameters in [op. cit.]; the authors of the original paper and of this discussion both acknowledge that these parameters go by many names in many different fields). The second relates to the fact that the uniform distribution for LD parameters for high-order polynomials leads to the generation of polynomials whose roots cluster close to the stability boundary. A modified algorithm avoiding this behavior is presented, together with simulation results.

{For further information pertaining to this item see [P. Shcherbakov and F. Dabbene, Eur. J. Control **17** (2011), no. 2, 161; MR2839120].} *David C. Saunders*

MR2839120 65C05 93D05

Shcherbakov, P.; Dabbene, F. [Dabbene, Fabrizio]

Final comments by the authors: "On the generation of random stable polynomials" [MR2839112; MR2839113].

Eur. J. Control **17** (2011), *no.* 2, 161.

The authors respond to the two points raised in [Ü. Nurges, Eur. J. Control **17** (2011), no. 2, 160–161; MR2839113]. They justify their choice of terminology on historical grounds. They raise some issues regarding the algorithm proposed in [op. cit.], and further note that clustering of roots near the stability boundary may not necessarily be a bad thing from the point of view of practical applications, pointing to the motivating examples in [P. S. Shcherbakov and F. Dabbene, Eur. J. Control **17** (2011), no. 2, 145–159; MR2839112] for justification. *David C. Saunders*

MR2839112 65C05 93D09

Shcherbakov, Pavel [Shcherbakov, Pavel S.] (RS-AOS-CN; Moscow)**;**
Dabbene, Fabrizio (I-TRNP-IEI; Turin)

On the generation of random stable polynomials. (English summary)

Eur. J. Control **17** (2011), *no.* 2, 145–159.

This paper presents a survey of various techniques for the random generation of stable polynomials. Both the case where the roots must lie in the open unit disk (Schur stable), and the case where they must lie in the left half-plane $C_- = \{s \in \mathbb{C} : \operatorname{Re} s < 0\}$ (Hurwitz stable), are considered. The paper begins with an introduction presenting motivating applications. Next, how general random sampling schemes may be adapted to the problem of generating stable random polynomials is discussed. Random generation schemes based on classical tests for stability of polynomials are then presented. Finally, the paper concludes with a list of interesting open problems in the area. Simulation results are presented for many of the schemes discussed in the paper.

{For further information pertaining to this item see [Ü. Nurges, Eur. J. Control **17** (2011), no. 2, 160–161; MR2839113; P. Shcherbakov and F. Dabbene, Eur. J. Control **17** (2011), no. 2, 161; MR2839120].} *David C. Saunders*

MR2834705 65C10 94A45 94A55

Li, Jie [Li, Jie[12]] (PRC-HUBMC; Wuhan)**;**
Zeng, Xiangyong [Zeng, Xiang Yong] (PRC-HUBMC; Wuhan)**;**
Hu, Lei [Hu, Lei[1]] (PRC-ASBJ-IFS; Beijing)

A new family of quadriphase sequences with low correlation. (English summary)

Coding and cryptology, 246–262, *Lecture Notes in Comput. Sci.*, 6639, *Springer*, *Heidelberg*, 2011.

The paper constructs a new family of quadriphase sequences and derives its correlation distribution. This family has two advantages over those given in the literature, namely, it has lower correlation and it provides more quadriphase sequences with different parameters. The period of this sequence is $4(2^n-1)$, where n is a natural number.

It is shown that the sequence with odd n is better than that with even n in the sense that, when n is odd, the maximum nontrivial correlation magnitude of the proposed family is less than that when n is even.

The results of the paper may have applications in cryptography and communication systems.

{For the entire collection see MR2866915 (2012h:94004).} *Adnan M. Awad*

MR2861250 65C20 34E13 60H25

Bal, Guillaume (1-CLMB-APM; New York, NY)**; Jing, Wenjia** (F-ENS-DAM; Paris)

Corrector theory for MSFEM and HMM in random media. (English summary)

Multiscale Model. Simul. **9** (2011), *no.* 4, 1549–1587.

This paper studies random fluctuations of the solution of a one-dimensional elliptic equation with a highly oscillatory random diffusion coefficient. The oscillations are involved in the calculation of the homogenized solution. The authors consider a random spatial process $a(x/\varepsilon,\omega)$ and study the random fluctuations of multiscale methods applied to the one-dimensional elliptic equation

$$-(a(x/\varepsilon,\omega)u'_\varepsilon(x,\omega))' = f(x) \quad \text{on } (0,1),$$
$$u_\varepsilon(0,\omega) = u_\varepsilon(1,\omega) = 0.$$

The paper considers both the multiscale finite element method (MsFEM) and the heterogeneous multiscale method (HMM) involving a parameter $\delta > 0$. The associated discretized solutions, obtained by using a finite spatial step $h > 0$, are denoted by u_ε^h (for MsFEM) and $u_\varepsilon^{h,\delta}$ (for HMM). The authors recall that, for a stationary, ergodic and uniformly elliptic a (i.e., $0 < \lambda \le a(x,\omega) \le \Lambda$), this equation has a homogenized associated equation (i.e., limit for $\varepsilon \to 0$) given by

$$-(a^* u'_0(x))' = f(x) \quad \text{on } (0,1),$$
$$u_0(0) = u_0(1) = 0,$$

where $1/a^* = E(1/a)$. This equation has a finite element solution u_0^h for the spatial step $h > 0$.

The paper initially considers a fixed discretization step $h > 0$ and the MsFEM fluctuations, given by $(u_\varepsilon^h - u_0^h)/\varepsilon^{\alpha/2}$, where $\alpha > 0$ is a parameter. The authors consider situations involving both the short range correlation (SRC, $\alpha = 1$) and the long range correlation (LRC, $0 < \alpha < 1$). The paper shows that the fluctuations converge when $\varepsilon \to 0+$. In the SRC case, the limit is a process $U^h(x,W)$ which is explicitly determined as

a stochastic integral of Wiener's process W. In the LRC case, an analogous result is established: the limit is $U^h(x, W^{1-\alpha/2})$, which is explicitly determined as a stochastic integral of the fractionary Wiener process $W^{1-\alpha/2}$. Then the authors analyse the limit for $h \to 0+$ and show that, in both cases, the limit corresponds to the processes obtained by taking the limit for $\varepsilon \to 0+$ in $(u_\varepsilon - u_0)/\varepsilon^{\alpha/2}$, which establishes the consistency of the approximation. In a second part, the authors study the HMM fluctuations, given by $(u_\varepsilon^{h,\delta} - u_0^h)/\varepsilon^{\alpha/2}$.

The paper analyses the choice of δ by studying the cases $\delta = h$ and $\delta < h$, establishes analogous convergence results for HMM and presents a modified method improving the behaviour of HMM, namely for $\delta < h$. *José Eduardo Souza de Cursi*

MR2855478 65C30 60G22 60H35 92D25

Ma, Wei-jun [Ma, Weijun] (PRC-NX-SMC; Yinchuan);
Zhang, Qi-min (PRC-NX-SMC; Yinchuan);
Han, Chong-zhao [Han, Chong Zhao] (PRC-XJU-EI; Xi'an)

Numerical analysis for stochastic age-dependent population equations with fractional Brownian motion. (English summary)

Commun. Nonlinear Sci. Numer. Simul. **17** (2012), *no.* 4, 1884–1893.

Summary: "Stochastic age-dependent population equations, one of the important classes of hybrid systems are studied. In general most equations of stochastic age-dependent population do not have explicit solutions. Thus numerical approximation schemes are invaluable tools for exploring their properties. The main purpose of this paper is to develop a numerical scheme and show the convergence of the numerical approximation solution to the analytic solution. In the last section a numerical example is given."

MR2844959 65C30 60H10 60J75 92D25

Wei, Mao [Mao, Wei[1]]

Exponential stability of numerical solutions to stochastic age-dependent population equations with Poisson jumps. (English summary)

Int. J. Comput. Math. Sci. **6** (2012), 28–33.

Summary: "The main aim of this paper is to investigate the exponential stability of the Euler method for a stochastic age-dependent population equations with Poisson random measures. It is proved that the Euler scheme is exponentially stable in mean square sense. An example is given for illustration."

MR2862020 65C40 60J10 60J22 60J27 65F08 65F10

Bolten, Matthias (D-WUPP-MNS; Wuppertal);
Brandt, Achi [Brandt, Achi E.] (IL-WEIZ-AC; Rehovot);
Brannick, James [Brannick, James J.] (1-PAS; University Park, PA);
Frommer, Andreas (D-WUPP-MNS; Wuppertal);
Kahl, Karsten (D-WUPP-MNS; Wuppertal);
Livshits, Ira [Livshits, I. Z.] (1-BLS; Muncie, IN)

A bootstrap algebraic multilevel method for Markov chains. (English summary)

SIAM J. Sci. Comput. **33** (2011), *no.* 6, 3425–3446.

Let A be the transition matrix of an irreducible finite Markov chain. Here, A is a column stochastic matrix. The authors present an algebraic multilevel method (using ideas based on compatible relaxation, algebraic distances, and least squares fitting of certain test vectors) for solving the equation

$$Ax = x$$

approximately, where x is a probability vector (there exists a unique probability vector

x such that $Ax = x$ because A is irreducible). A solution x is approximated iteratively.

Udrea Păun

MR2827093 65C40 60J22 65F08 65F10 65F35

De Sterck, H. [**De Sterck, Hans**] (3-WTRL-AM; Waterloo, ON);
Miller, K. [**Miller, Killian**] (3-WTRL-AM; Waterloo, ON);
Manteuffel, T. [**Manteuffel, Thomas A.**] (1-CO-AM; Boulder, CO);
Sanders, G. (1-CO-AM; Boulder, CO)

Top-level acceleration of adaptive algebraic multilevel methods for steady-state solution to Markov chains. (English summary)

Adv. Comput. Math. **35** (2011), *no.* 2-4, 375–403.

The authors propose some iterative multiplicative multilevel methods having, in addition, outer iterations (see Algorithm 3, p. 392, and Algorithm 4, p. 395) to solve the equation

$$Bx = x$$

approximately when B is an $n \times n$ irreducible column stochastic matrix and $x \in \mathbf{R}^n$, $\|x\|_1 = 1$, and $x > 0$ (i.e., $x = (x_1, \ldots, x_n)$ is a probability vector with $x_i > 0$, $\forall i \in \{1, \ldots, n\}$). The above equation is equivalent to

$$Ax = 0,$$

where $A := I - B$ (B and x are as above). An outer iterate is a linear combination of old iterates; only optimal outer iterates are important here, namely, the ones which depend on the minimum of a certain functional. Set

$$\mathcal{P} = \mathcal{P}_n = \{w |\ w \in \mathbf{R}^n,\ \|w\|_1 = 1,\ \text{and } w \geq 0\}.$$

$\mathcal{P}$ is the space of probability vectors of dimension n. In this article, the basic functionals are (see Theorem 3.1)

$$\mathcal{F}_1(w) := \frac{\langle Aw, Aw\rangle}{\langle w, w\rangle}, \quad \forall w \in \mathcal{P} \setminus \{0\}$$

and

$$\mathcal{F}_2(w) := \langle Aw, Aw\rangle, \quad \forall w \in \mathcal{P}.$$

Udrea Păun

MR2863629 65C40 65K05 65N55 90C25

De Sterck, Hans (3-WTRL-AM; Waterloo, ON);
Miller, Killian (3-WTRL-AM; Waterloo, ON);
Sanders, Geoffrey (1-LLL-AC; Livermore, CA)

Iterant recombination with one-norm minimization for multilevel Markov chain algorithms via the ellipsoid method. (English summary)

Comput. Vis. Sci. **14** (2011), *no.* 2, 51–65.

Summary: "Recently, it was shown how the convergence of a class of multigrid methods for computing the stationary distribution of sparse, irreducible Markov chains can be accelerated by the addition of an outer iteration based on iterant recombination. The acceleration was performed by selecting a linear combination of previous fine-level iterates with probability constraints to minimize the two-norm of the residual using a quadratic programming method. In this paper we investigate the alternative of minimizing the one-norm of the residual. This gives rise to a nonlinear convex program which must be solved at each acceleration step. To solve this minimization problem we propose to use a deep-cuts ellipsoid method for nonlinear convex programs.

The main purpose of this paper is to investigate whether an iterant recombination approach can be obtained in this way that is competitive in terms of execution time and robustness. We derive formulas for subgradients of the one-norm objective function and the constraint functions, and show how an initial ellipsoid can be constructed that is guaranteed to contain the exact solution and give conditions for its existence. We also investigate using the ellipsoid method to minimize the two-norm. Numerical tests show that the one-norm and two-norm acceleration procedures yield a similar reduction in the number of multigrid cycles. The tests also indicate that one-norm ellipsoid acceleration is competitive with two-norm quadratic programming acceleration in terms of running time with improved robustness."

MR2875999 65C40 80A32 92C99
Sunkara, Vikram (5-ANU-CMA; Canberra)**;**
Hegland, Markus (5-ANU-CMA; Canberra)
Parallelising the finite state projection method. (English summary)
ANZIAM J. Electron. Suppl. **52** (2010), (*C*), *C*853–*C*865.

Summary: "Many realistic mathematical models of biological and chemical systems, such as enzyme cascades and gene regulatory networks, need to include stochasticity. These systems are described as Markov processes and are modelled using the Chemical Master Equation. The Chemical Master Equation is a differential-difference equation (continuous in time and discrete in the state space) for the probability of a certain state at a given time. The state space is the population count of species in the system. A successful method for computing the Chemical Master Equation is the Finite State Projection Method. We give a new algorithm to distribute the Finite State Projection Method method onto multi-core systems. This method is called the Parallel Finite State Projection method. This article also analyses the theory needed for parallelisation of the Chemical Master Equation."

65D Numerical approximation and computational geometry (primarily algorithms)

MR2861915 65D05 41A05 65D17
Aslam, Muhammad [Aslam, Muhammad^2];
Mustafa, Ghulam [Mustafa, Ghulam^2] (PAK-ISLA-NDM; Bahawalpur)**;**
Ghaffar, Abdul (PAK-ISLA-NDM; Bahawalpur)
$(2n-1)$-point ternary approximating and interpolating subdivision schemes. (English summary)
J. Appl. Math. **2011,** *Art. ID* 832630, 12 *pp.*

Subdivision is a technique used to generate smooth curves and surfaces approximated by a sequence of successively refined control polygons. In the paper under review the authors use Lagrange interpolation polynomials with integer nodes to obtain an explicit formula for the coefficients of the mask of a $(2n-1)$-point ternary scheme which contains free parameters and generalizes and unifies existing odd-point ternary interpolating and approximating subdivision schemes.

The authors compare the error bounds of odd-point and even-point ternary interpolating schemes and conclude that odd-point schemes are better than even-point schemes in the sense of computational cost, support and error bounds. *Luis Verde-Star*

MR2853514 65D05 41A05 65D17

Li, Baojun [Li, Bao Jun[1]] (PRC-DUTVM-IAE; Dalian)**;**
Li, Bo (PRC-NCUA-CMI; Nanchang)**; Liu, Xiuping** (PRC-DUT-SM; Dalian)**;**
Su, Zhixun (PRC-DUT-SM; Dalian)**;**
Yu, Bowen [Yu, Bo Wen] (PRC-DUT-SM; Dalian)

Exact evaluation of limits and tangents for interpolatory subdivision surfaces at rational points. (English summary)

J. Comput. Appl. Math. **236** (2011), *no.* 5, 906–915.

The paper gives an efficient method for exact evaluation in rational points of a surface generated by stationary, symmetric interpolatory subdivision schemes as well as the computation of the tangents at these points. The 1D ternary subdivision of M. F. Hassan et al. [Comput. Aided Geom. Design **19** (2002), no. 1, 1–18; MR1879678 (2002k:65019)] and the 2D quadmesh scheme of G. Q. Li and W. Y. Ma [Comput. Aided Geom. Design **23** (2006), no. 1, 45–77; MR2183817 (2006j:65033)] in 2D are used as examples. The basis function satisfies a dilation equation $\varphi(t) = \sum_{j=-N}^{N} a_j \varphi(Mt - j)$, $a_j \in \mathbb{R}$, $t \in \mathbb{R}^s$, $j, N \in \mathbb{Z}^s$, and M is an integer dilation matrix. This results in a scheme $\Phi(\frac{t+k}{m}) = T_k \Phi(t)$ where Φ is a vector stacking values of φ and T_k, $k \in \mathbb{Z}^s$, is a refinement matrix. Because of the form $(t+k)/m$, some computational advantages can be obtained in the evaluation algorithm if the number t is expressed in a number system with basis m. The limiting vector Φ is a fixed point of a contractive operator T that corresponds to the cycle in the m-ary digits of t (T is a product of T_{d_i} where d_i are the m-ary digits in the cycle of t). An eigenvalue decomposition of T is used in the algorithm. Thus the limiting surface is obtained by attaching the limit function φ to the initial control points. Similar arguments hold for the evaluation of the limiting tangents. The method can be generalized to evaluate other stationary non-polynomial subdivision schemes. *A. Bultheel*

MR2882943 65D07 41A55

Sablonnière, P. (F-INSAR-CM; Rennes)

Some approximate methods for computing arc lengths based on quadratic and cubic spline interpolation or quasi-interpolation. (English summary)

Rend. Semin. Mat. Univ. Politec. Torino **69** (2011), *no.* 1, 1–20.

The paper presents a comparison of two families of methods for the computation of arc lengths. The first method is based on computing the exact length of a quadratic spline approximant of the original function or parametric curve. The author recalls a formula which gives the length of an arc of a parabola in Bernstein-Bézier form, and then he describes a list of C^1 quadratic spline approximants. Regarding the second method, the values of the first derivatives are approximated by those of cubic spline approximants, and then these estimates are used for the approximate computation of the arc length by means of Simpson's quadrature formula. Note that the overall convergence order of both classes of methods is $O(h^4)$. For each family of methods, several types of interpolants or quasi-interpolants are compared and numerous numerical examples illustrate the considered methods and procedures. *Alexandru Ioan Mitrea*

MR2870198 65D10 41A30

Le Gia, Q. T. [Le Gia, Quoc Thong] (5-NSW-SMS; Sydney)**;**
Tran, T. [Tran, Thanh] (5-NSW-SMS; Sydney)

Additive Schwarz preconditioners for interpolation of divergence-free vector fields on spheres. (English summary)

ANZIAM J. Electron. Suppl. **52** (2010), (*C*), *C*742–*C*758.

Summary: "The linear system arising from the interpolation problem of surface

divergence-free vector fields using radial basis functions tends to be ill-conditioned when the separation radius of the scattered data is small. When the surface under consideration is the unit sphere, we introduce a preconditioner based on the additive Schwarz method to accelerate the solution process. Theoretical estimates for the condition number of the preconditioned matrix are given. Numerical experiments using scattered data from MAGSAT satellite show the effectiveness of our preconditioner."

MR2895215 65D17 34A25 34A45

Li, Hongbo [Li, Hong Bo[1]] (PRC-ASBJ-MML; Beijing)**;**
Sun, Ruiyong (PRC-ASBJ-MML; Beijing)**; Yao, Shoubin** (PRC-ASBJ-MML; Beijing)**;**
Li, Ge (PRC-ASBJ-MML; Beijing)

Approximate rational solutions to rational ODEs defined on discrete differentiable curves. (English summary)

ISSAC 2011—*Proceedings of the* 36*th International Symposium on Symbolic and Algebraic Computation*, 217–224, *ACM*, *New York*, 2011.

Summary: "In this paper, a new concept is proposed for discrete differential geometry: *discrete n-differentiable curve*, which is a tangent n-jet on a sequence of space points. A complete method is proposed to solve ODEs of the form

$$\mathbf{n}^{(m)} = \frac{\mathbf{F}(\mathbf{r}, \mathbf{r}', \ldots, \mathbf{r}^{(n)}, \mathbf{n}, \mathbf{n}', \ldots, \mathbf{n}^{(m-1)}, u)}{G(\mathbf{r}, \mathbf{r}', \ldots, \mathbf{r}^{(n)}, \mathbf{n}, \mathbf{n}', \ldots, \mathbf{n}^{(m-1)}, u)}, \tag{0.1}$$

where $\mathbf{F}, G$ are respectively vector-valued and scalar-valued polynomials, where $\mathbf{r}$ is a discrete curve obtained by sampling along an unknown smooth curve parametrized by u, and where $\mathbf{n}$ is the vector field to be computed along the curve. Our Maple-13 program outputs an approximate rational solution with the highest order of approximation for given data and neighborhood size.

"The method is used to compute rotation minimizing frames of space curves in CAGD. For one-step backward-forward chasing, a 6th-order approximate rational solution is found, and 6 is guaranteed to be the highest order of approximation by rational functions. The theoretical order of approximation is also supported by numerical experiments."

{For the entire collection see MR2895188 (2012j:68010).}

MR2861554 65D17 65N50

Sun, Feng (PRC-HK-C; Hong Kong)**; Choi, Yi-King** (PRC-HK-C; Hong Kong)**;**
Wang, Wenping [Wang, Wen Ping[1]] (PRC-HK-C; Hong Kong)**;**
Yan, Dong-Ming (PRC-HK-C; Hong Kong)**;**
Liu, Yang [Liu, Yang[4]] (F-INRIA6-LR; Villers-les-Nancy)**;**
Lévy, Bruno (F-INRIA6-LR; Villers-les-Nancy)

Obtuse triangle suppression in anisotropic meshes. (English summary)

Comput. Aided Geom. Design **28** (2011), *no.* 9, 537–548.

It has been observed that the maximal angle of triangle elements used in meshes determines the accuracy and convergence of interpolating functions in finite element methods. Hence it is desirable to have as few obtuse triangles as possible to reduce the discretisation errors. In this paper the authors develop a method for reducing the number of obtuse triangles in anisotropic triangulations. A variational approach is used to suppress obtuse triangles in anisotropic meshes. The authors introduce a so-called Hexagonal Minkowski metric to give a new formulation of the Centroid Voronoĭ Tesselation (CVT). Experiments using their approach show that the algorithm produces anisotropic meshes with much fewer obtuse triangles, while maintaining mesh anisotropy. In addition the authors point out that much as this approach reduces the number of obtuse triangles in anisotropic meshes, it is not capable of reducing

the maximal angles of triangles. Secondly the method cannot remove obtuse triangles completely. *Mapundi K. Banda*

MR2763709 65D18 68T45 90C08

Enqvist, Olof (S-LUND-CM; Lund)**; Kahl, Fredrik** (S-LUND-CM; Lund)**;**
Olsson, Carl (S-LUND-CM; Lund)**; Åström, Kalle** (S-LUND-CM; Lund)

Global optimization for one-dimensional structure and motion problems. (English summary)

SIAM J. Imaging Sci. **3** (2010), *no.* 4, 1075–1095.

The navigation control of an autonomous vehicle can be realized using an inexpensive one-dimensional (1D) camera that performs as a laser scanner that determines the direction from the autonomous vehicle to the different strips of tape (on walls or objects along the route of the vehicle). During the navigation process, the control is based on simultaneous localization and mapping (SLAM), a technique used to build up a map/representation within an unknown environment and simultaneously to keep track of the current location of the vehicle. Using the 1D camera, the accuracy of the localization is determined by the quality of the set of images processed (complexity of the environment, details of movement). If there are multiple views, a global optimum solution can be obtained, which is the goal of this research. After revisiting the geometry of the problem and discussing the limitations involving the resection and intersection, the authors propose an optimization method for the structure and motion problem, namely two algorithms. The theoretical description of the optimization method is complemented by a few experiments that support its efficiency and performance. The experiments are conducted on synthetic data (3 views of 7 points) and on real data provided by (i) omnidirectional cameras, in four experiments with a different number of objects and camera positions and (ii) cameras with a limited field of view (pinhole cameras). *Dragos Calitoiu*

MR2861097 65D18 51K99 94A08

März, Thomas (4-OX; Oxford)

Image inpainting based on coherence transport with adapted distance functions. (English summary)

SIAM J. Imaging Sci. **4** (2011), *no.* 4, 981–1000.

In computer vision and image processing, image inpainting (or image interpolation) means finding the values of a missing digital image. The author has introduced the method of image inpainting, based on coherence transport, in a previous paper, and he serialized the pixels by their distance to the boundary map, where the distance can be computed quickly and easily for every type of inpainting domain. However, sometimes this method is not sufficient. In this paper, the pixel serializations are all induced by a more general type of distance function, which respects geometric constraints specified by the user. After a short introduction with good examples, section 2 is dedicated to a summary of the existing results and to an explanation of the basic algorithm. In section 3 the focus is on the interface of the algorithm. Section 4 presents concrete distance functions, which are used to serialize the pixels of the inpainting domain: distance by harmonic interpolation, modified distance to boundary, and distance to skeleton. There are several synthetic examples (because their image geometry is easy to understand), and in section 5 some natural examples are shown, with a total of 17 clear and useful figures. *Michael M. Dediu*

MR2864829 65D18 68U10 94A08

Qiu, Huining (PRC-ZHO-NDM; Guangzhou)**;**
Chen, Xiaoming (PRC-ZHO-NDM; Guangzhou)**;**
Liu, Wanquan (5-CURT-NDM; Bentley)**; Zhou, Guanglu** (5-CURT-NDM; Bentley)**;**
Wang, Yiju [Wang, Yi Ju] (PRC-QTC2; Rizhao)**;**
Lai, Jianhuang [Lai, Jian-Huang] (PRC-ZHO-NDM; Guangzhou)

A fast ℓ_1-solver and its applications to robust face recognition. (English summary)

J. Ind. Manag. Optim. **8** (2012), *no.* 1, 163–178.

Summary: "In this paper we apply a recently proposed Lagrange Dual Method (LDM) to design a new Sparse Representation-based Classification (LDM-SRC) algorithm for robust face recognition problem. The proposed approach improves the efficiency of the SRC algorithm significantly. The proposed algorithm has the following advantages: (1) it employs the LDM ℓ_1-solver to find solution of the ℓ_1-norm minimization problem, which is much faster than other state-of-the-art ℓ_1-solvers, e.g. ℓ_1-magic and $\ell_{1\_}\ell_s$. (2) The LDM ℓ_1-solver utilizes a new Lagrange-dual reformulation of the original ℓ_1-norm minimization problem, not only reducing the problem size when the dimension of training image data is much less than the number of training samples, but also making the dual problem become smooth and convex. Therefore it converts the non-smooth ℓ_1-norm minimization problem into a sequence of smooth optimization problems. (3) The LDM-SRC algorithm can maintain good recognition accuracy whilst reducing the computational time dramatically. Experimental results are presented on some benchmark face databases."

MR2816832 65D30

Akhmedov, D. M. (UZ-AOS-IFT; Tashkent)

Computation of the coefficients of optimal quadrature formulas for a singular Cauchy-type integral in the Sobolev space $L_2^{(2)}(0,1)$. (Russian. English and Uzbek summaries)

Uzbek. Mat. Zh. **2011,** *no.* 2, 48–56.

Summary: "In the present paper in S. L. Sobolev space $L_2^{(2)}(0,1)$ the optimal quadrature formula is constructed for approximate calculation of Cauchy type singular integral."

MR2870183 65D30 41A55

Hegland, Markus (5-ANU-MT; Canberra)**; Leopardi, Paul C.** (5-ANU-MT; Canberra)

The rate of convergence of sparse grid quadrature on the torus. (English summary)

ANZIAM J. Electron. Suppl. **52** (2010), (*C*), *C*500–*C*517.

The rate of convergence of a sparse grid quadrature on a weighted Korobov space is considered. Integration over a torus Π^d is equivalent to integration of a periodic function over the d-dimensional unit cube. Given quadrature points x_i, $i = 1, \ldots, d$, the weights of the optimal quadrature method are obtained by solving a linear system with a matrix whose elements are the values of the reproducing kernel $K(x_i, x_j)$ of the reproducing kernel Hilbert space. The approach is compared with the weighted tensor product algorithm of G. W. Wasilkowski and H. Woźniakowski [J. Complexity **15** (1999), no. 3, 402–447; MR1716741 (2000h:65200)]. *G. A. Evans*

MR2846703 65D32 65D30

Babenko, V. F. [**Babenko, Vladislav F.**] (UKR-DNEP-NDM; Dnepropetrovsk); **Borodachov, S. V.** [**Borodachev, S. V.**] (1-TOWU-NDM; Towson, MD); **Skorokhodov, D. S.** (UKR-DNEP-NDM; Dnepropetrovsk)

Optimal cubature formulas for tensor products of certain classes of functions. (English summary)

J. Complexity **27** (2011), *no.* 6, 519–530.

Summary: "We study the problem of constructing an optimal formula of approximate integration along a d-dimensional parallelepiped. Our construction utilizes mean values along intersections of the integration domain with n hyperplanes of dimension $(d-1)$, each of which is perpendicular to some coordinate axis. We find an optimal cubature formula of this type for two classes of functions. The first class controls the moduli of continuity with respect to all variables, whereas the second class is the intersection of certain periodic multivariate Sobolev classes. We prove that all node hyperplanes of the optimal formula in each case are perpendicular to a certain coordinate axis and are equally spaced and the weights are equal. For specific moduli of continuity and for sufficiently large n, the formula remains optimal for the first class among cubature formulas with arbitrary positions of hyperplanes." *Miodrag M. Spalević*

65F Numerical linear algebra

MR2859906 65F05 15A23

Dureisseix, David (F-INSAL-CTM; Villeurbanne)

Generalized fraction-free LU factorization for singular systems with kernel extraction. (English summary)

Linear Algebra Appl. **436** (2012), *no.* 1, 27–40.

The paper is concerned with an extension of complete fraction-free LU factorization for singular systems. Specifically, it investigates first the solution of linear systems with singular coefficient matrix A in an integral domain. The proposed strategy provides the factorization of a regularized matrix whose inverse is a pseudo-inverse of A. Additionally it yields the fraction-free determination of the kernels of A and of A^T. Thereby, a solvability condition can be tested and the general form of the solutions can be derived. Furthermore, the case of rectangular matrices, which exhibit a rank deficiency, is derived analogously as another extension. Finally, two examples demonstrate the potential of the theoretical results. The algorithms utilized for deriving the numerical results are presented analytically in the appendix. All computations are exact in any integral domain and singular linear systems can be solved within their input domain.

Christos Kravvaritis

MR2895846 65F05 78A30

Wan, Ting (PRC-NST-CME; Nanjing); **Jiang, Zhao Neng** (PRC-NST-CME; Nanjing); **Sheng, Yi Jun** (PRC-NST-CME; Nanjing)

Hierarchical matrix techniques based on matrix decomposition algorithm for the fast analysis of planar layered structures. (English summary)

IEEE Trans. Antennas and Propagation **59** (2011), *no.* 11, 4132–4141.

Summary: "The matrix decomposition algorithm (MDA) provides an efficient matrix-vector product for the iterative solution of the integral equation (IE) by a blockwise compression of the impedance matrix. The MDA with a singular value decomposition (SVD) recompression scheme, i.e., so-called MDA-SVD method, shows strong ability for the analysis of planar layered structures. However, iterative solution faces the problem

of convergence rate. An efficient hierarchical ($\mathcal{H}$-) LU decomposition algorithm based on the $\mathcal{H}$-matrix techniques is proposed to handle this problem. Exploiting the data-sparse representation of the MDA-SVD compressed impedance matrix, $\mathcal{H}$-LU decomposition can be efficiently implemented by $\mathcal{H}$-matrix arithmetic. $\mathcal{H}$-matrix techniques provide a flexible way to control the accuracy of the approximate $\mathcal{H}$-LU-factors. $\mathcal{H}$-LU decomposition with low accuracy can be used as an efficient preconditioner for the iterative solver due to its low computational cost, while $\mathcal{H}$-LU decomposition with high accuracy can be used as a direct solver for dealing with multiple right-hand-side (RHS) vector problems particularly. Numerical examples demonstrate that the proposed method is very robust for the analysis of various planar layered structures."

MR2876575 65F08 76B15 76M25

Hejranfar, Kazem (IR-SHAR-AE; Tehran)**;**
Kamali-Moghadam, Ramin (IR-SHAR-AE; Tehran)

Assessment of three preconditioning schemes for solution of the two-dimensional Euler equations at low Mach number flows. (English summary)

Internat. J. Numer. Methods Engrg. **89** (2012), *no.* 1, 20–52.

Summary: "Three preconditioners proposed by Eriksson, Choi and Merkel, and Turkel are implemented in a 2D upwind Euler flow solver on unstructured meshes. The mathematical formulations of these preconditioning schemes for different sets of primitive variables are drawn, and their eigenvalues and eigenvectors are compared with each other. For this purpose, these preconditioning schemes are expressed in a unified formulation. A cell-centered finite volume Roe's method is used for the discretization of the preconditioned Euler equations. The accuracy and performance of these preconditioning schemes are examined by computing steady low Mach number flows over a NACA0012 airfoil and a two-element NACA4412–4415 airfoil for different conditions. The study shows that these preconditioning schemes greatly enhance the accuracy and convergence rate of the solution of low Mach number flows. The study indicates that the preconditioning methods implemented provide nearly the same results in accuracy; however, they give different performances in convergence rate. It is demonstrated that although the convergence rate of steady solutions is almost independent of the choice of primitive variables and the structure of eigenvectors and their orthogonality, the condition number of the system of equations plays an important role, and it determines the convergence characteristics of solutions."

MR2806536 65F08 65F10

Scott, Jennifer (4-RAPL-CPE; Didcot)**; Tůma, Miroslav** (CZ-AOS-IC; Prague)

The importance of structure in incomplete factorization preconditioners. (English summary)

BIT **51** (2011), *no.* 2, 385–404.

The authors are interested in structure-based incomplete factorization preconditioners that both have predictable memory requirements and depend on the entries of A. They present an improved strategy that considers the individual entries of the system matrix and restricts small entries to contributing to fewer levels of fill than the largest entries. The preconditioners are applied to symmetric positive-definite problems arising from a wide range of practical applications. Their efficiency with respect to incomplete Cholesky factorizations resulting from the standard level-based approach is proved by several numerical results. *Elena Zampieri*

MR2874191 65F10 65F08 76D05 76M10

Börm, Steffen (D-KIEL-C; Kiel)**; Le Borne, Sabine** (1-TTU; Cookeville, TN)

$\mathcal{H}$-LU factorization in preconditioners for augmented Lagrangian and grad-div stabilized saddle point systems. (English summary)

Internat. J. Numer. Methods Fluids **68** (2012), *no.* 1, 83–98.

Summary: "The (mixed finite element) discretization of the linearized Navier-Stokes equations leads to a linear system of equations of saddle point type. The iterative solution of this linear system requires the construction of suitable preconditioners, especially in the case of high Reynolds numbers. In the past, a stabilizing approach has been suggested which does not change the exact solution but influences the accuracy of the discrete solution as well as the effectiveness of iterative solvers. This stabilization technique can be performed on the continuous side before the discretization, where it is known as 'grad-div' (GD) stabilization, as well as on the discrete side where it is known as an 'augmented Lagrangian' (AL) technique (and does not change the discrete solution). In this paper, we study the applicability of $\mathcal{H}$-LU factorizations to solve the arising subproblems in the different variants of stabilized saddle point systems. We consider both the saddle point systems that arise from the stabilization in the continuous as well as on the discrete setting. Recently, a modified AL preconditioner has been proposed for the system resulting from the discrete stabilization. We provide a straightforward generalization of this approach to the GD stabilization. We conclude the paper with numerical tests for a variety of problems to illustrate the behavior of the considered preconditioners as well as the suitability of $\mathcal{H}$-LU factorization in the preconditioners."

MR2865015 65F10

van Gijzen, Martin B. (NL-DELF-IAM; Delft)**;**
Sonneveld, Peter (NL-DELF-IAM; Delft)

Algorithm 913: an elegant IDR(s) variant that efficiently exploits biorthogonality properties. (English summary)

ACM Trans. Math. Software **38** (2011), *no.* 1, *Art.* 5, 19 *pp.*

Summary: "The IDR(s) method that is proposed in [P. Sonneveld and M. B. van Gijzen, SIAM J. Sci. Comput. **31** (2008/09), no. 2, 1035–1062; MR2466147 (2009m:65062)] is a very efficient limited memory method for solving large nonsymmetric systems of linear equations. IDR(s) is based on the induced dimension reduction theorem, that provides a way to construct subsequent residuals that lie in a sequence of shrinking subspaces. The IDR(s) algorithm that is given in [op. cit.] is a direct translation of the theorem into an algorithm. This translation is not unique. This article derives a new IDR(s) variant, that imposes (one-sided) biorthogonalization conditions on the iteration vectors. The resulting method has lower overhead in vector operations than the original IDR(s) algorithms. In exact arithmetic, both algorithms give the same residual at every $(s+1)$-st step, but the intermediate residuals and also the numerical properties differ. We show through numerical experiments that the new variant is more stable and more accurate than the original IDR(s) algorithm, and that it outperforms other state-of-the-art techniques for realistic test problems."

MR2895742 65F10

Kalitkin, N. N. [Kalitkin, Nikolaĭ Nikolaevich] (RS-AOS-M; Moscow)**;**
Kuz′mina, L. V. (RS-AOS-M; Moscow)

An improved form of the conjugate gradient method. (Russian. English and Russian summaries)

Mat. Model. **23** (2011), *no.* 7, 33–51; *translation in Math. Models Comput. Simul.* **4** (2012), *no.* 1, 68–81.

The authors consider the problem of the numerical solution of the system of linear equations

$$A\mathbf{x} = \mathbf{b}, \quad A = A^H > 0. \tag{1}$$

They propose the following iterative procedure for solving (1):

$$\begin{aligned} \mathbf{r}_n &= \begin{cases} A\mathbf{x}_n - \mathbf{b}, \\ \mathbf{r}_{n-1} - \mathbf{q}_n/(\mathbf{p}_{n-1}, \mathbf{q}_{n-1}) \quad (n = 2, 3, \dots), \end{cases} \\ \mathbf{p}_n &= \mathbf{p}_{n-1} + \mathbf{r}_n/(\mathbf{r}_n, \mathbf{r}_n), \\ \mathbf{q}_n &= A\mathbf{p}_n, \\ \mathbf{x}_{n+1} &= \mathbf{x}_n - \mathbf{p}_n/(\mathbf{p}_n, \mathbf{q}_n), \end{aligned} \tag{2}$$

with the following initial approximation: $\mathbf{x}_1$ is an arbitrary vector and $\mathbf{p}_0 = 0$. They construct a criterion for ending the iterations, based on the prevalence of rounding errors. They carry out numerical computations that illustrate the features of the convergence of the procedure (2) for well- and ill-posed problems. They generalize the procedure (2) to the case when, in order to increase the rate of convergence of the iterative process, the conditionality of the system is improved by the multiplication of both parts of (1) by the corresponding matrix. *Vladimir B. Larin*

MR2841414 65F10

Oh, Seyoung (KR-CHGN; Taejŏn)**; Yun, Jae Heon** (KR-CHBKS; Cheongju (Ch'ongju))

Convergence of multi-relaxed nonstationary multisplitting methods. (English summary)

J. Appl. Math. Inform. **29** (2011), *no.* 3-4, 753–762.

The authors consider an iterative algorithm for solving the following system of linear equations:

$$Ax = b, \quad x, b \in \mathbb{R}^n. \tag{1}$$

Let $\omega, \omega_1, \omega_2, \dots, \omega_l$ be positive numbers, let (M_k, N_k, E_k), $k = 1, 2, \dots, l$, be triples of matrices such that $A = M_k - N_k$, and let the matrices M_k have inverses, $\sum_{k=1}^{l} E_k = I$. For a given approximation x_0, the ith step of the iterative algorithm considered in the paper under review has the following form (Algorithm 2 in the paper):

For $k = 1, \dots, l$,
  $y_{k,0} = x_{i-1}$.
  For $j = 1, \dots, s(k,i)$,
    $y_{k,j} = \omega_k M_k^{-1} N_k y_{k,j-1} + (1 - \omega_k) y_{k,j-1} + \omega_k M_k^{-1} b$,
$x_i = \omega \sum_{k=1}^{l} E_k y_{k,s(k,i)} + (1 - \omega) x_{i-1}$.

The authors prove the convergence of this algorithm. They also present a proof of the convergence of a generalized version of Algorithm 2 when the matrix M_k can be decomposed into two matrices: $M_k = B_k - C_k$. *Vladimir B. Larin*

MR2831605 65F15

Freitag, M. A. (4-BATH; Bath)**; Spence, A.** (4-BATH; Bath)

A Newton-based method for the calculation of the distance to instability. (English summary)

Linear Algebra Appl. **435** (2011), *no.* 12, 3189–3205.

A matrix $A \in \mathbb{C}^{n\times n}$ with complex entries is said to be stable if all its eigenvalues lie in the open left half of the complex plane. The problem of finding the "smallest" perturbation matrix E which makes $A+E$ unstable has been dealt with in the literature [C. F. Van Loan, in *Linear algebra and its role in systems theory (Brunswick, Maine, 1984)*, 465–478, Contemp. Math., 47, Amer. Math. Soc., Providence, RI, 1985; MR0828319 (87e:15021); R. Byers, SIAM J. Sci. Statist. Comput. **9** (1988), no. 5, 875–881; MR0957478 (89k:65036)]. In this regard, the notion of the distance of a matrix A to instability is defined by

$$\beta(A) = \min\{\|E\|\colon \eta(A+E) = 0,\ E \in \mathbb{C}^{n\times n}\},$$

where $\eta(A) = \max\{\mathrm{Re}(\lambda)\colon \lambda \in \sigma(A)\}$. Here $\sigma(A)$ is the spectrum of A.

In the paper under review, the authors present a new fast algorithm for computing the distance of a stable matrix to the unstable matrices. Comparisons are made with certain benchmark problems. *K. Kanakadurga*

MR2812564 65F15 15A18 37N30

Guglielmi, Nicola (I-LAQL-PM; L'Aquila)**;**
Lubich, Christian (D-TBNG-MI; Tübingen)

Differential equations for roaming pseudospectra: paths to extremal points and boundary tracking. (English summary)

SIAM J. Numer. Anal. **49** (2011), *no.* 3, 1194–1209.

The paper is devoted to the computation of points in the pseudospectrum of a matrix A having maximal real part (the *pseudospectral abscissa*) or largest modulus (the *pseudospectral radius*).

In another paper [N. Guglielmi and M. L. Overton, SIAM J. Matrix Anal. Appl. **32** (2011), no. 4, 1166–1192; MR2854608] a discrete dynamical system was tracked, related to the sequence of perturbations $\{E_k\}$ which determine the extremal point at the limit. The resulting algorithm was fast but theoretically hard to analyze.

Here the discrete dynamical system is replaced by a continuous one, whose theoretical analysis is simpler. A solution $E(t)$ of the differential equations is approximated through an exponential Euler method, ensuring that an appropriate eigenvalue $\lambda(t)$ of $A+\varepsilon E(t)$ has growing real part (or modulus, if the pseudospectral radius is sought).

A variant is presented where the dynamics follows the boundary contour.

Fabio Di Benedetto

MR2854616 65F15 15A18 15B99

Mönnigmann, M. (D-BCHM-ACS; Bochum)

Fast calculation of spectral bounds for Hessian matrices on hyperrectangles. (English summary)

SIAM J. Matrix Anal. Appl. **32** (2011), *no.* 4, 1351–1366.

The author presents a computationally efficient approach to solving the following problem.

Let $\varphi\colon U \subseteq \mathbb{R}^n \to \mathbb{R}$ be a twice continuously differentiable function on an open set $U \subseteq \mathbb{R}^n$ and let S be a closed hyperrectangle in U. Find $\underline{\lambda} \in \mathbb{R}$, $\overline{\lambda} \in \mathbb{R}$ such that $\underline{\lambda} \le \lambda \le \overline{\lambda}$ for all eigenvalues λ of all matrices $A \in \mathcal{H}(\varphi; \mathbb{S})$, where $\mathcal{H}(\varphi; \mathbb{S})$ is the set of Hessian matrices of φ on S.

The proposed method is an extension of a method previously presented by the author to compute bounds on the spectrum of a single real Hessian matrix and exhibits the same computational complexity $\mathcal{O}(n)N(\varphi)$, where $N(\varphi)$ denotes the number of operations needed to evaluate φ at a point in its domain. Therefore this new method belongs to the same complexity class as the computationally cheapest existing method, which is based essentially on Gershgorin's circle criterion. However, it is shown that there exists a class of functions φ for which the bounds from the new method are tighter than those from any other method. *Raffaella Pavani*

MR2894804 65F15 65F50

Najafi, H. Saberi [Najafi, Hashem Saberi] (IR-GUILM-AM; Rasht)**;**
Sheikhani, A. H. Refahi [Refahi Sheikhani, Amir Hosein] (IR-GUILM-AM; Rasht)

New numerical method for determining inertia and stability of nonsymmetric large sparse matrix. (English summary)

J. Math. Sci. Adv. Appl. **7** (2011), *no.* 2, 105–114.

The authors resort to well-known results in the literature to build an algorithm that computes the exact inertia of a nonsymmetric large sparse matrix without computing eigenvalues explicitly. Numerical tests show the effectiveness of the approach. Since convergence and properties of the method are taken from the literature, no other result is added. *Raffaella Pavani*

MR2854604 65F15 15A18 15B57

Paige, Christopher C. (3-MGL-C; Montreal, QC)**;**
Panayotov, Ivo (3-MGL; Montreal, QC)

Hessenberg matrix properties and Ritz vectors in the finite-precision Lanczos tridiagonalization process. (English summary)

SIAM J. Matrix Anal. Appl. **32** (2011), *no.* 4, 1079–1094.

The kth step of the Lanczos process for tridiagonalizing a given Hermitian matrix A of order n is given by the recurrence relation

$$AV_k = V_k T_k + v_{k+1}\beta_{k+1}e_k^{\mathsf{T}},$$

where V_k is an $n \times k$ matrix with orthonormal columns, T_k is a real symmetric tridiagonal matrix, and $\beta_j > 0$ for $j > 2$. This process was introduced by C. Lanczos in [J. Research Nat. Bur. Standards **45** (1950), 255–282; MR0042791 (13,163d)] to solve eigenvalue problems or linear systems of equations. The idea of the Lanczos process is that one may solve an eigenvalue problem or a linear system with the simpler matrix T_k to obtain an approximation to the corresponding problem for A.

If $\{\mu_m, y_m\}$ is an exact eigen-pair of T_k with y_m having the unit norm, then $z_m = V_k y_m$ is the Ritz vector of A corresponding to the Ritz value μ_m. If $\beta_{k+1}|e_k^{\mathsf{T}} y_m|$ is small, then μ_m will be a good approximation to an eigenvalue of A provided the Ritz vector has the norm close to one or at least bounded away from zero.

In the literature, it was shown that for an isolated Ritz value the corresponding Ritz vector norm is indeed close to one and that, in a tight Ritz cluster well separated from the rest of the spectrum of T_k, at least one Ritz vector has the norm close to or greater than one.

This paper essentially re-establishes the same results by using a simpler analysis. This new analysis is also more general in that it applies to the Lanczos process adapted to any form of normal matrix with collinear eigenvalues. The theory developed here may be useful in the analysis of nonnormal matrix algorithms such as the nonsymmetric Lanczos process and Arnoldi's eigenvalue method. Also, developed are some properties of complex Hessenberg matrices. Since the class of Hessenberg matrices includes the

class of tri-diagonal matrices, some of these properties are used in the above-mentioned results. *Vadlamudi China Venkaiah*

MR2881010 65F15 15A18

Xie, Huiqing [Xie, Hui Qing] (PRC-EUST; Shanghai)

Computation of eigenpair partial derivatives by Rayleigh-Ritz procedure. (English summary)

J. Comput. Appl. Math. **236** (2012), *no.* 10, 2607–2621.

Given a nonsymmetric eigenvalue problem $A(p)x(p) = \lambda(p)x(p)$ depending on the parameter $p = (p_1, \dots, p_N)^{\mathsf{T}}$, with $A(p) \in \mathbb{C}^{n\times n}$, an algorithm for estimating the partial derivatives of eigenvalues $\lambda_i(p)$ and eigenvectors $x_i(p)$ at a parameter value p^* is proposed. Given an r-dimensional subspace $\mathcal{V}$ with orthonormal basis V, the algorithm constructs the derivatives $\frac{\lambda_i(p^*)}{\partial p_j}$ and $\frac{x_i(p^*)}{\partial p_j}$, for $i = 1, \dots, k$ $(k \le r)$, from the corresponding partial derivatives of the $r \times r$ matrix $H(p) = V^*A(p)V$. This can be performed relatively cheaply by solving k small bordered linear systems with $H(p)$. An error analysis for the case $k = r$ is developed, under the assumption that $\mathcal{V}$ is a sufficiently good approximation to an invariant subspace of $A(p^*)$. Numerical experiments show the effectiveness of the proposed algorithm. *Daniel Kressner*

MR2835851 65F20 65F10

Eldar, Yonina C. (IL-TECH-E; Haifa)**; Needell, Deanna** (1-STF-S; Stanford, CA)

Acceleration of randomized Kaczmarz method via the Johnson-Lindenstrauss lemma. (English summary)

Numer. Algorithms **58** (2011), *no.* 2, 163–177.

Consider an overdetermined consistent system of linear equations $Ax = b$. Given an initial guess x_0 and denoting by a_i the rows of the $m \times n$ matrix A, each iteration of the Kaczmarz method orthogonally projects the current estimation x_k onto the hyperplane $\langle a_i, x\rangle = b_i$, chosen in a cyclic fashion, that is, $i = (k \bmod m) + 1$:

$$x_{k+1} = x_k + \frac{b_i - a_i x_k}{\|a_i\|_2^2} a_i.$$

T. Strohmer and R. Vershynin [in *Approximation, randomization and combinatorial optimization*, 499–507, Lecture Notes in Comput. Sci., 4110, Springer, Berlin, 2006; MR2305035 (2008a:15005); J. Fourier Anal. Appl. **15** (2009), no. 2, 262–278; MR2500924 (2010f:60126)] proposed a randomized Kaczmarz method, where the rows of A are chosen randomly instead of cyclically:

$$x_{k+1} = x_k + \frac{b_{p(i)} - a_{p(i)} x_k}{\|a_{p(i)}\|_2^2} a_{p(i)},$$

where $p(i)$ takes values in $\{1, \dots, m\}$ with probabilities $\|a_{p(i)}\|_2^2/\|A\|_F^2$. The convergence rate of this randomized method is bounded as

$$\mathbb{E}\|x_k - x\|_2^2 \le \left(1 - \frac{1}{R}\right)^k \|x_0 - x\|_2^2,$$

where $R = \|A^{-1}\|_2^2\|A\|_F^2$, $\|A\|_F$ is the Frobenius norm of A and $\|\cdot\|_2$ denotes the spectral matrix norm.

The authors of the present article accelerate the randomized Kaczmarz method by selecting the optimal projection from a randomly chosen set of n rows I_k. The optimal projection in the kth iteration is the one that maximizes the term $|b_i - a_i x_k|/\|a_i\|_2$, $i \in I_k$. To significantly reduce the cost of computation of the inner products $\langle a_i, x_k\rangle$, the vectors a_i and x_k are approximated via Johnson-Lindenstrauss type projections of a_i

and x_k onto a space of dimension $O(\log n)$, which approximately preserve geometry.

Alexander N. Malyshev

MR2876680 65F22 65Y15

Hansen, Per Christian (DK-TUD-IMM; Lyngby)**;**
Saxild-Hansen, Maria (DK-TUD-IMM; Lyngby)

AIR-tools—a MATLAB package of algebraic iterative reconstruction methods. (English summary)

J. Comput. Appl. Math. **236** (2012), *no.* 8, 2167–2178.

Summary: "We present a MATLAB package with implementations of several algebraic iterative reconstruction methods for discretizations of inverse problems. These so-called row action methods rely on semi-convergence for achieving the necessary regularization of the problem. Two classes of methods are implemented: Algebraic Reconstruction Techniques (ART) and Simultaneous Iterative Reconstruction Techniques (SIRT). In addition we provide a few simplified test problems from medical and seismic tomography. For each iterative method, a number of strategies are available for choosing the relaxation parameter and the stopping rule. The relaxation parameter can be fixed, or chosen adaptively in each iteration; in the former case we provide a new 'training' algorithm that finds the optimal parameter for a given test problem. The stopping rules provided are the discrepancy principle, the monotone error rule, and the NCP criterion; for the first two methods 'training' can be used to find the optimal discrepancy parameter."

MR2907759 65F22 65F10

Liu, Chein-Shan (RC-NTAI-CE; Taipei)

A revision of relaxed steepest descent method from the dynamics on an invariant manifold. (English summary)

CMES Comput. Model. Eng. Sci. **80** (2011), *no.* 1, 57–86.

Summary: "Based on the ordinary differential equations defined on an invariant manifold, we propose a theoretical procedure to derive a Relaxed Steepest Descent Method (RSDM) for numerically solving an ill-posed system of linear equations when the data are polluted by random noise. The invariant manifold is defined in terms of a squared-residual-norm and a fictitious time-like variable, and in the final stage we can derive an iterative algorithm including a parameter, which is known as the relaxation parameter. Through a Hopf bifurcation, this parameter indeed plays a major role to switch the situation of slow convergence to a new situation with faster convergence. Several numerical examples, including the first-kind Fredholm integral equation and backward heat conduction problem, are examined and compared with exact solutions, revealing that the RSDM has superior computational efficiency and accuracy even for the highly ill-conditioned linear equations with a large noise imposed on the given data."

MR2865012 65F30 65Y05

D'Alberto, Paolo; Bodrato, Marco (I-ROME2-NDM; Rome)**;**
Nicolau, Alexandru [Nicolau, Alexandru^2] (1-CA3-NDM; Irvine, CA)

Exploiting parallelism in matrix-computation kernels for symmetric multiprocessor systems. (English summary)

ACM Trans. Math. Software **38** (2011), *no.* 1, *Art.* 2, 30 *pp.*

Summary: "We present a simple and efficient methodology for the development, tuning, and installation of matrix algorithms such as the hybrid Strassen's and Winograd's fast matrix multiply or their combination with the 3M algorithm for complex matrices (i.e., hybrid: a recursive algorithm as Strassen's until a highly tuned BLAS matrix multiplication allows performance advantages). We investigate how modern Symmet-

ric Multiprocessor (SMP) architectures present old and new challenges that can be addressed by the combination of an algorithm design with careful and natural parallelism exploitation at the function level (optimizations) such as function-call parallelism, function percolation, and function software pipelining.

"We have three contributions: first, we present a performance overview for double- and double-complex-precision matrices for state-of-the-art SMP systems; second, we introduce new algorithm implementations: a variant of the 3M algorithm and two new different schedules of Winograd's matrix multiplication (achieving up to 20% speedup with respect to regular matrix multiplication). About the latter Winograd's algorithms: one is designed to minimize the number of matrix additions and the other to minimize the computation latency of matrix additions; third, we apply software pipelining and threads allocation to all the algorithms and we show how this yields up to 10% further performance improvements."

MR2854880 65F30 15A24 65G20

Frommer, Andreas (D-WUPP-MNS; Wuppertal)**;**
Hashemi, Behnam (IR-SUTB-M; Shiraz)

Verified error bounds for solutions of Sylvester matrix equations. (English summary)

Linear Algebra Appl. **436** (2012), *no.* 2, 405–420.

Summary: "We develop methods for computing verified solutions of Sylvester matrix equations $AX + XB = C$. To this purpose we propose a variant of the Krawczyk interval operator with a factorized preconditioner so that the complexity is reduced to cubic when A and B are dense and diagonalizable. Block diagonalizations can be used in cases where A or B are not diagonalizable. The Lyapunov equation, as a special case, is also considered."

MR2863516 65F30 65G40

Ozaki, Katsuhisa (J-SHIB-SEM; Saitama)**; Ogita, Takeshi** (J-TOKYOW; Suginami)**;**
Rump, Siegfried M. (D-TUHH-RCP; Hamburg)**;**
Oishi, Shin'ichi (J-WASEFS-NDM; Shinjuku)

Fast algorithms for floating-point interval matrix multiplication. (English summary)

J. Comput. Appl. Math. **236** (2012), *no.* 7, 1795–1814.

Summary: "We discuss several methods for real interval matrix multiplication. First, earlier studies of fast algorithms for interval matrix multiplication are introduced: naive interval arithmetic, interval arithmetic by midpoint-radius form by Oishi-Rump and its fast variant by Ogita-Oishi. Next, three new and fast algorithms are developed. The proposed algorithms require one, two or three matrix products, respectively. The point is that our algorithms quickly predict which terms become dominant radii in interval computations. We propose a hybrid method to predict which algorithm is suitable for optimizing performance and width of the result. Numerical examples are presented to show the efficiency of the proposed algorithms."

MR2874950 65F40 15A06

Habgood, Ken (1-TN-ECS; Knoxville, TN)**; Arel, Itamar** (1-TN-ECS; Knoxville, TN)

A condensation-based application of Cramer's rule for solving large-scale linear systems. (English summary)

J. Discrete Algorithms **10** (2012), 98–109.

Summary: "State-of-the-art software packages for solving large-scale linear systems are predominantly founded on Gaussian elimination techniques (e.g. LU-decomposition).

This paper presents an efficient framework for solving large-scale linear systems by means of a novel utilization of Cramer's rule. While the latter is often perceived to be impractical when considered for large systems, it is shown that the algorithm proposed retains an $\mathcal{O}(N^3)$ complexity with pragmatic forward and backward stability properties. Empirical results are provided to substantiate the stated accuracy and computational complexity claims."

MR2867614 65F50 05C50 05C85

Buluç, Aydın (1-LBL-HPC; Berkeley, CA)**;**
Gilbert, John [Gilbert, John Russell] (1-UCSB-C; Santa Barbara, CA)

New ideas in sparse matrix matrix multiplication. (English summary)

Graph algorithms in the language of linear algebra, 315–337, *Software Environ. Tools*, 22, *SIAM*, *Philadelphia*, *PA*, 2011.

Summary: "Generalized sparse matrix matrix multiplication is a key primitive for many high performance graph algorithms as well as some linear solvers such as multigrid. We present the first parallel algorithms that achieve increasing speedups for an unbounded number of processors. Our algorithms are based on the two-dimensional (2D) block distribution of sparse matrices where serial sections use a novel hypersparse kernel for scalability."

{For the entire collection see MR2867601 (2012h:05004).}

MR2865011 65F50

Davis, Timothy A. [Davis, Timothy A.[1]] (1-FL-CIE; Gainesville, FL)**;**
Hu, Yifan [Hu, Yi Fan[1]] (1-ATT3; Florham Park, NJ)

The University of Florida sparse matrix collection. (English summary)

ACM Trans. Math. Software **38** (2011), *no.* 1, *Art.* 1, 25 *pp.*

Summary: "We describe the University of Florida Sparse Matrix Collection, a large and actively growing set of sparse matrices that arise in real applications. The Collection is widely used by the numerical linear algebra community for the development and performance evaluation of sparse matrix algorithms. It allows for robust and repeatable experiments: robust because performance results with artificially generated matrices can be misleading, and repeatable because matrices are curated and made publicly available in many formats. Its matrices cover a wide spectrum of domains, include those arising from problems with underlying 2D or 3D geometry (as structural engineering, computational fluid dynamics, model reduction, electromagnetics, semiconductor devices, thermodynamics, materials, acoustics, computer graphics/vision, robotics/kinematics, and other discretizations) and those that typically do not have such geometry (optimization, circuit simulation, economic and financial modeling, theoretical and quantum chemistry, chemical process simulation, mathematics and statistics, power networks, and other networks and graphs). We provide software for accessing and managing the Collection, from MATLAB$^{\text{TM}}$, Mathematica$^{\text{TM}}$, Fortran, and C, as well as an online search capability. Graph visualization of the matrices is provided, and a new multilevel coarsening scheme is proposed to facilitate this task."

65H Nonlinear algebraic or transcendental equations

MR2872352 65H05

Džunić, Jovana (SE-NISEE; Niš)**; Petković, Miodrag S.** (SE-NISEE; Niš)

A family of three-point methods of Ostrowski's type for solving nonlinear equations. (English summary)

J. Appl. Math. **2012,** *Art. ID* 425867, 9 *pp.*

This paper introduces a new family of optimal three-point methods for finding a simple root of single-variable nonlinear equations. The first two steps in each cycle use the classic Ostrowski method. The third step uses Newton's method, i.e., $\widehat{x} = z - f(z)/f'(z)$. To produce an optimal method based on Kung and Traub's conjecture, the authors suggest approximating $f'(z)$ so that the proposed method supports this conjecture. Then applying CAS, they try to make some coefficients vanish in the error equation of the proposed method so that it becomes the desired method.

After constructing the optimal family, the authors introduce some important classes of it. Numerical implementations as well as comparisons with Bi, Wu and Ren's family, Kung and Traub's method (with and without derivative) and Liu and Wang's method are given.

As a reviewer, I think it is a very useful paper to anyone interested in studying optimal methods without memory based on Kung and Traub's conjecture. In this connection, I strongly recommend studying the papers [R. Thukral and M. S. Petković, J. Comput. Appl. Math. **233** (2010), no. 9, 2278–2284; MR2577765 (2011a:65125); W. Bi, H. Ren and Q. B. Wu, J. Comput. Appl. Math. **225** (2009), no. 1, 105–112; MR2490175 (2009m:65078); J. Džunić, M. S. Petković and L. D. Petković, Appl. Math. Comput. **217** (2011), no. 19, 7612–7619; MR2799775; Y. H. Geum and Y. I. Kim, Appl. Math. Lett. **24** (2011), no. 6, 929–935; MR2776163; B. Neta and M. S. Petković, Appl. Math. Comput. **217** (2010), no. 6, 2448–2455; MR2733687 (2011i:65078); L. D. Petković, M. S. Petković and J. Džunić, Appl. Math. Comput. **216** (2010), no. 2, 671–676; MR2601535; X. Wang and L. Liu, J. Comput. Appl. Math. **234** (2010), no. 5, 1611–1620; MR2610375 (2011c:65081)]. *Taher Lotfi*

MR2863523 65H10

Argyros, Ioannis K. (1-CMRN; Lawton, OK)**;**
Hilout, Saïd (F-POIT-LAM; Futuroscope)

Improved local convergence of Newton's method under weak majorant condition. (English summary)

J. Comput. Appl. Math. **236** (2012), *no.* 7, 1892–1902.

Summary: "We provide a local convergence analysis for Newton's method under a weak majorant condition in a Banach space setting. Our results provide under the same information a larger radius of convergence and tighter error estimates on the distances involved than before [O. P. Ferreira, J. Comput. Appl. Math. **235** (2011), no. 5, 1515–1522; MR2728107 (2011h:65075)]. Special cases and numerical examples are also provided in this study."

MR2825748 65H10 13P15

Cartwright, Dustin (1-CA; Berkeley, CA)

An iterative method converging to a positive solution of certain systems of polynomial equations. (English summary)

J. Algebr. Stat. **2** (2011), *no.* 1, 1–13.

This paper is devoted to the design of a numerical algorithm for finding real non-negative solutions to a class of polynomial equations. All the coefficients of a polynomial from

this class, other than the constant term, must be non-negative and the exponents are subjected to certain conditions. The method is inspired by interpreting the equations as a maximum likelihood problem for a statistical model and applying the methods of expectation-maximization and iterative proportional fitting.

The author presents his algorithm and discusses relevant examples. *Doru Ştefănescu*

MR2673891 65H10 05A15 05C30

Labelle, Gilbert (3-QU-MIF; Montreal, QC)

On extensions of the Newton-Raphson iterative scheme to arbitrary orders. (English and French summaries)

22*nd International Conference on Formal Power Series and Algebraic Combinatorics* (*FPSAC* 2010), 845–856, *Discrete Math. Theor. Comput. Sci. Proc., AN, Assoc. Discrete Math. Theor. Comput. Sci., Nancy*, 2010.

Summary: "The classical quadratically convergent Newton-Raphson iterative scheme for successive approximations of a root of an equation $f(t) = 0$ has been extended in various ways by different authors, going from cubical convergence to convergence of arbitrary orders. We introduce two such extensions, using appropriate differential operators as well as combinatorial arguments. We conclude with some applications including special series expansions for functions of the root and enumeration of classes of tree-like structures according to their number of leaves."

{For the entire collection see MR2894639 (2012j:05011).}

MR2827986 65H20 65H10 65H99 65Y20 68Q25 68W40

Bürgisser, Peter (D-PDRB-IM; Paderborn)

Smoothed analysis of condition numbers. (English summary)

Proceedings of the International Congress of Mathematicians. Volume IV, 2609–2633, *Hindustan Book Agency, New Delhi*, 2010.

This paper is devoted to the concept of smoothed analysis, already presented in the literature by Spielman and Teng in 2001. Smoothed analysis is a new form of analysis of algorithms which aims at blending the best of both worst-case analysis and average-case analysis. The goal of this paper is to survey some of the recent results in the direction of performing a smoothed analysis of the condition numbers involved in more meaningful probabilistic upper complexity bounds. Therefore smoothed analysis is applied to conic condition numbers, to the GCC-condition number in the context of the convex conic feasibility problem, and the Grossman condition number. The last section is dedicated to the solution of complex polynomial systems.

{For the entire collection see MR2840857 (2012d:00008).} *Raffaella Pavani*

65J Numerical analysis in abstract spaces

MR2863787 65J08 34G10 47D06

Bátkai, András (H-EOTVO-IM; Budapest)**; Sikolya, Eszter** (H-EOTVO-IM; Budapest)

The norm convergence of a Magnus expansion method. (English summary)

Cent. Eur. J. Math. **10** (2012), *no.* 1, 150–158.

Summary: "We consider numerical approximation to the solution of non-autonomous evolution equations. The order of convergence of the simplest possible Magnus method is investigated."

MR2876751 65J20 35K05 35K08 44A15 46E22

Castro, L. P. (P-UDA; Aveiro)**; Saitoh, S. [Saitoh, Saburou]** (P-UDA; Aveiro)

Natural outputs and global inputs of linear systems with a finite number of input data. (English summary)

Appl. Anal. **91** (2012), *no.* 2, 225–236.

In [T. Matsuura, S. Saitoh and Dang Duc Trong, J. Inverse Ill-Posed Probl. **13** (2005), no. 3-6, 479–493; MR2188625 (2006h:80002)] the authors solved the heat equation $u_t = u_{xx}$ with initial condition $u_t(x,0) = F(x)$. The solution is an integral (i.e., Weierstrass) transform of F. In the paper under review, reproducing kernel techniques for inversion with Tikhonov regularization are used to recover the initial condition in terms of a parametrized solution. However, the initial condition is only approximately known at a finite number of points. The crux is then that the above inversion technique defines a "natural" interpolant for the given data points. In this way a natural minimal norm, regularized least squares solution of the original equation is obtained. In this paper, this method is explained on a more general level for a linear equation $Lf = d$ where L maps f from a reproducing kernel Hilbert space to some Hilbert space. First, as an example, the heat equation is explained again with variations in the intermediate spaces that are used. Then the technique is also applied to the wave equation $u_{tt} = c^2 u_{xx}$ with $u(x,0) = 0$ and $u_t(x,0) = F(x)$. See also [T. Matsuura and S. Saitoh, J. Comput. Math. Optim. **1** (2005), no. 1, 1–19; MR2128936]. Theorems are formulated but formal proofs are to be found in the references. *A. Bultheel*

MR2854326 65J20 35J25 35J91 35R30 65J22

Kaltenbacher, Barbara (A-KLAG; Klagenfurt)**;**
Kirchner, Alana (D-MUTUM2-MOP; Garching)**;**
Vexler, Boris (D-MUTUM2-MOP; Garching)

Adaptive discretizations for the choice of a Tikhonov regularization parameter in nonlinear inverse problems. (English summary)

Inverse Problems **27** (2011), *no.* 12, 125008, 28 *pp.*

The paper extends the idea of adaptive discretization developed in [A. Griesbaum, B. Kaltenbacher and B. Vexler, Inverse Problems **24** (2008), no. 2, 025025; MR2408562 (2009c:65130)] for linear ill-posed problems to nonlinear ill-posed problems.

Let $F(q) = g$ be a nonlinear ill-posed problem with a solution $q^\dagger$ where $F: \mathcal{D} \subset Q \to G$ is a nonlinear operator between two Hilbert spaces. Instead of g an approximation g^δ with $\|g - g^\delta\| \le \delta$ is given. An approximation q^δ to the solution is a stationary point of $j_\beta(q) = \|F(q) - g^\delta\|_G^2 + \frac{1}{\beta}\|q - q_0\|_Q^2$. A suitable value of the regularizing parameter β_* is calculated using the discrepancy principle $\|F(q^\delta_{\beta_*}) - g^\delta\| = \tau\delta$ for a $\tau > 1$. This can be calculated using Newton's method for the equation $i(\beta_*) = \|F(q^\delta_{\beta_*}) - g^\delta\|^2 = \tau^2\delta^2$. Using discretization, finite-dimensional subspaces Q_h and V_h of Q and G are employed and therefore stationary points of $j_{h,\beta}(q) = \|F_h(q) - g^\delta\|_G^2 + \frac{1}{\beta}\|q - q_0\|_Q^2$ have to be calculated.

In Section 2 it is shown that under suitable conditions on F the described approximations converge to the solution $q^\dagger$. The rate of convergence is derived under source conditions.

The main results are contained in Section 3 where so-called goal oriented error estimators are derived and used for refinements of the subspaces Q_h and V_h, as treated in [A. Griesbaum, B. Kaltenbacher and B. Vexler, op. cit.; R. Becker and B. Vexler, Numer. Math. **96** (2004), no. 3, 435–459; MR2028723 (2004k:65197); J. Comput. Phys. **206** (2005), no. 1, 95–110; MR2135836 (2005k:65273)]. If locally supported basis functions are used then local refinements can be used where it is necessary. The developed strategy diminishes the computation time substantially, up to 90% in comparision with the

method where refinements are uniform.

Section 4 treats in full detail a parameter identification problem for a nonlinear elliptic partial defferential equation from measurements of the solution of the equation. The calculations show improvement of the efficiency of the adaptive refinement strategy over the uniform refinement. *Anton Suhadolc*

MR2876856 65J22 62F15 65C20 65R32
Kolehmainen, V. (FIN-UEF2-AP; Kuopio)**;**
Lassas, M. [**Lassas, Matti**] (FIN-HELS-MS; Helsinki)**;**
Niinimäki, K. (FIN-UEF2-AP; Kuopio)**;**
Siltanen, S. [**Siltanen, Samuli**] (FIN-HELS-MS; Helsinki)
Sparsity-promoting Bayesian inversion. (English summary)
Inverse Problems **28** (2012), *no.* 2, 025005, 28 *pp.*
Summary: "A computational Bayesian inversion model is demonstrated. It is discretization invariant, describes prior information using function spaces with a wavelet basis and promotes reconstructions that are sparse in the wavelet transform domain. The method makes use of the Besov space prior with $p = 1$, $q = 1$ and $s = 1$, which is related to the total variation prior. Numerical evidence is presented in the context of a one-dimensional deconvolution task, suggesting that edge-preserving and noise-robust reconstructions can be achieved consistently at various resolutions."

65K Mathematical programming, optimization and variational techniques

MR2835588 65K05 62H35 65D18 68U10 94A08
Chan, Raymond H. (PRC-CHHK; Shatin)**; Liang, Hai-Xia** (PRC-CHHK; Shatin)**;**
Ma, Jun [**Ma, Jun^3**] (5-MCQR-S; North Ryde)
Positively constrained total variation penalized image restoration. (English summary)
Adv. Adapt. Data Anal. **3** (2011), *no.* 1-2, 187–201.
The authors study the numerical solution of a minimization problem arising from total variation models in image processing. This numerical algorithm is derived from the so-called multiplicative iterative algorithm, which was recently proposed for the reconstruction of tomographic images. This algorithm is derived by taking into account the usual Karush-Kuhn-Tucker condition for the total variation minimization problem with positivity constraint for the pixel values. In particular, it is an iterative procedure, where in each step the inequalities arising from such a condition are solved by considering the positive part and the negative part of the gradient of the objective function. The authors consider three different noise models, and describe the three corresponding versions of the proposed numerical algorithm. The paper concludes with some numerical experiments on two different images. *Pierluigi Maponi*

MR2907506 65K05 34C15
Kim, P. [**Kim, Peter**] (1-CASP-NDM; Pomona, CA)**;**
Latulippe, J. (1-CASP-NDM; Pomona, CA)**;**
Muehlbacher, S. (1-CASP-NDM; Pomona, CA)**;**
Shen, E. (1-CASP-NDM; Pomona, CA)**; Shun, K.** (1-CASP-NDM; Pomona, CA)
Genetic algorithm and the pendulum problem. (English summary)
Math. Sci. **36** (2011), *no.* 2, 133–146.
Summary: "In this paper we present a mathematical model for a nonlinear damped

pendulum. We compare the theoretical model with experimentally generated data recorded by a pendulum apparatus. We use a genetic algorithm to find the best fit model parameters. A detailed description of the algorithm is given and adapted for our pendulum model. We also illustrate that air friction and drag forces cannot always be ignored when modeling pendular motion."

MR2869501 65K10 65G40 90C26 90C30
Markót, Mihály Csaba (A-WIENM; Vienna); **Schichl, Hermann** (A-WIENM; Vienna)
Comparison and automated selection of local optimization solvers for interval global optimization methods. (English summary)
SIAM J. Optim. **21** (2011), *no.* 4, 1371–1391.
Summary: "We compare six state-of-the-art local optimization solvers, with a focus on their efficiency when invoked within an interval-based global optimization algorithm. For comparison purposes we design three special performance indicators: a solution check indicator (measuring whether the local minimizers found are good candidates for near-optimal verified feasible points), a function value indicator (measuring the contribution to the progress of the global search), and a running time indicator (estimating the computational cost of the local search within the global search). The solvers are compared on the COCONUT Environment test set consisting of 1307 problems. Our main goal is to predict the behavior of the solvers in terms of the three performance indicators on a new problem. For this we introduce a k-nearest neighbor method applied over a feature space consisting of several categorical and numerical features of the optimization problems. The quality and robustness of the prediction is demonstrated by various quality measurements with detailed comparative tests. In particular, we found that on the test set we are able to pick a 'best' solver in 66–89% of the cases and avoid picking all 'useless' solvers in 95–99% of the cases (when a useful alternative exists). The resulting automated solver selection method is implemented as an inference engine of the COCONUT Environment."

65L Ordinary differential equations

MR2861642 65L03 65L06 65L20 65L60 65L70
Huang, Qiumei (PRC-BJUT-CAS; Beijing); **Xie, Hehu** (PRC-ASBJ-ENM; Beijing); **Brunner, Hermann** (3-NF; St. John's, NL)
Superconvergence of discontinuous Galerkin solutions for delay differential equations of pantograph type. (English summary)
SIAM J. Sci. Comput. **33** (2011), *no.* 5, 2664–2684.
The superconvergence properties of the discontinuous Galerkin (DG) method applied to delay differential equations of pantograph type are studied. Unlike with ordinary differential equations, the achievable superconvergence order of a DG method applied to delay differential equations is much lower. A standard approach for achieving superconvergence is by postprocessing. The authors study two such approaches, namely the iteration postprocessing method and interpolation postprocessing. The key results underlying the proposed interpolated postprocessing methods are (i) the supercloseness between the DG solution and a suitable interpolant of the exact solution, and (ii) the location of superconvergence points. The improvement of convergence is from $m+1$ to $m+2$, where m is the degree of the polynomial DG space, for all proposed methods and is verified by carefully conducted numerical experiments. *Sebastian Reich*

MR2895270 65L04

Akinfenwa, A. O. (PRC-HRBEU-CS; Harbin);
Jator, S. N. (1-AUSP-DM; Clarksville, TN);
Yao, N. M. [Yao, Nianmin] (PRC-HRBEU-CS; Harbin)

On the 7-step backward differentiation formula with continuous coefficients for stiff systems. (English summary)

Far East J. Math. Sci. (*FJMS*) **56** (2011), *no.* 1, 23–41.

From the introduction: "We show that the instability of the 7-step Backward Differentiation Formula (BDF) for stiff systems is improved to L_0-stability in the sense of J. R. Cash [SIAM J. Numer. Anal. **18** (1981), no. 5, 808–821; MR0629666 (83b:65072)] via a block form. This is achieved by constructing a continuous representation of the 7-step BDF, using it to produce the standard 7-step BDF, which are combined with additional methods and applied as a BBDF to solve stiff IVPs." *Omid S. Fard*

MR2822275 65L05 34E10 65L06 65L20 65L70 65P10

Calvo, M. [Calvo, Manuel] (E-ZRGZ-AMM; Zaragoza);
Laburta, M. P. (E-ZRGZ-AMM; Zaragoza);
Montijano, J. I. [Montijano, Juan I.] (E-ZRGZ-AMM; Zaragoza);
Rández, L. [Rández, Luis] (E-ZRGZ-AMM; Zaragoza)

Error growth in the numerical integration of periodic orbits. (English summary)

Math. Comput. Simulation **81** (2011), *no.* 12, 2646–2661.

The paper analyzes the long term behavior of the error committed by one step methods in the numerical integration of ordinary differential equations possessing periodic solutions whose period depends smoothly on the initial point. The numerical integrators considered are those whose local error possesses an asymptotic expansion and the idea is to get sufficient conditions that guarantee that the corresponding global error grows only linearly with the number of periods of the orbit. In particular, it is shown that such a linear growth of the error is obtained if the period of the solution is preserved up to order $O(h^{2r})$ by the method, h being the step size and r the order of consistency of the numerical integrator. A study of the error growth of the first integrals of the system is also carried out. It is also shown that when the period depends only on these first integrals, then numerical methods preserving them by construction also lead to a linear error growth. Although mainly integrators with constant step size are considered, the analysis is easily generalized to the case of variable step size integrations. Finally, some numerical experiments are included to illustrate the main theoretical results of the paper. *Fernando Casas*

MR2837106 65L05 65Y05

Christlieb, Andrew (1-MIS; East Lansing, MI);
Ong, Benjamin (1-MIS; East Lansing, MI)

Implicit parallel time integrators. (English summary)

J. Sci. Comput. **49** (2011), *no.* 2, 167–179.

In a previous work the authors developed a high-order parallel explicit time integrator called Revisionist Integral Deferred Correction (RIDC). The word revisionist was adopted because successive corrections, running in parallel but lagging in time, *revise* and improve the approximate solution. As is well known, explicit solvers are only conditionally stable. To remove the condition, the authors here develop implicit time integrators. The stability of the algorithm is discussed. Each node performs a Newton step on a system of N equations instead of sN equations for s-stage implicit Runge-Kutta. The number of nodes is not to exceed 12 because of the Runge phenomenon. This idea is different than the parareal algorithm due to [J.-L. Lions, Y. Maday and

G. Turinici, C. R. Acad. Sci. Paris Sér. I Math. **332** (2001), no. 7, 661–668; MR1842465 (2002c:65140)], where the time domain is subdivided and given to the nodes.

Several examples are given to show the speedup attained. *Beny Neta*

MR2863110 65L05 34K40 45J05 65L06 65L20

Wang, Wansheng (PRC-CSUST-MS; Changsha)**;**
Li, Dongfang [**Li, Dong Fang**$^{[2]}$] (PRC-HUST-SMS; Wuhan)

Stability analysis of Runge-Kutta methods for nonlinear neutral Volterra delay-integro-differential equations. (English summary)

Numer. Math. Theory Methods Appl. **4** (2011), *no.* 4, 537–561.

Summary: "This paper is concerned with the numerical stability of implicit Runge-Kutta methods for nonlinear neutral Volterra delay-integro-differential equations with constant delay. Using a Halanay inequality generalized by Liz and Trofimchuk, we give two sufficient conditions for the stability of the true solution to this class of equations. Runge-Kutta methods with compound quadrature rule are considered. Nonlinear stability conditions for the proposed methods are derived. As an illustration of the application of these investigations, the asymptotic stability of the presented methods for Volterra delay-integro-differential equations is proved under some weaker conditions than those in the literature. An extension of the stability results to such equations with weakly singular kernel is also discussed." *Zbigniew Bartoszewski*

MR2880829 65L05

Yang, Changqing (PRC-HHIT-SC; Lianyungang)**;**
Hou, Jianhua (PRC-HHIT-SC; Lianyungang)

A numerical method for Lane-Emden equations using hybrid functions and the collocation method. (English summary)

J. Appl. Math. **2012,** *Art. ID* 316534, 9 *pp.*

Second-order singular differential equations are solved by approximating the unknown solution in subintervals $\left[\left(\frac{n-1}{N}\right), \frac{n}{N}\right]$ of $(0, 1]$, $n = 1, 2, \ldots, N$, by piecewise (hybrid) Chebyshev polynomials of degree $m = 1, 2, \ldots, M-1$. The roots of Chebyshev polynomials are used as collocations points. Numerical examples for linear and nonlinear Lane-Emden equations demonstrate the performance of the method.

Bülent Karasözen

MR2907749 65L06

Prentice, J. S. C. [**Prentice, Justin Steven Calder**] (SA-UJ-AM; Johannesburg)

Runge-Kutta methods: local error control does not imply global error control. (English summary)

J. Pure Appl. Math. Adv. Appl. **6** (2011), *no.* 1, 71–84.

This paper offers the author's interpretation of the well-known fact that local error control via local extrapolation (a technique where a lower-order integrator is embedded in a higher-order integrator) does not imply global error control, for the numerical integration of ordinary differential equations (ODEs) using the Runge-Kutta method. Interested readers may wish to consult the more general treatment of the subject by L. F. Shampine [J. Sci. Comput. **25** (2005), no. 1-2, 3–16; MR2231939 (2007d:65071)], where it is pointed out that the stability of the scheme depends on the stability of the higher-order integrator. *Sateesh R. Mane*

MR2855443 65L11

Liu, Chein-Shan (RC-NTAI-CE; Taipei)

The Lie-group shooting method for solving nonlinear singularly perturbed boundary value problems. (English summary)

Commun. Nonlinear Sci. Numer. Simul. **17** (2012), *no.* 4, 1506–1521.

Summary: "A new computational method for solving the second-order nonlinear singularly perturbed boundary value problems (SPBVPs) is provided in this paper. In order to overcome a highly singular behavior very near to the boundary as being not easy to treat by numerical method, we adopt a coordinate transformation from an x-domain to a t-domain via a rescaling technique, which can reduce the singularity within the boundary layer. Then, we construct a Lie-group shooting method (LGSM) to search a missing initial condition through the finding of a suitable value of a parameter $r \in [0, 1]$. Moreover, we can derive a closed-form formula to express the initial condition in terms of r, which can be determined properly by an accurate matching to the right-boundary condition. Numerical examples are examined, showing that the present approach is highly efficient and accurate."

MR2878943 65L60 65L10

Doss, L. Jones Tarcius (6-ANUN; Chennai)**; Nandini, A. P.**

Discrete mixed Petrov-Galerkin finite element method for a fourth-order two-point boundary value problem. (English summary)

Int. J. Math. Math. Sci. **2012,** *Art. ID* 962070, 18 *pp.*

Summary: "A quadrature-based mixed Petrov-Galerkin finite element method is applied to a fourth-order linear ordinary differential equation. After employing a splitting technique, a cubic spline trial space and a piecewise linear test space are considered in the method. The integrals are then replaced by the Gauss quadrature rule in the formulation itself. Optimal order *a priori* error estimates are obtained without any restriction on the mesh."

MR2862671 65L60 33C45 65L05

Yan, Jian-Ping [Yan, Jian Ping^2] (PRC-SNO; Shanghai)**;**
Guo, Ben-Yu [Guo, Ben Yu] (PRC-SNO; Shanghai)

A collocation method for initial value problems of second-order ODEs by using Laguerre functions. (English summary)

Numer. Math. Theory Methods Appl. **4** (2011), *no.* 2, 283–295.

Summary: "We propose a collocation method for solving initial value problems of second-order ODEs by using modified Laguerre functions. This new process provides global numerical solutions. Numerical results demonstrate the efficiency of the proposed algorithm."

MR2854040 65L80

Bao, Wendi [Bao, Wen Di] (PRC-NJN-NSM; Nanjing)**;**
Song, Yongzhong (PRC-NJN-NSM; Nanjing)

Two stage waveform relaxation method for the initial value problems of differential-algebraic equations. (English summary)

J. Comput. Appl. Math. **236** (2011), *no.* 6, 1123–1136.

Summary: "In this paper, we consider a two stage strategy for waveform relaxation (WR) iterations, applied to initial value problems for differential-algebraic equations (DAEs) in the form $A\dot{y}(t) + By(t) = f(t)$. Outer iterations of TSWR are defined by $M_A\dot{y}^{(k+1)}(t) + M_1 y^{(k+1)}(t) = N_1 y^{(k)}(t) + N_A\dot{y}^{(k)}(t) + f(t)$, where $A = M_A - N_A$, $B = M_1 - N_1$, and each iteration $y^{(k+1)}(t)$ is computed using an inner iterative process, based

on another splitting $M_1 = M_2 - N_2$. Meanwhile, by the means of the Theta method, the discretized TSWR of DAEs is realized. Furthermore, when M_A is an Hermitian positive semi-definite matrix with P-regular splittings, the convergence and the comparison theorems of TSWR are analyzed. Finally, the numerical experiments are presented."

MR2863929 65L99 26A33 34A25 34K37 45J05
Vanani, S. Karimi [Karimi Vanani, S.] (IR-KNTU; Tehran)**;**
Aminataei, A. (IR-KNTU; Tehran)
Operational Tau approximation for a general class of fractional integro-differential equations. (English summary)
Comput. Appl. Math. **30** (2011), *no.* 3, 655–674.
Nonlinear fractional integro-differential equations are considered. An algorithm for numerical solving of the given equation is suggested. The theoretical basis of the method under consideration is the operational Tau method. An efficient error estimate for the proposed method is presented. Three examples illustrate the efficiency and practical application of the suggested scheme. *Snezhana Hristova*

65M Partial differential equations, initial value and time-dependent initial-boundary value problems

MR2874200 65M06 76M20
Appadu, A. R. (SA-CAPE-CM; Rondebosch)
Some applications of the concept of minimized integrated exponential error for low dispersion and low dissipation. (English summary)
Internat. J. Numer. Methods Fluids **68** (2012), *no.* 2, 244–268.
Summary: "Several techniques to optimize parameters that regulate dispersion and dissipation effects in finite difference schemes have been devised in our previous works. They all use the notion that dissipation neutralizes dispersion. These techniques are the minimized integrated square difference error (MISDE) and the minimized integrated exponential error for low dispersion and low dissipation (MIEELDLD). It is shown in this work based on several numerical schemes tested that the technique of MIEELDLD is more accurate than MISDE to optimize the parameters that regulate dispersion and dissipation effects with the aim of improving the shock-capturing properties of numerical methods.

"First, we consider the family of third-order schemes proposed by Takacs. We use the techniques MISDE and MIEELDLD to optimize two parameters, namely, the cfl number and another variable which also controls dispersion and dissipation. Second, these two techniques are used to optimize a numerical scheme proposed by Gadd. Moreover, we compute the optimal cfl for some multi-level schemes in 1D. Numerical tests for some of these numerical schemes mentioned above are performed at different cfl numbers and it is shown that the results obtained are dependent on the cfl number chosen. The errors from the numerical results have been quantified into dispersion and dissipation using a technique devised by Takacs. Finally, we make use of a composite scheme made of corrected Lax-Friedrichs and the two-step Lax-Friedrichs schemes like the CFLF4 scheme at its optimal cfl number, to solve some problems in 2D, namely: solid body rotation test, acoustics and the circular Riemann problem."

MR2864077 65M06 76M20

Deng, Xiaogang [Deng, Xiao Gang] (PRC-ADRD-AED; Mianyang);
Mao, Meiliang [Mao, Mei Liang] (PRC-ADRD-AED; Mianyang);
Tu, Guohua [Tu, Guo Hua] (PRC-ADRD-AED; Mianyang);
Zhang, Hanxin (PRC-ADRD-AED; Mianyang);
Zhang, Yifeng (PRC-ADRD-AED; Mianyang)

High-order and high accurate CFD methods and their applications for complex grid problems. (English summary)

Commun. Comput. Phys. **11** (2012), *no.* 4, 1081–1102.

Summary: "The purpose of this article is to summarize our recent progress in high-order and high accurate CFD methods for flow problems with complex grids as well as to discuss the engineering prospects in using these methods. Despite the rapid development of high-order algorithms in CFD, the applications of high-order and high accurate methods on complex configurations are still limited. One of the main reasons which hinder the widely applications of these methods is the complexity of grids. Many aspects which can be neglected for low-order schemes must be treated carefully for high-order ones when the configurations are complex. In order to implement high-order finite difference schemes on complex multi-block grids, the geometric conservation law and block-interface conditions are discussed. A conservative metric method is applied to calculate the grid derivatives, and a characteristic-based interface condition is employed to fulfil high-order multi-block computing. The fifth-order WCNS-E-5 proposed by X. G. Deng [X. G. Deng and H. X. Zhang, J. Comput. Phys. **165** (2000), no. 1, 22–44; MR1795391 (2001h:76088); X. G. Deng, Sci. China Ser. A **45** (2002), no. 3, 356–370; MR1903631 (2003m:65136)] is applied to simulate flows with complex grids, including a double-delta wing, a transonic airplane configuration, and a hypersonic X-38 configuration. The results in this paper and the references show pleasant prospects in engineering-oriented applications of high-order schemes."

MR2869524 65M06 65M08

Domingues, Margarete O. [Domingues, Margarete Oliveira] (BR-INPE-CAM; São José dos Campos);
Gomes, Sônia M. [Gomes, Sônia Maria] (BR-ECPM-IM; Campinas);
Roussel, Olivier [Roussel, Olivier^2] (F-ENSET-AM; Cachan);
Schneider, Kai (F-PROV-MMP; Marseille)

Adaptive multiresolution methods. (English summary)

Summer School on Multiresolution and Adaptive Mesh Refinement Methods, 1–96, *ESAIM Proc.*, 34, *EDP Sci.*, *Les Ulis*, 2011.

Summary: "These lecture notes present adaptive multiresolution schemes for evolutionary PDEs in Cartesian geometries. The discretization schemes are based either on finite volume or finite difference schemes. The concept of multiresolution analyses, including Harten's approach for point and cell averages, is described in some detail. Then the sparse point representation method is discussed. Different strategies for adaptive time-stepping, like local scale dependent time stepping and time step control, are presented. Numerous numerical examples in one, two and three space dimensions validate the adaptive schemes and illustrate the accuracy and the gain in computational efficiency in terms of CPU time and memory requirements. Another aspect, modeling of turbulent flows using multiresolution decompositions, the so-called Coherent Vortex Simulation approach is also described and examples are given for computations of three-dimensional weakly compressible mixing layers. Most of the material concerning applications to PDEs is assembled and adapted from previous publications [R. Deiterding et al., in *Multiresolution and adaptive methods for convection-dominated*

problems, 28–42, ESAIM Proc., 29, EDP Sci., Les Ulis, 2009; MR2768219 (2011k:76064); M. O. Domingues, S. Gomes and L. Álvarez Díaz, Appl. Numer. Math. **47** (2003), no. 3-4, 421–437; MR2023829 (2004j:65138); M. O. Domingues et al., J. Comput. Phys. **227** (2008), no. 8, 3758–3780; MR2403866 (2009b:65204); M. O. Domingues, O. Roussel and K. Schneider, Internat. J. Numer. Methods Engrg. **78** (2009), no. 6, 652–670; MR2517617 (2010d:65224); O. Roussel and K. Schneider, J. Comput. Phys. **229** (2010), no. 6, 2267–2286; MR2586248 (2010j:76135); O. Roussel et al., J. Comput. Phys. **188** (2003), no. 2, 493–523; MR1985307 (2004f:65142)]."

{For the entire collection see MR2905893 (2012i:65004).}

MR2871985 65M06 35L65 76N15

Glaister, P. (4-RDNG-MS; Reading)

A comparison of upwind difference schemes for compressible flows of ideal and non-ideal gases in a duct. (English summary)

Math. Æterna **1** (2011), *no.* 7-8, 425–448.

This paper is a continuation of the previous works of the author [Comput. Math. Appl. **56** (2008), no. 7, 1787–1796; MR2445325 (2009i:65137); Comput. Math. Appl. **57** (2009), no. 9, 1432–1437; MR2509956 (2010b:65160)], in which he presented numerical schemes for Euler equations of compressible flows of an ideal gas in a duct of variable cross section. In the present paper, the author provides one numerical example in which his schemes are implemented for a test problem of a converging cylindrical shock. No comparison is made with other numerical methods. The paper has only two references, which are the references to the previous two works of the author. *Doron Levy*

MR2864664 65M06 65M60 76D05 76M20

He, Yinnian [He, Yin Nian] (PRC-XJUS-MPF; Xi'an)

The Crank-Nicolson/Adams-Bashforth scheme for the time-dependent Navier-Stokes equations with nonsmooth initial data. (English summary)

Numer. Methods Partial Differential Equations **28** (2012), *no.* 1, 155–187.

The author proposes an algorithm for the incompressible Navier-Stokes equations with nonsmooth initial data on bounded, spatially 2d domains under homogeneous Dirichlet boundary conditions. The algorithm consists in a 3-level implicit finite-difference scheme for the temporal discretization, and a finite element Galerkin method for the spatial discretization. A priori L^2-bounds for the discretized solution, as well as L^2-error bounds, are derived, establishing in particular the stability of the scheme for all sufficiently small time steps. The proofs make repeated use of a discretized version of the Gronwall lemma. *Reinhard Redlinger*

MR2869653 65M06 35C08 35Q55

Hoseini, S. M. [Hoseini, Sayed M.] (IR-VRU-M; Rafsanjan)**;**
Marchant, T. R. [Marchant, Timothy R.] (5-WLG-SMS; Wollongong)

The analytical evolution of NLS solitons due to the numerical discretization error. (English summary)

J. Phys. A **44** (2011), *no.* 50, 505205, 17 *pp.*

In this paper, soliton perturbation theory is used to obtain analytical solutions describing solitary wave tails or shelves, due to the numerical discretization error, for soliton numerical solutions of the nonlinear Schrödinger equation. Two important implicit numerical schemes for the nonlinear Schrödinger equation are considered. These are the Crank-Nicolson scheme and a scheme due to Taha and based on the inverse scattering transform (with second-order temporal and spatial discretization errors). Optimal choices of the discretization parameters for the numerical schemes are found, which min-

imize the amplitude of the solitary wave tail. Analytical solutions are compared with numerical simulations, and the properties of the two numerical schemes (symmetries, etc.) are also compared. *Serge Dumont*

MR2863782 65M06 35M13 65M12

Jovanović, Boško S. (SE-BELGM; Belgrade); **Vulkov, Lubin G.** (BG-RUS; Ruse)

Analysis and numerical approximation of a parabolic-hyperbolic transmission problem. (English summary)

Cent. Eur. J. Math. **10** (2012), *no.* 1, 73–84.

Summary: "In this paper we investigate a mixed parabolic-hyperbolic initial boundary value problem in two disconnected intervals with Robin-Dirichlet conjugation conditions. A finite difference scheme approximating this problem is proposed and analyzed. An estimate of the convergence rate is obtained." *Bruno Scheurer*

MR2869615 65M06 76M20

Lin, San-Yih [Lin, San Yih] (RC-TAIN-DAA; Tainan);
Chin, Ya-Hsien (RC-OCU-MKD; Taichung); **Hu, Jeu-Jiun**;
Chen, Yi-Cheng (RC-TAIN-DAA; Tainan)

A pressure correction method for fluid-particle interaction flow: direct-forcing method and sedimentation flow. (English summary)

Internat. J. Numer. Methods Fluids **67** (2011), *no.* 12, 1771–1798.

Summary: "A direct-forcing pressure correction method is developed to simulate fluid-particle interaction problems. In this paper, the sedimentation flow is investigated. This method uses a pressure correction method to solve incompressible flow fields. A direct-forcing method is introduced to capture the particle motions. It is found that the direct-forcing method can also be served as a wall-boundary condition. By applying Gauss's divergence theorem, the formulas for computing the hydrodynamic force and torque acting on the particle from flows are derived from the volume integral of the particle instead of the particle surface. The order of accuracy of the present method is demonstrated by the errors of velocity, pressure, and wall stress. To demonstrate the efficiency and capability of the present method, sedimentations of many spherical particles in an enclosure are simulated."

MR2894053 65M06

Liu, Yi Zhong (PRC-GUIZ-MCS; Guiyang); **Li, Wu Lan** (PRC-WZMC-CIE; Wenzhou);
Fang, Chun Hua (PRC-HNIST-CM; Yueyang); **Zeng, Cheng**

A class of higher-order algorithms and numerical experiments for a hyperbolic equation. (Chinese. English and Chinese summaries)

J. Nat. Sci. Hunan Norm. Univ. **34** (2011), *no.* 3, 1–5.

For a scalar hyperbolic equation, a class of schemes with parameters is constructed. Its accuracy is higher than that of known algorithms. A general stability condition is given. The schemes are systematically assessed via a test problem. *Yueling Jia*

MR2871302 65M06 65M15

Lu, Tongchao [Lu, Tong Chao] (PRC-SHAN-SM; Jinan);
Jia, Jinhong (PRC-SHAN-SM; Jinan)

An optimal-order error estimate for a finite difference method to transient degenerate advection-diffusion equations. (English summary)

Int. J. Numer. Anal. Model. **9** (2012), *no.* 1, 56–72.

Summary: "We prove an optimal-order error estimate in a degenerate-diffusion weighted energy norm for implicit Euler and Crank-Nicolson finite difference methods to two-

dimensional time-dependent advection-diffusion equations with degenerate diffusion. In the estimate, the generic constants depend only on certain Sobolev norms of the true solution but not on the lower bound of the diffusion. This estimate, combined with a known stability estimate of the true solution of the governing partial differential equations, yields an optimal-order estimate of the finite difference methods, in which the generic constants depend only on the Sobolev norms of the initial and right-hand side data." *Boško S. Jovanović*

MR2866558 65M06 65M12

Rogov, B. V. (RS-AOS-M; Moscow)**;**
Mikhaĭlovskaya, M. N. (RS-MIPE-NDM; Dolgoprudnyĭ)

Monotone bicompact schemes for a linear transfer equation. (Russian. English and Russian summaries)

Mat. Model. **23** (2011), *no.* 6, 98–110; *translation in Math. Models Comput. Simul.* **4** (2012), *no.* 1, 92–100.

Summary (reviewer's translation): "For the numerical solution of a linear transport equation an implicit monotonic bicompact difference scheme is proposed. The scheme has the fourth-order approximation in spatial coordinate on a two-point stencil and the first-order approximation in time. The scheme is absolutely stable and can be solved by explicit formulas of the running calculation method. On the basis of this scheme the monotone nonlinear homogeneous difference scheme of high- (third- for smooth solutions) order accuracy in time is constructed. Calculations on the test problems with discontinuous solutions show a significant advantage in the accuracy of the proposed scheme over known nonoscillatory schemes of high-order approximation."

Boško S. Jovanović

MR2862011 65M06 35B25 35L65

Saran, Haseena (1-IASU; Ames, IA)**; Liu, Hailiang** (1-IASU; Ames, IA)

Alternating evolution schemes for hyperbolic conservation laws. (English summary)

SIAM J. Sci. Comput. **33** (2011), *no.* 6, 3210–3240.

The authors develop local alternating evolution (AE) schemes, for nonlinear hyperbolic conservation laws, that enjoy a relatively easy formulation and implementation, together with an accurate and efficient computation of the solution. While a general algorithm is presented for constructing AE schemes of any desired order, first- and second-order schemes are explicitly given and tested on both scalar conservation laws and compressible Euler equations along with comparisons to the global AE scheme and some standard central schemes that attest to their accuracy and capacity.

David A. Voss

MR2845019 65M06 65M70

Shahbazi, Khosro; Albin, Nathan (1-KSS; Manhattan, KS)**;**
Bruno, Oscar P. (1-CAIT-ACM; Pasadena, CA)**;**
Hesthaven, Jan S. (1-BRN-A; Providence, RI)

Multi-domain Fourier-continuation/WENO hybrid solver for conservation laws. (English summary)

J. Comput. Phys. **230** (2011), *no.* 24, 8779–8796.

Summary: "We introduce a multi-domain Fourier-continuation/WENO hybrid method (FC-WENO) that enables high-order and non-oscillatory solution of systems of non-linear conservation laws, and which enjoys essentially dispersionless, spectral character away from discontinuities, as well as mild CFL constraints (comparable to those of finite

difference methods). The hybrid scheme employs the expensive, shock-capturing WENO method in small regions containing discontinuities and the efficient FC method in the rest of the computational domain, yielding a highly effective overall scheme for applications with a mix of discontinuities and complex smooth structures. The smooth and discontinuous solution regions are distinguished using the multi-resolution procedure of A. Harten [J. Comput. Phys. **115** (1994), no. 2, 319–338; MR1304579 (96d:65175)]. We consider WENO schemes of formal orders five and nine and a FC method of order five. The accuracy, stability and efficiency of the new hybrid method for conservation laws is investigated for problems with both smooth and non-smooth solutions. In the latter case, we solve the Euler equations for gas dynamics for the standard test case of a Mach three shock wave interacting with an entropy wave, as well as a shock wave (with Mach 1.25, three or six) interacting with a very small entropy wave and evaluate the efficiency of the hybrid FC-WENO method as compared to a purely WENO-based approach as well as alternative hybrid based techniques. We demonstrate considerable computational advantages of the new FC-based method, suggesting a potential of an order of magnitude acceleration over alternatives when extended to fully three-dimensional problems."

MR2858703 65M06 35B25 35K20 65M12 65M50

Shishkin, G. I. (RS-AOSUR-A; Ekaterinburg)

Grid approximation of a parabolic convection-diffusion equation on a priori adaptive grids: ε-uniformly converging schemes. (Russian. Russian summary)

Zh. Vychisl. Mat. Mat. Fiz. **48** (2008), *no.* 6, 1014–1033; *translation in Comput. Math. Math. Phys.* **48** (2008), *no.* 6, 956–974.

In this paper the author considers a Dirichlet problem for the equations $Lu(x,t) = f(x,t)$, where L is a singularly perturbed convection-diffusion operator of parabolic type in the form

$$L = \varepsilon a(x,t)\frac{\partial^2}{\partial x^2} + b(x,t)\frac{\partial}{\partial x} - c(x,t) - p(x,t)\frac{\partial}{\partial t}$$

with sufficiently smooth given functions a, b, c, p and f, and the parameter ε is assumed to be small on the interval $(0,1]$. A finite difference scheme is constructed for the boundary value problem on the locally one-dimensional meshes. An adaptive algorithm is given on a uniform sub-mesh where the solution is refined by an iterative process. The convergence of this approach is analyzed. It is shown that the convergence depends only weakly on the small parameter ε. In the paper it is also proven that the convergence on the piecewise-uniform meshes is ε-uniform under the condition $N^{-1} \ll \varepsilon$, where N denotes the number of the mesh-points in the direction x. The convergence in the sense of ε-almost everywhere uniform is also considered. *István Faragó*

MR2849742 65M06 35K57

Shishkin, G. I. (RS-AOSUR-A; Ekaterinburg)

Improved scheme on adapted locally-uniform meshes for a singularly perturbed parabolic convection-diffusion problem. (English summary)

BAIL 2010—*boundary and interior layers, computational and asymptotic methods*, 207–215, *Lect. Notes Comput. Sci. Eng.*, 81, *Springer, Heidelberg*, 2011.

The author considers an initial-boundary value problem for a singularly perturbed parabolic convection-diffusion equation, in which highest derivative is multiplied by a small parameter ε, $\varepsilon \in (0,1]$. A difference scheme based on classical approximation of this problem is constructed. An algorithm for constructing a locally-uniform (adapted in the boundary layer) grid is given. Using the Richardson technique on embedded grids, a finite difference solution is constructed that converges almost ε-uniformly with order

of convergence close to 2.

{For the entire collection see MR2849747 (2012h:65002).} *Givi K. Berikelashvili*

MR2850899 65M06 76Q05

Staudacher, J. (F-ONERA-AES; Châtillon)**;**
Savin, É. [**Savin, Eric**] (F-ONERA-AES; Châtillon)

Conservative finite-difference scheme for high-frequency acoustic waves propagating at an interface between two media. (English summary)

Commun. Comput. Phys. **11** (2012), *no.* 2, 351–366.

A new conservative finite difference scheme for solving the Liouville equation for high-frequency acoustic energy density valid on a straight interface of a piecewise homogeneous medium is derived. The new scheme conserves the total acoustic energy reflected and transmitted by the interface. *Ebrahim Momoniat*

MR2862446 65M08 76X05

Bonnement, A. (F-INRIA2; Sophia Antipolis)**;**
Fajraoui, T. (F-VALN-NDM; Valenciennes)**;**
Guillard, H. [**Guillard, Hervé**] (F-INRIA2; Sophia Antipolis)**;**
Martin, M. (F-NICE-NDM; Nice)**;**
Mouton, A. [**Mouton, Alexandre**] (F-TOUL3-NDM; Toulouse)**;**
Nkonga, B. (F-NICE-NDM; Nice)**; Sangam, A.** (F-NICE-NDM; Nice)

Finite volume method in curvilinear coordinates for hyperbolic conservation laws. (English summary)

*CEMRACS'*10 *research achievements*: *numerical modeling of fusion*, 163–176, *ESAIM Proc.*, 32, *EDP Sci.*, *Les Ulis*, 2011.

Summary: "This paper deals with the design of finite volume approximation of hyperbolic conservation laws in curvilinear coordinates. Such coordinates are encountered naturally in many problems as for instance in the analysis of a large number of models coming from magnetic confinement fusion in tokamaks. In this paper we derive a new finite volume method for hyperbolic conservation laws in curvilinear coordinates. The method is first described in a general setting and then is illustrated in 2D polar coordinates. Numerical experiments show its advantages with respect to the use of Cartesian coordinates."

{For the entire collection see MR2906045 (2012i:65002).}

MR2862438 65M08 76B15 76M12

Boutin, Benjamin (F-RENN-MR; Rennes)**; Deriaz, Erwan** (F-ECMR-M2P; Marseille)**; Hoch, Philippe; Navaro, Pierre** (F-STRAS-I; Strasbourg)

Extension of ALE methodology to unstructured conical meshes. (English and French summaries)

*CEMRACS'*10 *research achievements*: *numerical modeling of fusion*, 31–55, *ESAIM Proc.*, 32, *EDP Sci.*, *Les Ulis*, 2011.

Summary: "We propose a bi-dimensional finite volume extension of a continuous ALE method on unstructured cells whose edges are parameterized by rational quadratic Bezier curves. For each edge, the control point possesses a weight that permits to represent any conic [see, e.g., M. Li, X.-S. Gao and S.-C. Chou, Visual Comput. **22** (2006), no. 9-11, 906–917, doi:10.1007/s00371-006-0075-6] and thanks to [G. Wang and T. W. Sederberg, Comput. Aided Draft. Des. Manuf. **4** (1994), no. 2, 18–27; per bibl.; G. Wang, J. Softw. **7** (1996), no. 9, 542–546], we are able to compute the *exact area* of our cells. We then give an extension of scheme for remapping step based on volume fluxing [L. G. Margolin and M. Yu. Shashkov, J. Comput. Phys. **184** (2003),

no. 1, 266–298; MR1961976 (2004c:65164)] and self-intersection flux [P. Hoch, "An arbitrary Lagrangian-Eulerian strategy to solve compressible fluid flows", preprint, hal. archives-ouvertes.fr/hal-00366858]. For the rezoning phase, we propose a three step process based on moving nodes, followed by control point and weight re-adjustment. Finally, for the hydrodynamic step, we present the GLACE scheme [G. Carré et al., J. Comput. Phys. **228** (2009), no. 14, 5160–5183; MR2537850 (2010h:76110)] extension (at first-order) on conic cell using the same formalism. We only propose some preliminary first-order simulations for each steps: Remap, Pure Lagrangian and finally ALE (rezoning and remapping)."

{For the entire collection see MR2906045 (2012i:65002).}

MR2869526 65M08 65M50

Brix, K. [**Brix, Kolja**] (D-AACH-G; Aachen)**;**
Melian, S. [**Melian, Silvia Sorana**] (D-AACH-G; Aachen)**;**
Müller, S. [**Müller, Siegfried**] (D-AACH-G; Aachen)**;**
Bachmann, M. [**Bachmann, Mathieu**] (D-AACH-G; Aachen)

Adaptive multiresolution methods: practical issues on data structures, implementation and parallelization. (English and French summaries)

Summer School on Multiresolution and Adaptive Mesh Refinement Methods, 151–183, *ESAIM Proc.*, 34, *EDP Sci.*, *Les Ulis*, 2011.

Summary: "The concept of fully adaptive multiresolution finite volume schemes has been developed and investigated during the past decade. Here grid adaptation is realized by performing a multiscale decomposition of the discrete data at hand. By means of hard thresholding the resulting multiscale data are compressed. From the remaining data a locally refined grid is constructed.

"The aim of the present work is to give a self-contained overview on the construction of an appropriate multiresolution analysis using biorthogonal wavelets, its efficient realization by means of hash maps using global cell identifiers and the parallelization of the multiresolution-based grid adaptation via MPI using space-filling curves."

{For the entire collection see MR2905893 (2012i:65004).}

MR2867599 65M08

Dumbser, M. [**Dumbser, Michael**] (I-TRNT-LAM; Trento)

High-order schemes for multidimensional hyperbolic problems. (English summary)

Lecture notes on numerical methods for hyperbolic equations: *short course book*, 85–103, *CRC Press*, *Boca Raton*, *FL*, 2011.

Summary: "In this lecture a review of better than second order accurate finite volume schemes for hyperbolic conservation laws in multiple space dimensions is given. The lecture is divided in five parts. In the first part, a short recall of higher order one-dimensional WENO reconstruction techniques is given. In the second part, implementation details for higher order polynomial WENO finite volume reconstruction operators are shown on two-dimensional Cartesian meshes. In the third part, higher order WENO reconstruction operators are presented for unstructured triangular meshes. In the fourth part, a brief overview of high order one-step time-discretizations is given and in the last part some computational results are presented."

{For the entire collection see MR2867595 (2012h:65005).}

MR2843067 65M08 82D10

Filbet, Francis (F-LYON-ICJ; Villeurbanne);
Duclous, Roland (F-BORD-LIA; Talence); **Dubroca, Bruno** (F-BORD-LIA; Talence)

Analysis of a high order finite volume scheme for the 1D Vlasov-Poisson system. (English summary)

Discrete Contin. Dyn. Syst. Ser. S **5** (2012), *no.* 2, 283–305.

The authors consider the numerical approximation of the one-dimensional Vlasov-Poisson system on the interval (0,1) with physical boundary conditions. The unknown functions are the particle distribution and the electronic potential.

Considering the problem as a bidimensional conservation law, a finite-volume MUSCL-like approximation is introduced. This involves using properly defined numerical fluxes in the (x, v) space (position-velocity) as well as the so-called flux limitation procedure. The main theorem of the paper proposes a proof of a convergence result: first, the weak convergence of the approximate particle distribution towards the exact one; second, the strong convergence of the approximate discrete potential. The proof relies on the compactness method in suitably defined functional spaces. Several numerical experiments are given at the end of the paper on a 128×128 grid (without convergence rate displayed), showing the merits of the scheme. *Jean-Pierre Croisille*

MR2869527 65M08 65M50

Tenaud, Christian (F-CNRS-LI; Orsay);
Duarte, Max (F-ECAM-EM; Châtenay-Malabry)

Tutorials on adaptive multiresolution for mesh refinement applied to fluid dynamics and reactive media problems. (English and French summaries)

Summer School on Multiresolution and Adaptive Mesh Refinement Methods, 184–239, *ESAIM Proc.*, 34, *EDP Sci.*, *Les Ulis*, 2011.

Summary: "This work aims at evaluating in practical situations the capability of the mesh refinement technique based on the multiresolution adaptive method coupled with high resolution spatial and temporal approximations, to recover elementary physical mechanisms by achieving gains in both CPU time and memory use compared to single grid computations. We first present a summary of the multiresolution procedure. We then describe MR algorithms. Finally, the evaluation of the method is presented on several well known numerical test cases in 1D and multi-D configurations."

{For the entire collection see MR2905893 (2012i:65004).}

MR2869529 65M20 65L06 65M60 92C50

Duarte, Max (F-ECAM-EM; Châtenay-Malabry);
Massot, Marc (F-ECAM-EM; Châtenay-Malabry);
Descombes, Stéphane (F-NICE-LD; Nice); **Tenaud, Christian** (F-CNRS-LI; Orsay);
Dumont, Thierry (F-LYON-ICJ; Villeurbanne);
Louvet, Violaine (F-LYON-ICJ; Villeurbanne);
Laurent, Frédérique (F-ECAM-EM; Châtenay-Malabry)

New resolution strategy for multi-scale reaction waves using time operator splitting and space adaptive multiresolution: application to human ischemic stroke. (English summary)

Summer School on Multiresolution and Adaptive Mesh Refinement Methods, 277–290, *ESAIM Proc.*, 34, *EDP Sci.*, *Les Ulis*, 2011.

Summary: "We tackle the numerical simulation of reaction-diffusion equations modeling multi-scale reaction waves. This type of problems induces peculiar difficulties and potentially large stiffness which stem from the broad spectrum of temporal scales in the nonlinear chemical source term as well as from the presence of large spatial

gradients in the reactive fronts, spatially very localized. A new resolution strategy was recently introduced [M. Duarte et al., SIAM J. Sci. Comput. **34** (2012), no. 1, A76–A104; MR2890259] that combines a performing time operator splitting with high order dedicated time integration methods and space adaptive multiresolution. Based on recent theoretical studies of numerical analysis, such a strategy leads to a splitting time step which is not restricted neither by the fastest scales in the source term nor by stability limits related to the diffusion problem, but only by the physics of the phenomenon. In this paper, the efficiency of the method is evaluated through 2D and 3D numerical simulations of a human ischemic stroke model, conducted on a simplified brain geometry, for which a simple parallelization strategy for shared memory architectures was implemented, in order to reduce computing costs related to 'detailed chemistry' features of the model."

{For the entire collection see MR2905893 (2012i:65004).}

MR2831065 65M20 65L06 65L20

Ketcheson, David I. (SAR-KAU; Thuwal)

Step sizes for strong stability preservation with downwind-biased operators. (English summary)

SIAM J. Numer. Anal. **49** (2011), *no.* 4, 1649–1660.

Strong-stability-preserving (SSP) methods for the numerical solution of initial-value problems in ordinary differential equations can possess the desirable nonlinear stability property of preserving solution properties, such as monotonicity, in time. Such properties are particularly useful when approximating the solution of semi-discretizations of hyperbolic conservation laws, for which spurious oscillations are common in numerical solutions. Classically, upwind-biased spatial discretizations are used, and the restrictions on the allowable time-step restrictions that guarantee the SSP property are well known. This paper examines the effect of using downwind-biased spatial discretizations on the corresponding time-step restrictions. Time-step restrictions for an SSP method are often quantified in terms of the size of their *CFL coefficient*, i.e., the size of the maximum SSP time step relative to the maximum SSP time step that can be realized by the forward Euler method applied to a specific problem with a given spatial discretization. It can be expected that the added freedom of allowing downwind biasing should allow for larger SSP time steps, but it is not clear *a priori* whether the gains are worthwhile.

It is found that the SSP coefficient of an s-stage Runge-Kutta method cannot exceed s even when downwind biasing is allowed; the analogous result with upwind biasing is known to hold for explicit Runge-Kutta methods. It is also found that the SSP coefficient of any second-order linear multistep method cannot exceed two; again the analogous bound holds in the case of linear multistep methods with upwind biasing, where in fact the bound holds for all methods of *at least* second order.

Perhaps the most interesting result is that two-stage, second-order implicit Runge-Kutta methods can achieve arbitrarily large SSP coefficients when downwind biasing is allowed. The method is shown to be A-stable and its stability function approaches zero in the extreme left-half plane (the L-stability limit).

Three numerical examples are given. The first is the linear advection of a square wave to show the relative dissipation of a member of the proposed family of methods compared to the standard backward Euler and trapezoidal Runge-Kutta methods. Some analysis is presented to show the necessity of high-order spatial discretizations for use with the proposed methods. Accordingly the second example is linear advection but of a (smooth) sine wave discretized in space by the fifth-order weighted essentially non-oscillatory (WENO5) spatial discretization. The solution demonstrates that the proposed method achieves the designed order of convergence. Finally, the third example is the one-

dimensional Burgers equation with periodic boundary conditions and discretized in space by WENO5. Here excellent agreement is found with the reference solution up to a time just after a shock in the solution has formed, even with a CFL number of 6.5.

As a final note, it should be re-emphasized that the proposed methods are fully implicit and involve evaluations of both upwind- and downwind-biased operators at every step. Consequently, they are relatively expensive per step compared to standard (upwind-biased) explicit SSP Runge-Kutta methods. No performance analysis is provided so it is not clear where the break-even point lies or whether it is feasible. Research into efficient methods for the efficient solution of the nonlinear equations generated at each step is ongoing. *Raymond J. Spiteri*

MR2863529 65M25 76N99 76S05

Helluy, Philippe (F-STRAS-I; Strasbourg)**;**
Hérard, Jean-Marc (F-EDF2-FDP; Chatou)**; Mathis, Hélène** (F-STRAS-I; Strasbourg)
A well-balanced approximate Riemann solver for compressible flows in variable cross-section ducts. (English summary)
J. Comput. Appl. Math. **236** (2012), *no.* 7, 1976–1992.

Summary: "A well-balanced approximate Riemann solver is introduced in this paper in order to compute approximations of one-dimensional Euler equations in variable cross-section ducts. The interface Riemann solver is grounded on the VFRoe-ncv scheme, and it enforces the preservation of Riemann invariants of the steady wave. The main properties of the scheme are detailed. We provide numerical results to assess the validity of the scheme, even when the cross-section is discontinuous. A first series is devoted to analytical test cases, and the last results correspond to the simulation of a bubble collapse."

MR2861831 65M25 65M12 82C80

Penel, Yohan (F-CENS-MSY; Gif-sur-Yvette)
An explicit stable numerical scheme for the 1D **transport equation. (English summary)**
Discrete Contin. Dyn. Syst. Ser. S **5** (2012), *no.* 3, 641–656.

The paper presents a new numerical method, based on the method of characteristics, for solving a 1D transport equation. The main idea in the method consists in combining two interpolation formulae to ensure satisfying the maximum principle. The resulting method is second-order accurate and is shown to be unconditionally stable. The numerical experiments are carried out by solving a linear convection equation and a nonlinear Burgers equation, and the results are presented. *M. K. Kadalbajoo*

MR2856688 65M25 76D05 76M10

San Martín, J. [San Martín, Jorge Alonso] (RCH-UCS-NDM; Santiago)**;**
Scheid, J.-F. (F-NANC-NDM; Vandoeuvre-les-Nancy)**; Smaranda, L.** (R-UPIT; Piteşti)
Convergence of a discretization scheme based on the characteristics method for a fluid-rigid system.
Integral methods in science and engineering, 339–348, *Birkhäuser/Springer*, *New York*, 2011.

The authors propose a convergence analysis of a numerical method based on the Lagrangian formulation to discretize the equations modeling the motion of a rigid solid immersed in a viscous incompressible fluid. The main difficulties of this problem are related to the fact that on the one hand equations of the structure are coupled with those of the fluid, and on the other hand it is a free boundary problem, that is, the domain of the fluid is variable, and it is one of the unknowns of the problem. The

authors give a proof of convergence for such a problem when a finite element technique is applied.

{For the entire collection see MR2848605 (2012h:74004).} *Francis Filbet*

MR2837492 65M32 26A33 35R11 35R30 45K05 65J22 65M12

Zheng, G. H. (PRC-LAN-SSM; Lanzhou)**;**
Wei, T. [Wei, Ting] (PRC-LAN-SSM; Lanzhou)

A new regularization method for the time fractional inverse advection-dispersion problem. (English summary)

SIAM J. Numer. Anal. **49** (2011), *no.* 5, 1972–1990.

The following fractional-time inverse advection-dispersion problem is considered:

$$D_t^\alpha u + bu_x = au_{xx}, \quad x > 0,\ t > 0,$$

$$u(x,0) = 0, \quad x \geq 0,$$

$$u(1,t) = f(t), \quad |u(x,t)| < \infty \ \text{ as } x \to \infty,\ t \geq 0,$$

where u is the solute concentration, the constants $a > 0$ and $b \geq 0$ represent the dispersion coefficient and the average fluid velocity, respectively, and D_t^α is the Caputo fractional derivative of order α, with $0 < \alpha \leq 1$.

The authors' goal is to recover the solute concentration u and the dispersion flux u_x for $0 \leq x < 1$ from the measured data $f(t)$. Their approach consists in replacing the operator D_t^α by $P_\mu(t) * D_t^\alpha$, where

$$P_\mu(t) = \frac{1}{2\mu} \exp\left(-\frac{|t|}{\mu}\right),$$

$\mu > 0$ plays the role of regularization parameter, and $*$ denotes the convolution operation. By using suitable choices of the regularization parameter, convergence results are obtained for the case $0 \leq x < 1$ under an a priori bound assumption on the exact solution. Numerical results show that the authors' method is effective and stable.

Anatoly N. Bondarenko

MR2847113 65M38 65N80

Castro, Igor (P-CMBR-CE; Coimbra)**; Tadeu, António** (P-CMBR-CE; Coimbra)

Coupling of the BEM with the MFS for the numerical simulation of frequency domain 2-D elastic wave propagation in the presence of elastic inclusions and cracks. (English summary)

Eng. Anal. Bound. Elem. **36** (2012), *no.* 2, 169–180.

Summary: "This paper proposes a coupling formulation between the boundary element method (BEM displacement and TBEM traction formulations) and the method of fundamental solutions (MFS) for the transient analysis of elastic wave propagation in the presence of multiple elastic inclusions to overcome the specific limitations of each of these methods. The full domain of the original problem is divided into sub-domains, which are handled separately by the BEM or the MFS. The coupling is enforced by imposing the required boundary conditions.

"The accuracy, efficiency and stability of the proposed algorithms, using different combinations of BEM and MFS, are verified by comparing the solutions against reference solutions. The computational efficiency of the proposed coupling formulation is illustrated by computing the CPU time and the error at high frequencies.

"The potential of the proposed procedures is illustrated by simulating the propagation of elastic waves in the vicinity of an empty crack, with null thickness placed close to an elastic inclusion."

MR2869525 65M50 65M08

Deiterding, Ralf (1-ORNL-NDM; Oak Ridge, TN)

Block-structured adaptive mesh refinement—theory, implementation and application. (English summary)

Summer School on Multiresolution and Adaptive Mesh Refinement Methods, 97–150, *ESAIM Proc.*, 34, *EDP Sci.*, *Les Ulis*, 2011.

Summary: "Structured adaptive mesh refinement (SAMR) techniques can enable cutting-edge simulations of problems governed by conservation laws. Focusing on the strictly hyperbolic case, these notes explain all algorithmic and mathematical details of a technically relevant implementation tailored for distributed memory computers. An overview of the background of commonly used finite volume discretizations for gas dynamics is included and typical benchmarks to quantify accuracy and performance of the dynamically adaptive code are discussed. Large-scale simulations of shock-induced realistic combustion in non-Cartesian geometry and shock-driven fluid-structure interaction with fully coupled dynamic boundary motion demonstrate the applicability of the discussed techniques for complex scenarios."

{For the entire collection see MR2905893 (2012i:65004).}

MR2861657 65M55 65D18 65F10 94A08

Chen, D. [Chen, Donghui^2] (1-TUFT; Medford, MA)**;**
MacLachlan, S. [MacLachlan, Scott P.] (1-TUFT; Medford, MA)**;**
Kilmer, M. [Kilmer, Misha E.] (1-TUFT; Medford, MA)

Iterative parameter-choice and multigrid methods for anisotropic diffusion denoising. (English summary)

SIAM J. Sci. Comput. **33** (2011), *no.* 5, 2972–2994.

It is generally agreed that during the formation, transmission, and recording processes, images deteriorate with various types of noise. Hence it is a challenge to design an approach which eliminates the noise efficiently and automatically. The so-called Anisotropic Denoising (AD) has been widely accepted as a tool for removing the noise while preserving edges. In addition to finding efficient algorithms for solving linearized AD equations, it is also important to select a good regularization parameter. The authors propose a fixed-point iteration using a multigrid solver to solve a regularised anisotropic differential equation, which is not only well-posed, but also has a nontrivial steady-state solution. Further, a new regularization parameter-choice method which combines Brent's method and the normalised cumulative periodogram information of the misfit vector is also presented. Tests show that the proposed algorithm can find near optimal regularization parameters for the AD process efficiently. *Mapundi K. Banda*

MR2864640 65M60 74F10 76D99

Boffi, Daniele (I-PAVI; Pavia)**; Cavallini, Nicola** (I-PAVI; Pavia)**;**
Gastaldi, Lucia (I-BRSC; Brescia)

Finite element approach to immersed boundary method with different fluid and solid densities. (English summary)

Math. Models Methods Appl. Sci. **21** (2011), *no.* 12, 2523–2550.

Summary: "The Immersed Boundary Method (IBM) has been designed by Peskin for the modeling and the numerical approximation of fluid-structure interaction problems, where flexible structures are immersed in a fluid. In this approach, the Navier-Stokes equations are considered everywhere and the presence of the structure is taken into account by means of a source term which depends on the unknown position of the structure. These equations are coupled with the condition that the structure moves at the same velocity of the underlying fluid.

"Recently, a finite element version of the IBM has been developed, which offers interesting features for both the analysis of the problem under consideration and the robustness and flexibility of the numerical scheme. Initially, we considered structure and fluid with the same density, as it often happens when dealing with biological tissues. Here we study the case of a structure which can have a density higher than that of the fluid. The higher density of the structure is taken into account as an excess of Lagrangian mass located along the structure, and can be dealt with in a variational way in the finite element approach.

"The numerical procedure to compute the solution is based on a semi-implicit scheme. In fluid-structure simulations, nonimplicit schemes often produce instabilities when the density of the structure is close to that of the fluid. This is not the case for the IBM approach. In fact, we show that the scheme enjoys the same stability properties as in the case of equal densities."

MR2871308 65M60 65M25 76M10 76S05
Cheng, Aijie (PRC-SHAN-SM; Jinan)**;**
Ren, Yongqiang [Ren, Yong Qiang] (PRC-SHAN-SM; Jinan)**;**
Xi, Kaihua [Xi, Kai Hua] (PRC-SHAN-SM; Jinan)
An error estimate for MMOC-MFEM based on convolution for porous media flow. (English summary)
Int. J. Numer. Anal. Model. **9** (2012), *no.* 1, 149–168.
Summary: "A modification of the modified method of characteristics (MMOC) is introduced for solving the coupled system of partial differential equations governing miscible displacement in porous media. The pressure-velocity is approximated by a mixed finite element procedure using a Raviart-Thomas space of index k over a uniform grid. The resulting Darcy velocity is post-processed by convolution with Bramble-Schatz kernel and this enhanced velocity is used in the evaluation of the coefficients in MMOC for the concentration equation. If the concentration space is of local degree l, then, the error in the concentration is $O(h_c^{l+1} + h_p^{2k+2})$, which reflects the superconvergence of velocity approximation."

MR2803122 65M60 74S05
Coutinho, A. L. G. A. (BR-FRJ-CPL; Rio de Janeiro)**;**
Franca, L. P. [Franca, Leopoldo Penna] (1-COD-MS; Denver, CO)**;**
Valentin, F. [Valentin, Frederic G. C.]
Simulating transient phenomena via residual free bubbles. (English summary)
Comput. Methods Appl. Mech. Engrg. **200** (2011), *no.* 25-28, 2127–2130.
Summary: "We derive two stabilized methods for transient equations using static condensation of residual-free bubbles. The methods enhance the stability of the Discontinuous Galerkin method."

MR2862449 65M60 76M10 76X05
Crouseilles, N. (F-STRAS-I; Strasbourg)**;**
Mehrenberger, M. (F-STRAS-I; Strasbourg)**; Vecil, F.** (E-VLNC-AM; Burjasot)
Discontinuous Galerkin semi-Lagrangian method for Vlasov-Poisson. (English and French summaries)
CEMRACS'10 research achievements: *numerical modeling of fusion*, 211–230, *ESAIM Proc.*, 32, *EDP Sci.*, *Les Ulis*, 2011.
Summary: "We present a discontinuous Galerkin scheme for the numerical approximation of the one-dimensional periodic Vlasov-Poisson equation. The scheme is based on a Galerkin-characteristics method in which the distribution function is projected onto

a space of discontinuous functions. We present comparisons with a semi-Lagrangian method to emphasize the good behavior of this scheme when applied to Vlasov-Poisson test cases."

{For the entire collection see MR2906045 (2012i:65002).}

MR2862440 65M60 65Y15 76M10 76W05

Deriaz, Erwan (F-PROV-MMP; Marseille)**;**
Despres, Bruno [Després, Bruno] (F-PARIS6-N; Paris)**;**
Faccanoni, Gloria (F-TLN-IM; La Garde)**;**
Gostaf, Kirill Pichon (F-PARIS6-N; Paris)**;**
Imbert-Gérard, Lise-Marie (F-PARIS6-N; Paris)**;**
Sadaka, Georges (F-PCRD-LFD; Amiens)**; Sart, Remy [Sart, Rémy]**

Magnetic equations with FreeFem++: the Grad-Shafranov equation & the current hole. (English summary)

CEMRACS'10 research achievements: *numerical modeling of fusion*, 76–94, *ESAIM Proc.*, 32, *EDP Sci.*, *Les Ulis*, 2011.

Summary: "`FreeFem++` [F. Hecht et al., *FreeFem++*, third edition, Lab. Jacques-Louis Lions, Univ. Pierre Marie Curie, Paris, http://www.freefem.org/ff++/ftp/freefem++doc.pdf] is a software for the numerical solution of partial differential equations. It is based on finite element method. The `FreeFem++` platform aims at facilitating teaching and basic research through prototyping. For the moment this platform is restricted to the numerical simulations of problems which admit a variational formulation. Our goal in this work is to evaluate the `FreeFem++` tool on basic magnetic equations arising in Fusion Plasma in the context of the ITER project.

"First we consider the Grad-Shafranov equation, which is derived from the static ideal MHD equations assuming axisymmetry. Some of the properties of the equation and its analytical solutions are discussed. Second we discretize a reduced resistive MHD model which admits solutions of the Grad-Shafranov equation as stationary solutions. Then the physical stability of these stationary solutions is investigated through numerical experiments and the numerical stability of the algorithm is discussed."

{For the entire collection see MR2906045 (2012i:65002).}

MR2823470 65M60

Eftang, Jens L. (N-NUST; Trondheim)**;**
Knezevic, David J. (1-MIT-ME; Cambridge, MA)**;**
Patera, Anthony T. (1-MIT-ME; Cambridge, MA)

An *hp* certified reduced basis method for parametrized parabolic partial differential equations. (English summary)

Math. Comput. Model. Dyn. Syst. **17** (2011), *no.* 4, 395–422.

The authors introduce an *hp* certified reduced basis (RB) method for parabolic partial differential equations that invokes a Proper Orthogonal Decomposition (POD) (in time)/Greedy (in parameter) sampling procedure first in the initial partition of the parameter domain (h-refinement) and subsequently in the construction of RB approximation spaces restricted to each parameter subdomain (p-refinement).

The certified reduced basis method for the solution of partial differential equations represents a model-order reduction framework that allows the rapid evaluation of functional outputs for PDEs that depend on an input parameter vector. This vector can be related to geometric or material property factors.

The four key ingredients to the certified RB framework are:

(1) Galerkin projection;
(2) POD/Greedy sampling;

(3) a posteriori error estimation; and
(4) offline-online computational decomposition.

In this paper the authors extend their work previously introduced in [J. L. Eftang, A. T. Patera and E. M. Rønquist, in *Spectral and High Order Methods for Partial Differential Equations*, 179–187, Lect. Notes Comput. Sci. Eng., 76, Springer, Berlin, 2011, doi:10.1007/978-3-642-15337-2_15] in several important ways by introducing an improvement to the algorithm and an a priori convergence theory for the initial subdivision process, presenting a very detailed account of the algorithm and the results.

All in all the authors show how the confluence of ideas such as the h- and the p-refinements, the use of POD, and the offline/online splitting of the computational effort results in a fast computational approach for the evaluation of functionals based on the solution of PDEs. This type of approach will certainly find a lot of practical and theoretical applications in science and engineering.

It is a remarkable fact that, almost a century after B. G. Galerkin published his method, the mathematics and engineering communities are still taking advantage of it and finding new ways to apply his ideas to the approximated solution of differential equations.

See also [J. L. Eftang, *Reduced basis methods for parametrized partial differential equations*, Ph.D. thesis, Nor. Univ. Sci. Tech., 2011, ntnu.diva-portal.org/smash/get/diva2:414290/FULLTEXT03; A. E. Løvgren, *Reduced basis modeling of hierarchical flow systems*, Ph.D. thesis, Nor. Univ. Sci. Tech., 2005, ntnu.diva-portal.org/smash/get/diva2:124326/FULLTEXT01; A. Quarteroni, G. Rozza and A. Manzoni, J. Math. Ind. **1** (2011), Art. 3; MR2824231 (2012g:65266)]. *Mario A. Forcinito*

MR2837109 65M60 65M12
Galán del Sastre, Pedro (E-UPMAK-AMU; Madrid)**;**
Bermejo, Rodolfo (E-UPMIE-AM; Madrid)
Error analysis for hp-FEM semi-Lagrangian second order BDF method for convection-dominated diffusion problems. (English summary)
J. Sci. Comput. **49** (2011), *no.* 2, 211–237.

A semi-Lagrangian second-order backward difference formula combined with hp-finite element methods is applied to the numerical approximation of convection-diffusion equations in $\mathbb{R}^2$. The error analysis developed establishes a priori estimates for the error along the characteristic curves, and the error related to the calculation of the characteristic curves. These estimates are verified by numerical experiments.

Dimitra C. Antonopoulou

MR2862008 65M60 78A25 78M10
Li, Jichun (1-NVLV; Las Vegas, NV)**;**
Huang, Yunqing [Huang, Yun Qing] (PRC-XIA-CPE; Xiangtan)**;**
Lin, Yanping [Lin, Yan Ping] (PRC-HP-AM; Kowloon)
Developing finite element methods for Maxwell's equations in a Cole-Cole dispersive medium. (English summary)
SIAM J. Sci. Comput. **33** (2011), *no.* 6, 3153–3174.

Maxwell's equations are considered in a Cole-Cole dispersive medium, where a fractional-order time derivative appears in the equation relating the induced polarization and electric fields. Numerical techniques for standard dispersive media models and for fractional-order diffusion equations are combined to construct fully discrete Crank-Nicolson (implicit) and leap-frog (explicit) schemes based on a finite element discretization of weak forms of the equations using lowest-order Raviart-Thomas-Nédélec elements. Stability

and optimal rates of convergence are proved in $L^\infty(L^2)$ for these methods. Numerical results are presented to support these error estimates. *Martin Stynes*

MR2870491 65M60 65M12 76D05 76M10 76R99

Ravindran, S. S. (1-ALH; Huntsville, AL)

Convergence of extrapolated BDF2 finite element schemes for unsteady penetrative convection model. (English summary)

Numer. Funct. Anal. Optim. **33** (2012), *no.* 1, 48–79.

The author proposes and analyzes fully discrete approximations for a model of buoyancy-driven convection flow. The challenging feature of this model is that a momentum equation is nonlinear with respect to both the velocity $\mathbf{u}$ and the temperature θ which is of the form

$$\partial_t \mathbf{u} - \nu\Delta\mathbf{u} + \mathbf{u}\cdot\nabla\mathbf{u} + \nabla p - (\gamma_1\theta + \gamma_2\theta^2)\mathbf{i} = \mathbf{f}.$$

This equation is complemented with the following mass and energy conservation equations:

$$\operatorname{div}\mathbf{u} = 0, \quad \partial_t\theta - \kappa\Delta\theta + \mathbf{u}\cdot\nabla\theta = g.$$

The spatial discretization is based on an inf-sup stable finite-element pair for the velocity and pressure, and a finite-element approximation for the temperature with the same order as that of the velocity field approximation. For the time discretization, the author considers the second-order two-step finite-difference formula

$$\partial_t\varphi(t_{n+1}) \approx \frac{3\varphi(t_{n+1}) - 4\varphi(t_n) + \varphi(t_{n-1})}{2\Delta t}.$$

He also uses the second-order two-step approximation

$$\varphi(t_{n+1}) \approx 2\varphi(t_n) - \varphi(t_{n-1})$$

to linearize the terms $\mathbf{u}\cdot\nabla\mathbf{u}$, $(\gamma_1\theta + \gamma_2\theta^2)\mathbf{i}$, and $\mathbf{u}\cdot\nabla\theta$.

In particular, the linearization of the buoyancy term leads to two different schemes, which are referred to as the coupled and the decoupled scheme. The author shows that both schemes are unconditionally stable and that the rate of convergence of the coupled scheme is conditioned to a sufficiently small time step, whereas such a restriction does not apply to the uncoupled scheme. The authors present numerical experiments for a two-dimensional model of penetrative convection in water near 3.98°C, considering the P2-P1 Taylor-Hood finite-element pair (and piecewise quadratic finite elements for the temperature) on a uniform triangular grid. *Saulo Pomponet Oliveira*

MR2811705 65M60 76B15 76M10

Ricchiuto, M. [Ricchiuto, Mario] (F-INRIA9; Talence)

On the C-property and generalized C-property of residual distribution for the shallow water equations. (English summary)

J. Sci. Comput. **48** (2011), *no.* 1-3, 304–318.

Summary: "In this paper we consider the discretization of the Shallow Water equations by means of Residual Distribution (RD) schemes. We review the conditions allowing the exact preservation of some exact steady solutions. These conditions are shown to be related both to the type of spatial approximation and to the quadrature used to evaluate the cell residual. Numerical examples are shown to validate the theory."

MR2853698 65M60 45K05 65M15

Shi, Dongyang [Shi, Dong Yang] (PRC-ZHEN; Zhengzhou)**; Wang, Lin**

An anisotropic nonconforming finite element scheme with moving grids for parabolic integro-differential equations. (English summary)

J. Syst. Sci. Complex. **24** (2011), *no.* 5, 1020–1032.

In this paper, the authors consider a parabolic integro-differential equation with homogeneous boundary conditions. The existence of a unique weak solution is stated. Then, using a nonconforming finite element method with moving grids to approximate the spatial variable and the Crank-Nicolson scheme to discretize the integral term, fully discrete approximations are introduced and a convergence analysis and a priori error estimates are provided. The main error is split into three parts: the interpolation error for the finite element method, the difference error with respect to the time, and the error on the moving grids. Some technical lemmas, the Cauchy-Schwarz inequality and the discrete Gronwall lemma are used to estimate the terms, from which the a priori estimates are deduced. *José R. Fernández*

MR2871300 65M60

Wang, Kaixin (PRC-SHAN-SM; Jinan)**;**
Wang, Hong [Wang, Hong[9]] (1-SC; Columbia, SC)**;**
Yu, Xijun (PRC-BIAP-LAP; Beijing)

An immersed Eulerian-Lagrangian localized adjoint method for transient advection-diffusion equations with interfaces. (English summary)

Int. J. Numer. Anal. Model. **9** (2012), *no.* 1, 29–42.

The authors consider a one-dimensional advection-diffusion equation with interfaces. The porosity and diffusion coefficients in the equation are assumed to be piecewise constant. The solution of the equation and the Darcy flux are continuous across the interfaces. The authors develop an immersed finite element method which is combined with an Eulerian-Lagrangian localized adjoint method. They prove an optimal-order error estimate for this scheme. They do not perform any numerical experiments with the new scheme. *Beny Neta*

MR2837760 65M60

Zhao, Guozhong [Zhao, Guozhong[2]]; Yu, Xijun (PRC-BIAP-CP; Beijing)**;**
Zhang, Rongpei [Zhang, Rong Pei] (PRC-BIAP-CP; Beijing)

The new numerical method for solving the system of two-dimensional Burgers' equations. (English summary)

Comput. Math. Appl. **62** (2011), *no.* 8, 3279–3291.

In this paper the authors consider the following Burgers-type system:

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\varepsilon\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right),\quad (x,y)\in D,\ t>0,$$
$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=\varepsilon\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right),\quad (x,y)\in D,\ t>0,$$

on a rectangular domain D with Dirichlet boundary conditions. Assuming some smoothness of the solution, the above system is transformed into a heat equation by the Hopf-Cole transform. The resulting heat equation is solved numerically by the local discontinuous Galerkin method in space and by some explicit scheme in time. The numerical results show that the proposed method works reasonably well for smooth solutions but seems to be limited to a moderate size of ε. *Dmitriy Leykekhman*

MR2853734 65M70 45K05 76B15

Boyd, John P. [**Boyd, John Philip**] (1-MI-OS; Ann Arbor, MI);
Xu, Zhengjie (1-MI-AID; Ann Arbor, MI)

Comparison of three spectral methods for the Benjamin-Ono equation: Fourier pseudospectral, rational Christov functions and Gaussian radial basis functions. (English summary)

Wave Motion **48** (2011), *no.* 8, 702–706.

Summary: "The Benjamin-Ono equation is especially challenging for numerical methods because (i) it contains the Hilbert transform, a nonlocal integral operator, and (ii) its solitary waves decay only as $O(1/|x|^2)$. We compare three different spectral methods for solving this one-space-dimensional equation. The Fourier pseudospectral method is very fast through use of the Fast Fourier Transform (FFT), but requires domain truncation: replacement of the infinite interval by a large but finite domain. Such truncation is unnecessary for a rational basis, but it is simple to evaluate the Hilbert Transform only when the usual rational Chebyshev functions $TB_n(x)$ are replaced by their cousins, the Christov functions; the FFT still applies. Radial basis functions (RBFs) are slow for a given number of grid points N because of the absence of a summation algorithm as fast as the FFT; because RBFs are meshless, however, very flexible grid adaptation is possible."

MR2864667 65M70

Dereli, Yılmaz (TR-ANAS; Eskişehir)

Solitary wave solutions of the MRLW equation using radial basis functions. (English summary)

Numer. Methods Partial Differential Equations **28** (2012), *no.* 1, 235–247.

Summary: "In this study, traveling wave solutions of the modified regularized long wave (MRLW) equation are simulated by using the meshless method based on collocation with well-known radial basis functions. The method is tested for three test problems which are single solitary wave motion, interaction of two solitary waves and interaction of three solitary waves. Invariant values for all test problems are calculated, also L_2, L_∞ norms and values of the absolute error for single solitary wave motion are calculated. Numerical results by using the meshless method with different radial basis functions are presented. Figures of wave motions for all test problems are shown. Altogether, meshless methods with radial basis functions solve the MRLW equation very satisfactorily."

MR2847114 65M70 41A30

Kazem, S. (IR-IKIU-M; Qazvin);
Rad, J. A. [**Amani Rad, Jamal**] (IR-SHBHM-CS; Tehran);
Parand, K. [**Parand, Kourosh**] (IR-SHBHM-CS; Tehran)

Radial basis functions methods for solving Fokker-Planck equation. (English summary)

Eng. Anal. Bound. Elem. **36** (2012), *no.* 2, 181–189.

Summary: "In this paper two numerical meshless methods for solving the Fokker-Planck equation are considered. Two methods based on radial basis functions to approximate the solution of Fokker-Planck equation by using collocation method are applied. The first is based on the Kansa's approach and the other one is based on the Hermite interpolation. In addition, to conquer the ill-conditioning of the problem for big number of collocation nodes, two time domain Discretizing schemes are applied. Numerical examples are included to demonstrate the reliability and efficiency of these methods. Also root mean square and N_e errors are obtained to show the convergence of the methods. The errors show that the proposed Hermite collocation approach results

obtained by the new time-Discretizing scheme are more accurate than the Kansa's approach."

MR2863789 65M70 35Q51 35Q53 65M12 65M15
Koley, Ujjwal (N-OSLO-CMA; Oslo)
Error estimate for a fully discrete spectral scheme for Korteweg-de Vries-Kawahara equation. (English summary)
Cent. Eur. J. Math. **10** (2012), *no.* 1, 173–187.

In this paper, an analysis is performed on the numerical approximation by the Fourier spectral method for the Korteweg-de Vries–Kawahara (KdV–K) equation. This equation is a transport equation perturbed by dispersive terms of 3rd and 5th order and it appears in several fluid dynamics problems and describes solitary wave propagation in a media in which the first-order dispersion is small.

The KdV–K equation has infinitely many invariants. Three of these invariants are introduced. The spatial discretization of this equation is done by using the standard Fourier-Galerkin method and it is shown that this discretization preserves the three invariants introduced for the original equation. The temporal dependence of the semidiscrete system is discretized using two different methods: a leap-frog and a Crank-Nicolson scheme. An $O(\Delta t^2)$ bound is obtained for both schemes, assuming that sufficiently accurate initial conditions are given and that $\Delta t N^5$ and $\Delta t N$, respectively, are small enough. *Damián P. Ginestar*

MR2869625 65M70 76M25
Mai-Duy, N. [**Mai-Duy, Nam**] (5-SQL-CER; Springfield)**;**
Tran-Cong, T. [**Tran-Cong, Thanh**] (5-SQL-CER; Springfield)
A high-order upwind control-volume method based on integrated RBFs for fluid-flow problems. (English summary)
Internat. J. Numer. Methods Fluids **67** (2011), *no.* 12, 1973–1992.

Summary: "This paper is concerned with the development of a high-order upwind conservative discretization method for the simulation of flows of a Newtonian fluid in two dimensions. The fluid-flow domain is discretized using a Cartesian grid from which non-overlapping rectangular control volumes are formed. Line integrals arising from the integration of the diffusion and convection terms over control volumes are evaluated using the middle-point rule. One-dimensional integrated radial basis function schemes using the multiquadric basis function are employed to represent the variations of the field variables along the grid lines. The convection term is effectively treated using an upwind scheme with the deferred-correction strategy. Several highly non-linear test problems governed by the Burgers and the Navier-Stokes equations are simulated, which show that the proposed technique is stable, accurate and converges well."

MR2864659 65M70 65M32
Shamsi, M. (IR-AUTMC-AM; Tehran)**;**
Dehghan, Mehdi [**Dehghan, Mehdi[2]**] (IR-AUTMC-AM; Tehran)
Determination of a control function in three-dimensional parabolic equations by Legendre pseudospectral method. (English summary)
Numer. Methods Partial Differential Equations **28** (2012), *no.* 1, 74–93.

The authors numerically study an inverse problem of determining a time-dependent coefficient in a three-dimensional diffusion equation from the integral overdetermination data. *Mansur I. Ismailov*

MR2863790 65M70 78M22

Yakhno, Valery G. [Yakhno, V. G.] (TR-DOK-EL; Izmir)**; Çerdik Yaslan, Handan; Yakhno, Tatiana M. [Yakhno, Tatyana M.]** (TR-IZU-CEN; Izmir)

Computation of the fundamental solution of electrodynamics for anisotropic materials. (English summary)

Cent. Eur. J. Math. **10** (2012), *no.* 1, 188–203.

Summary: "A new method for computation of the fundamental solution of electrodynamics for general anisotropic nondispersive materials is suggested. It consists of several steps: equations for each column of the fundamental matrix are reduced to a symmetric hyperbolic system; using the Fourier transform with respect to space variables and matrix transformations, formulae for Fourier images of the fundamental matrix columns are obtained; finally, the fundamental solution is computed by the inverse Fourier transform. Applying the suggested approach, the fundamental solution components are computed in general anisotropic media. Computational examples confirm robustness of the suggested method."

MR2862447 65M75 76M28 76X05 82D10

Charles, Fréderique [Charles, Frédérique] (F-PARIS6-N; Paris)**; Vauchelet, Nicolas** (F-PARIS6-N; Paris)**; Besse, Christophe; Goudon, Thierry; Lacroix-Violet, Ingrid; Dudon, Jean-Paul** (F-THAL; Cannes-la-Bocca)**; Navoret, Laurent** (F-TOUL3-IM; Toulouse)

Numerical approximation of Knudsen layer for the Euler-Poisson system. (English and French summaries)

*CEMRACS'*10 *research achievements*: *numerical modeling of fusion*, 177–194, *ESAIM Proc.*, 32, *EDP Sci.*, *Les Ulis*, 2011.

Summary: "In this work, we consider the computation of the boundary conditions for the linearized Euler-Poisson derived from the BGK kinetic model in the small mean free path regime. Boundary layers are generated from the fact that the incoming kinetic flux might be far from the thermodynamical equilibrium. In [C. Besse et al., Adv. Appl. Math. Mech. **3** (2011), no. 5, 519–561; MR2851093], the authors propose a method to compute numerically the boundary conditions in the hydrodynamic limit relying on an analysis of the boundary layers. In this paper, we will extend these techniques in the case of the coupled Euler-Poisson system."

{For the entire collection see MR2906045 (2012i:65002).}

MR2862232 65M75 76N99

Mason, Matthew S. (1-UT-ME; Salt Lake City, UT)**; Chen, Kuan** (1-UT-ME; Salt Lake City, UT)**; Hu, Patrick G.** (1-ADYN; Lexington, KY)**; Xue, Liping** (1-ADYN; Lexington, KY)

An effective limiting algorithm for particle-based numerical simulations of compressible flows. (English summary)

Int. J. Comput. Fluid Dyn. **25** (2011), *no.* 9, 487–500.

Summary: "Eulerian computational fluid dynamics (CFD) and Lagrangian computational structural dynamics (CSD) are used extensively in the aerospace industry. Combined mesh-based Eulerian and particle-based Lagrangian algorithms are very effective for modelling and simulation due to the increased efficiency of combining the two numerical simulations. However, when compressible flows are simulated using a particle-based algorithm, calculations of strong discontinuity, such as a shock wave, may become unstable. In the present study, a numerical limiter is integrated with a particle-based CFD code to remedy this instability. The limiting algorithm incorporates an 'averaging' technique which calculates average values using the properties of neighbouring parti-

cles (also known as material points), including mass, momentum and energy. These averaged values are then input to a min-mode limiter to eliminate numerical noise and incur dissipation in the flow in areas with steep property gradients. The results of this algorithm show very stable solutions with minimal oscillations when applied to the one-dimensional shock tube problem and an increased accuracy with reduced oscillations for a two-dimensional cylinder cross-flow problem."

MR2847116 65M99

Cheng, R. J. [**Cheng, Rong Jun**]**;**
Liew, K. M. [**Liew, Kim Moew**] (PRC-CHK-ARE; Kowloon)

A meshless analysis of three-dimensional transient heat conduction problems. (English summary)

Eng. Anal. Bound. Elem. **36** (2012), *no.* 2, 203–210.

Summary: "In this paper, we consider a numerical modeling of a three-dimensional transient heat conduction problem. The modeling is carried out using a meshless reproducing kernel particle (RKPM) method. In the mathematical formulation, a variational method is employed to derive the discrete equations. The essential boundary conditions of the formulated problems are enforced by the penalty method. Compared with numerical methods based on meshes, the RKPM needs only scattered nodes, rather than having to mesh the domain of the problem. An error analysis of the RKPM for three-dimensional transient heat conduction problem is also presented in this paper. In order to demonstrate the applicability of the proposed solution procedures, numerical experiments are carried out for a few selected three-dimensional transient heat conduction problems."

MR2807107 65M99 35A20 35L45 78A25

Halpern, L. [**Halpern, Laurence**] (F-PARIS13-GA; Villetaneuse)**;**
Petit-Bergez, S. (F-PARIS13-GA; Villetaneuse)**;**
Rauch, J. [**Rauch, Jeffrey**] (1-MI; Ann Arbor, MI)

The analysis of matched layers. (English summary)

Confluentes Math. **3** (2011), *no.* 2, 159–236.

Summary: "A systematic analysis of matched layers is undertaken with special attention to better understand the remarkable method of Bérenger. We prove that the Bérenger and closely related layers define well-posed transmission problems in great generality. When the Bérenger method or one of its close relatives is well-posed, perfect matching is proved. The proofs use the energy method, Fourier-Laplace transform, and real coordinate changes for Laplace transformed equations. It is proved that the loss of derivatives associated with the Bérenger method does not occur for elliptic generators. More generally, an essentially necessary and sufficient condition for loss of derivatives in Bérenger's method is proved. The sufficiency relies on the energy method with pseudodifferential multiplier. Amplifying and nonamplifying layers are identified by a geometric optics computation. Among the various flavors of Bérenger's algorithm for Maxwell's equations, our favorite choice leads to a strongly well-posed augmented system and is both perfect and nonamplifying in great generality. We construct by an extrapolation argument an alternative matched layer method which preserves the strong hyperbolicity of the original problem and though not perfectly matched has leading reflection coefficient equal to zero at all angles of incidence. Open problems are indicated throughout."

MR2830666 65M99 35L20
Yao, Huanmin (PRC-HARN-SM; Harbin)
Reproducing kernel method for the solution of nonlinear hyperbolic telegraph equation with an integral condition. (English summary)
Numer. Methods Partial Differential Equations **27** (2011), *no.* 4, 867–886.
Summary: "In this article, an iterative method is proposed for solving nonlinear hyperbolic telegraph equation with an integral condition. Its exact solution is represented in the form of series in the reproducing kernel space. In the mean time, the n-term approximation $u_n(xt)$ of the exact solution $u(x,t)$ is obtained and is proved to converge to the exact solution. Moreover, the partial derivatives of $u_n(x,t)$ are also convergent to the partial derivatives of $u(x,t)$. Some numerical examples have been studied to demonstrate the accuracy of the present method. Results obtained by the method have been compared with the exact solution of each example and are found to be in good agreement with each other."

65N Partial differential equations, boundary value problems

MR2877369 65N06 35J05 65N22
Erlangga, Yogi [Erlangga, Yogi A.] (3-BC-EO; Vancouver, BC);
Turkel, Eli (IL-TLAV; Tel Aviv)
Iterative schemes for high order compact discretizations to the exterior Helmholtz equation. (English summary)
ESAIM Math. Model. Numer. Anal. **46** (2012), *no.* 3, 647–660.
Summary: "We consider high order finite difference approximations to the Helmholtz equation in an exterior domain. We include a simplified absorbing boundary condition to approximate the Sommerfeld radiation condition. This yields a large, but sparse, complex system, which is not self-adjoint and not positive definite. We discretize the equation with a compact fourth or sixth order accurate scheme. We solve this large system of linear equations with a Krylov subspace iterative method. Since the method converges slowly, a preconditioner is introduced, which is a Helmholtz equation but with a modified complex wavenumber. This is discretized by a second or fourth order compact scheme. The system is solved by BICGSTAB with multigrid used for the preconditioner. We study, both by Fourier analysis and computations this preconditioned system especially for the effects of high order discretizations."

MR2864665 65N06 65B05 65N15
Feng, Xiufang (PRC-NX-SMC; Yinchuan);
Li, Zhilin [Li, Zhi Lin[1]] (1-NCS; Raleigh, NC)
Simplified immersed interface methods for elliptic interface problems with straight interfaces. (English summary)
Numer. Methods Partial Differential Equations **28** (2012), *no.* 1, 188–203.
This article deals with interface methods to solve elliptic partial/ordinary differential equations with discontinuous coefficients across interfaces that are isolated points in one dimension (1D) and straight lines or circles in two dimensions (2D). For problems in 1D, or problems in 2D with circular interfaces, a second-order finite difference method is presented and analyzed. For two-dimensional problems when the interfaces are straight lines, the authors use a first-order finite difference method, and apply Richardson's extrapolation technique to improve it to a second-order method. Error analysis is given, and numerical examples are provided for the various methods discussed.

Venkataraman Vanaja

MR2857748 65N06 80A20

Lan, Lin Hua (PRC-ZHO-AME; Guangzhou);
Fu, Ming Hui [Fu, Ming Hui[1]] (PRC-ZHO-AME; Guangzhou);
Gao, Wen Le (PRC-ZHO-AME; Guangzhou)

Layered precise exponential method for a steady heat conduction equation for functionally graded materials. (Chinese. English and Chinese summaries)

Acta Sci. Natur. Univ. Sunyatseni **50** (2011), *no.* 4, 1–6.

In this paper, the authors propose a layered precise exponential method, for steady heat conduction equations, which can be applied for functionally graded materials. First, they discretize the problem along the thickness direction. Then they use an expression for the solution of the resulting ODE system with constant coefficients to design the discrete scheme. This method is efficient for the functionally graded materials with constant or exponential thermal conductivity. *Zhongyi Huang*

MR2876544 65N06 35J25 65D05 65N22

Zadorin, A. I. (RS-AOSSI-IM; Omsk); **Zadorin, N. A.** (RS-OMSK-NDM; Omsk)

Interpolation of functions with boundary layer components and its application in a two-grid method. (Russian. English and Russian summaries)

Sib. Èlektron. Mat. Izv. **8** (2011), 247–267.

Elliptic equations with regular boundary layers can be solved using difference schemes. For this it is necessary to iteratively solve a system of algebraic equations. The number of iterations can be reduced if one first solves the problem on a coarse mesh, and then interpolates the mesh solution from a coarse mesh to a fine mesh.

In the present paper spline interpolation formulas, which are exact for the boundary-layer components, are constructed for a function of two variables. Errors for these formulas are estimated. It is shown that the proposed formulas can be used for solving an elliptic problem with boundary layers by a two-grid algorithm. Numerical results are presented and discussed. *Givi K. Berikelashvili*

MR2869636 65N08

Gao, Zhiming [Gao, Zhi Ming] (PRC-BIAP-CP; Beijing);
Wu, Jiming (PRC-BIAP-CP; Beijing)

A linearity-preserving cell-centered scheme for the heterogeneous and anisotropic diffusion equations on general meshes. (English summary)

Internat. J. Numer. Methods Fluids **67** (2011), *no.* 12, 2157–2183.

Summary: "In this paper a finite volume scheme for the heterogeneous and anisotropic diffusion equations is proposed on general, possibly nonconforming meshes. This scheme has both cell-centered unknowns and vertex unknowns. The vertex unknowns are treated as intermediate ones and are expressed as a linear weighted combination of the surrounding cell-centered unknowns, which reduces the scheme to a completely cell-centered one. We propose two types of new explicit weights which allow arbitrary diffusion tensors, and are neither discontinuity dependent nor mesh topology dependent. Both the derivation of the scheme and that of new weights satisfy the linearity-preserving criterion which requires that a discretization scheme should be exact on linear solutions. The resulting new scheme is called as the linearity-preserving cell-centered scheme and the numerical results show that it maintain optimal convergence rates for the solution and flux on general polygonal distorted meshes in case that the diffusion tensor is taken to be anisotropic, at times heterogeneous, and/or discontinuous."

MR2847117 65N20 35J25 35R30 65N21

Liu, Chein-Shan (RC-NTAI-CE; Taipei)**; Chang, Chih-Wen**

A novel mixed group preserving scheme for the inverse Cauchy problem of elliptic equations in annular domains. (English summary)

Eng. Anal. Bound. Elem. **36** (2012), *no.* 2, 211–219.

Summary: "In this paper, the inverse Cauchy problems for elliptic equations, including the Laplace equation, the Poisson equation, and the Helmholtz equation, defined in annular domains are investigated. When the outer boundary of an annulus is imposed by overspecified boundary data, we seek unknown data in the inner boundary through a combination of the spring-damping regularization method (SDRM) and the mixed group-preserving scheme (MGPS). Several numerical examples are examined to show that the MGPS plus the SDRM can overcome the ill-posed behavior of this highly ill-conditioned inverse Cauchy problem. The presently proposed novel algorithm has good efficiency and stability against the disturbance from large random noise even up to 50%, and the computational cost of MGPS is very time saving."

MR2851912 65N21 35R30 65J22 78A70

Hakula, Harri (FIN-ALT-MSA; Aalto)**; Harhanen, Lauri** (FIN-ALT-MSA; Aalto)**; Hyvönen, Nuutti** (FIN-ALT-MSA; Aalto)

Sweep data of electrical impedance tomography. (English summary)

Inverse Problems **27** (2011), *no.* 11, 115006, 19 *pp.*

The authors analyze a special data collection technique for electrical impedance tomography. From the summary: "One of the electrodes lies at a fixed position while the other is moved along the object boundary in a sweeping motion, with the corresponding measurement being the (relative) potential difference required for maintaining a unit current between the two electrodes. Assuming that the two-dimensional object of interest has constant background conductivity but is contaminated by compactly supported inhomogeneities, it is shown that such sweep data represent the boundary value of a holomorphic function defined in the exterior of the embedded inclusions."

Various ideas and techniques utilized in this work are borrowed from [M. Hanke, N. Hyvönen and S. Hollborn, Numer. Math. **117** (2011), no. 2, 373–396; MR2754855 (2012a:65307)]. The authors enhance that material by presenting the theoretical treatment of anisotropic conductivity inhomogeneities, and the formulation of the results for general smooth, bounded, simply connected domains. Moreover, they devise and test a numerical algorithm based on the convex source support method [M. Hanke, N. Hyvönen and S. Hollborn, SIAM J. Imaging Sci. **1** (2008), no. 4, 364–378; MR2486026 (2010d:35400)] using sweep data as input, in order to localize conductivity inhomogeneities. *Dario Fasino*

MR2861706 65N21 35J25 35R30 41A21 78A46

Hanke, Martin (D-MNZ-IM; Mainz)

Locating several small inclusions in impedance tomography from backscatter data. (English summary)

SIAM J. Numer. Anal. **49** (2011), *no.* 5, 1991–2016.

Let B be the two-dimensional unit disk, $T = \partial B$, and let

$$\Omega = \bigcup_{j=1}^{J} \overline{\Omega}_j \subset B,$$

where $\Omega_1, \ldots, \Omega_J$ are simply connected regions with C^2-boundary which are disjoint and do not touch T. The problem treated in the paper is the location of the inclusions

Ω_j using as data the measured backscatter function at some points on T. Recall that the potential on B is a solution of the equation $\nabla(\sigma\nabla u)=0$ in B, $\frac{\partial}{\partial\nu}u=f$ on T, $\int_T u ds=0$, where f is a current imposed on T with $\int_T f ds=0$. The conductivity is assumed to be piecewise constant:

$$\sigma(x)=\begin{cases}\kappa_j, & x\in\Omega_j,\ \kappa_j\neq 1,\ \kappa_j\geq 0;\\ 1, & \text{elsewhere.}\end{cases}$$

The backscatter data $b(\vartheta)$ is the value of the induced voltage at the point $(x_1,x_2)\in T$ where a dipole-type current is imposed. Using potential theory it is shown that the backscatter function can be extended as a holomorphic function to the complex plane with the exception of the set $\overline{\Omega}$ and its reflection $\overline{\Omega}^*$ with respect to the unit circle, and we have $b(\zeta^*)=\overline{b(\zeta)}$ for $\zeta\in\overline{B}\setminus\overline{\Omega}$, where for a point (x_1,x_2) in the plane $\zeta=x_1+ix_2$.

In case the inclusions are of the form

$$\Omega_j=x_j+\varepsilon O_j,\quad x_j\in B,\ 0\in O_j$$

it is shown that $b_\varepsilon(\zeta)\setminus\varepsilon^2$ converges, as $\varepsilon\to 0$, to a function

$$F(\zeta)=\frac{\zeta^2}{4\pi^2}\sum_{j=1}^{J}\left(\frac{\delta_j}{(\zeta-\zeta_j)^4}+\frac{\overline{\delta}_j}{(\overline{\zeta}_j\zeta-1)^4}+\frac{2\alpha_j}{(\zeta-\zeta_j)^2(\overline{\zeta}_j\zeta-1)^2}\right),$$

where $\zeta_j=x_{j1}+ix_{j2}$ corresponds to the point $x_j\in B$. This result means that in the limit $\varepsilon\to 0$ locations of the point inclusions are found.

The idea is that $b(\zeta)$ should provide approximations to the locations of inclusions in the case $\varepsilon=1$.

Assume that the backscatter function is given as a Laurent series $b(\zeta)=\sum_{\nu=-\infty}^{\infty}\beta_\nu\zeta^\nu$ convergent in a neighbourhood of T. This function can be approximated by the Laurent-Padé $(m-2,m)$-approximation r_m, a rational function with numerator of degree $m-2$ and denominator of degree m, whose Laurent expansion coefficients match those of b for $\nu=-2m+2,\dots,2m-2$. Notice that β_ν are just Fourier coefficients of $b(e^{i\vartheta})$ and that r_m has an expansion of the form

$$r_m(\zeta)=\lambda_0+\sum_{k=1}^{m}\left(\frac{\lambda_k}{\zeta-\zeta_k}+\frac{\overline{\lambda}_k\zeta}{1-\zeta\overline{\zeta}_k}\right).$$

Section 6 considers the question of how to choose m using the Fourier coefficients. In Section 7.1 determination of the poles using the exact data $b(\vartheta)$ for different m after discharging poles with small residues is discussed. In Section 7.2, instead of exact data on T, only exact data at say 32 or 64 equidistant points on T are used. Also, the influence of the values of κ_j's on the position of the poles is discussed.

In applications, measured values of $b(\vartheta)$ are corrupted by noise. As the problem of determining the location of the inclusion is extremely ill-posed, some regularization measures have to be used. Section 7.4 gives rules for how many Fourier coefficients of $b(\vartheta)$ should be used and which terms of the expansion of r_m should be discarded. The poles ζ_j obtained by the described procedure correspond to the position of the inclusions. The theory is illustrated by many numerical examples. *Anton Suhadolc*

MR2813235 65N21 74F10 74L15 76Z05 92C30 92C35

Perego, Mauro (1-EMRY-CS; Atlanta, GA);
Veneziani, Alessandro (1-EMRY-CS; Atlanta, GA);
Vergara, Christian (I-BERG-EIM; Bergamo)

A variational approach for estimating the compliance of the cardiovascular tissue: an inverse fluid-structure interaction problem. (English summary)

SIAM J. Sci. Comput. **33** (2011), *no.* 3, 1181–1211.

This paper is devoted to studying an inverse fluid-structure interaction problem which arises in the medical (cardiovascular) domain. It focuses particularly on the identification of the vessel displacement η. This latter enables one to estimate the *compliance* parameter, knowledge of which is relevant for diagnosis of certain diseases.

Mathematically, it consists in a problem formulated through the following system of partial differential equations:

$$(1)\qquad \begin{cases} \rho_f \dfrac{D^A u}{Dt} + \rho_f((u-w)\cdot\nabla)u - \nabla\cdot T_f = f_f & \text{in } \Omega_f^t \times (0,T), \\ \nabla\cdot u = 0 & \text{in } \Omega_f^t \times (0,T), \\ \rho_s \dfrac{\partial^2 \eta}{\partial t^2} - \nabla\cdot(ES_s) = f_s & \text{in } \Omega_s \times (0,T), \\ + \text{ boundary conditions}, \end{cases}$$

where the subscripts f and s refer either to the fluid structure (blood) or to the solid structure (vessel wall), u is the blood velocity, ρ is a density, $\frac{D^A}{Dt}$ is the ALE derivative, w is the velocity of the points of the fluid domain and the boundary conditions mainly bring into play the stress tensors.

Firstly, the authors establish the weak formulation of the direct discretized problem (1) and show that it admits a unique solution. Next, they provide a complete study of the inverse problem using a classical but efficient regularization procedure, i.e. a Tikhonov-like term is added to the cost functional which evaluates the mismatch between the measurements of η and the values computed through system (1). The problem is tackled with the Karush-Kuhn-Tucker method leading to the study of optimal conditions. Even if the mathematical tools used are standard, the whole analysis is very complete (Gateaux differentiability, existence, continuous dependence of the minimum on the measurements). In the last part, good numerical results with no noise are presented and some discussions are given concerning the best way to improve noise filtering.

Yannick Fischer

MR2888529 65N21 35J05 35R30

Yang, Jiaqing (PRC-ASBJ-AMM; Beijing);
Zhang, Bo [Zhang, Bo[9]] (PRC-ASBJ-AMM; Beijing);
Zhang, Ruming (PRC-ASBJ-AMM; Beijing)

A sampling method for the inverse transmission problem for periodic media. (English summary)

Inverse Problems **28** (2012), *no.* 3, 035004, 17 *pp.*

Summary: "This paper is concerned with the inverse scattering problem of reconstructing the support of a periodic inhomogeneous medium from knowledge of the scattered field measured on a straight line above and below the periodic structure. A linear sampling method is proposed to reconstruct the support of the periodic inhomogeneous medium based on a linear operator equation. The mathematical analysis of the sampling method is developed and numerical examples are given showing the practicality of the reconstruction algorithm."

MR2859612 65N22 65F10 74B05 90C52

Aubry, R. [**Aubry, Romain**] (1-GMSN-CPD; Fairfax, VA);
Mut, F. [**Mut, Fernando**] (1-GMSN-CPD; Fairfax, VA);
Dey, S. [**Dey, Saikat**] (1-NRL; Washington, DC);
Löhner, R. [**Löhner, Rainald**] (1-GMSN-CPD; Fairfax, VA)

Deflated preconditioned conjugate gradient solvers for linear elasticity. (English summary)

Internat. J. Numer. Methods Engrg. **88** (2011), *no.* 11, 1112–1127.

Summary: "Extensions of deflation techniques previously developed for the Poisson equation to static elasticity are presented. Compared to the (scalar) Poisson equation [R. Aubry et al., J. Comput. Phys. **227** (2008), no. 24, 10196–10208; MR2467949 (2009k:76080); R. Löhner et al., Int. J. Numer. Methods Eng. **87** (2011), no. 1-5, 2–14, doi:10.1002/nme.2932; F. Mut et al., Int. J. Numer. Methods Biomed. Eng. **26** (2010), no. 1, 73–85, doi:10.1002/cnm.1235], the elasticity equations represent a system of equations, giving rise to more complex low-frequency modes [U. Trottenberg, C. W. Oosterlee and A. Schüller, *Multigrid*, Academic Press, San Diego, CA, 2001; MR1807961 (2002b:65002)]. In particular, the straightforward extension from the scalar case does not provide generally satisfactory convergence. However, a simple modification allows to recover the remarkable acceleration in convergence and CPU time reached in the scalar case. Numerous examples and timings are provided in a serial and a parallel context and show the dramatic improvements of up to two orders of magnitude in CPU time for grids with moderate graph depths compared to the non-deflated version. Furthermore, a monotonic decrease of iterations with increasing subdomains, as well as a remarkable acceleration for very few subdomains are also observed if all the rigid body modes are included."

MR2875245 65N25 41A58

Adcock, Ben (4-CAMB-CMA; Cambridge);
Iserles, Arieh (4-CAMB-CMA; Cambridge); **Nørsett, Syvert P.** (N-NUST; Trondheim)

From high oscillation to rapid approximation II: expansions in Birkhoff series. (English summary)

IMA J. Numer. Anal. **32** (2012), *no.* 1, 105–140.

Summary: "We consider the use of eigenfunctions of polyharmonic operators, equipped with homogeneous Neumann boundary conditions, to approximate nonperiodic functions in compact intervals. Such expansions feature a number of advantages in comparison with classical Fourier series, including uniform convergence and more rapid decay of expansion coefficients. Having derived an asymptotic formula for expansion coefficients, we describe a systematic means to find eigenfunctions and eigenvalues. Next we demonstrate uniform convergence of the expansion and give estimates for the rate of convergence. This is followed by the introduction and analysis of Filon-type quadrature techniques for rapid approximation of expansion coefficients. Finally, we consider special quadrature methods for eigenfunctions corresponding to a multiple zero eigenvalue."

{For Part I see [A. Iserles and S. P. Nørsett, IMA J. Numer. Anal. **28** (2008), no. 4, 862–887; MR2457350 (2010g:65253)].}

MR2863101 65N25 65N30

Yao, Changhui (PRC-ZHEN; Zhengzhou); **Qiao, Zhonghua** (PRC-BAP-ICM; Kowloon)

Extrapolation of mixed finite element approximations for the Maxwell eigenvalue problem. (English summary)

Numer. Math. Theory Methods Appl. **4** (2011), *no.* 3, 379–395.

Summary: "In this paper, a general method to derive asymptotic error expansion for-

mulas for the mixed finite element approximations of the Maxwell eigenvalue problem is established. Abstract lemmas for the error of the eigenvalue approximations are obtained. Based on the asymptotic error expansion formulas, the Richardson extrapolation method is employed to improve the accuracy of the approximations for the eigenvalues of the Maxwell system from $\mathcal{O}(h^2)$ to $\mathcal{O}(h^4)$ when applying the lowest order Nédélec mixed finite element and a nonconforming mixed finite element. To our best knowledge, this is the first superconvergence result of the Maxwell eigenvalue problem by the extrapolation of the mixed finite element approximation. Numerical experiments are provided to demonstrate the theoretical results."

MR2840197 65N30 65F08 65N22 65N55

Aksoylu, Burak (TR-ETU-M; Ankara)**; Yeter, Zuhal** (1-LAS; Baton Rouge, LA)

Robust multigrid preconditioners for the high-contrast biharmonic plate equation. (English summary)

Numer. Linear Algebra Appl. **18** (2011), *no.* 4, 733–750.

Summary: "We study the high-contrast biharmonic plate equation with Hsieh-Clough-Tocher discretization. We construct a preconditioner that is robust with respect to contrast size and mesh size simultaneously based on the preconditioner proposed by B. Aksoylu et al. [Comput. Vis. Sci. **11** (2008), no. 4-6, 319–331; MR2425499 (2010d:65067)]. By extending the devised singular perturbation analysis from linear finite element discretization to the above discretization, we prove and numerically demonstrate the robustness of the preconditioner. Therefore, we accomplish a desirable preconditioning design goal by using the same family of preconditioners to solve the elliptic family of PDEs with varying discretizations. We also present a strategy on how to generalize the proposed preconditioner to cover high-contrast elliptic PDEs of order $2k$, $k > 2$. Moreover, we prove a fundamental qualitative property of the solution to the high-contrast biharmonic plate equation. Namely, the solution over the highly bending island becomes a linear polynomial asymptotically. The effectiveness of our preconditioner is largely due to the integration of this qualitative understanding of the underlying PDE into its construction."

MR2884118 65N30 74B05 74S05

An, Jing [An, Jing[1]] (PRC-GUZN-SMC; Guiyang)**;**
Sun, Ping (PRC-GUZN-SMC; Guiyang)**;**
Luo, Zhen Dong [Luo, Zhen Dong[1]] (PRC-EPU2-SMP; Beijing)

A simplified stabilized second-order mixed finite element formulation based on bubble functions for plane elasticity problems. (Chinese. English and Chinese summaries)

Acta Math. Sci. Ser. A Chin. Ed. **31** (2011), *no.* 5, 1253–1265.

The third author of this paper has presented (in Chinese) a conforming finite element method with second-order convergence rate for plane elasticity problems, using bubble functions which satisfy the BB condition without losing the conforming property of the finite element space. In this paper all the bubble function terms are eliminated from the resulting discrete problem that saves $18N$ degrees of freedom, where N is the number of vertices of triangularization, and retains the second-order convergence rate. *Shaochun Chen*

MR2894806 65N30 35Q35 65N15 76D07
Bahaj, Mohamed (MRC-HAS1ST-MCS; Settat)**;**
Rachid, Anas (MRC-HAS1ST-MCS; Settat)
A posteriori error estimator for nonconforming finite volume element approximations of the Stokes problem. (English summary)
J. Math. Sci. Adv. Appl. **7** (2011), *no.* 2, 133–148.
The authors consider a finite volume element method for the two-dimensional Stokes equations. In particular, they derive an explicit residual-based computable error indicator for the method based on the nonconforming Crouzeix-Raviart element in H^1-norms and prove its reliability and efficiency. *JaEun Ku*

MR2884553 65N30 35F20 49J40 49L20
Boulbrachene, Messaoud (OM-SUQA-MS; Muscat)
Finite element methods for HJB equations. (English summary)
Mathematics in science and technology, 259–290, *World Sci. Publ.*, *Hackensack*, *NJ*, 2011.
Summary: "The paper surveys recent results on the finite element approximation of Hamilton-Jacobi-Bellman equations. Various methods are analyzed and error estimates in the maximum norm are derived. Also, a finite element monotone iterative scheme for the computation of the approximate solution is given and its geometrical convergence proved."
{For the entire collection see MR2893670 (2012i:00025).}

MR2846773 65N30 35J40 65N12
Gudi, Thirupathi (6-IIS; Bangalore)**; Neilan, Michael** (1-LAS; Baton Rouge, LA)
An interior penalty method for a sixth-order elliptic equation. (English summary)
IMA J. Numer. Anal. **31** (2011), *no.* 4, 1734–1753.
The authors develop a C^0 interior penalty (IP) method for the sixth-order elliptic boundary value problem

$$-\Delta^3 u = f \quad \text{in } \Omega, \qquad u = \partial_n u = \partial^2_{nn} u = 0 \quad \text{on } \partial\Omega, \tag{1}$$

where Ω is a two-dimensional polygonal domain. They show the existence and uniqueness of a solution to (1), as well as a quasi-optimal convergence of the C^0 IP method. The quasi-optimality, which assumes minimal regularity of the exact solution $u \in H^3(\Omega)$ to (1), relies on a combined enriching operator that connects the C^0 Lagrangian finite element space to the C^2 finite element space and on a posteriori analysis techniques.
The results are justified through some numerical examples. *Mohammad Asadzadeh*

MR2863778 65N30 65N12
Schweitzer, Marc Alexander (D-STGT-PDS; Stuttgart)
Generalizations of the finite element method. (English summary)
Cent. Eur. J. Math. **10** (2012), *no.* 1, 3–24.
Summary: "This paper is concerned with the generalization of the finite element method via the use of non-polynomial enrichment functions. Several methods employ this general approach, e.g. the extended finite element method and the generalized finite element method. We review these approaches and interpret them in the more general framework of the partition of unity method. Here we focus on fundamental construction principles, approximation properties and stability of the respective numerical method. To this end, we consider meshbased and meshfree generalizations of the finite element method and the use of smooth, discontinuous, singular and numerical enrichment functions."

MR2869630 65N30 65N12 76D07 76M10

Song, Lina (PRC-XJU-SC; Xi'an);
Hou, Yanren [Hou, Yan Ren] (PRC-XJU-SC; Xi'an);
Zheng, Haibiao (PRC-XJU-SC; Xi'an)

The two-grid stabilization of equal-order finite elements for the Stokes equations. (English summary)

Internat. J. Numer. Methods Fluids **67** (2011), *no.* 12, 2054–2061.

Summary: "This work presents a two-grid stabilized method of equal-order finite elements for the Stokes problems. This method only offsets the discrete pressure space by the residual of pressure on two grids to circumvent the discrete Babuška-Brezzi condition. The method can be done locally in a two-grid approach without stabilization parameter by projecting the pressure onto a finite element space based on coarse mesh. Also, it leads to a linear system with minimal additional cost in implement. Optimal error estimates are obtained. Finally, some numerical simulations are presented to show stability and accuracy properties of the method."

MR2824859 65N30 65N55

Tu, Xuemin (1-KS; Lawrence, KS)

A three-level BDDC algorithm for a saddle point problem. (English summary)

Numer. Math. **119** (2011), *no.* 1, 189–217.

Two-level BDDC (Balancing Domain Decomposition by Constraints) can lead to large coarse-level problems. This is due to the fact that all iterates are required to stay in a benign space (the subspace where all preconditioned operators are positive definite). For this reason, the author of this paper introduced (in his earlier works [in *Domain decomposition methods in science and engineering XVI*, 437–444, Lect. Notes Comput. Sci. Eng., 55, Springer, Berlin, 2007; MR2334133; SIAM J. Sci. Comput. **29** (2007), no. 4, 1759–1780; MR2341811 (2008i:65294); Internat. J. Numer. Methods Engrg. **69** (2007), no. 1, 33–59; MR2282536 (2007j:65115)]) an additional third level. The original coarse-level problem is then solved inexactly via a two-level method. In this paper, the earlier result is extended to saddle point problems arising from mixed formulations of incompressible Stokes problems. A nearly (up to a logarithm) optimal convergence rate is proved. Some computational results are presented. *Josef Daněk*

MR2831038 65N30 49M25 70H20

Zhang, Yong-Tao (1-NDM-ACM; Notre Dame, IN);
Chen, Shanqin (1-INSB; South Bend, IN); **Li, Fengyan** (1-RSP; Troy, NY);
Zhao, Hongkai (1-CA3; Irvine, CA); **Shu, Chi-Wang** (1-BRN-A; Providence, RI)

Uniformly accurate discontinuous Galerkin fast sweeping methods for Eikonal equations. (English summary)

SIAM J. Sci. Comput. **33** (2011), *no.* 4, 1873–1896.

The paper is devoted to an approximation of the viscosity solution of the Eikonal equation $|\nabla\varphi(\mathbf{x})| = f(\mathbf{x})$ for $\mathbf{x} \in \Omega \setminus \Gamma$, $\varphi(\mathbf{x}) = g(\mathbf{x})$ for $\mathbf{x} \in \Gamma \subset \Omega$ with the functions $f > 0$ and g Lipschitz continuous and a domain Ω of an arbitrary dimension. This problem is a special case of the static Hamilton-Jacobi equations with extensive applications.

The method works on a Cartesian mesh $\Omega_h = \bigcup_{1\le i\le N, 1\le j\le M} I_{ij}$ with $I_{ij} = [x_{i-1/2}, x_{i+1/2}] \times [y_{j-1/2,j+1/2}]$ and $x_{i+1/2} - x_{i-1/2} > 0$, $y_{j+1/2} - y_{j-1/2} > 0$. It calculates approximations φ_{ij} of the exact values $\varphi(x_i, y_j)$ for $1 \le i \le N$, $1 \le j \le M$. New causality indicators controlling the directions of the information flow are developed. Their initial values are determined by a high-order finite-difference type fast sweeping method based on high-order WENO approximations. They allow one to compute new values of the solution φ in nodes whose causality information is consistent with

the actual sweeping directions only by the local discontinuous Galerkin (DG) solver. Then $\max_{1\le i\le N,1\le j\le M} |\varphi_{ij}^{\text{new}} - \varphi_{ij}^{\text{old}}|$ is calculated. If this value is less than a given accuracy δ, the procedure stops. Otherwise the step consisting of an effective update of the causality indicators and a recalculation of the values φ_{ij} by the local DG solver is repeated.

A series of numerical examples illustrates a uniform second-order accuracy of the proposed method in smooth regions and its linear computational complexity.

Josef Dalík

MR2862659 65N35 60H15 65N75

Cao, Yanzhao (1-ABRN; Auburn, AL)**; Yin, Li [Yin, Li[1]]** (PRC-BIAP-CP; Beijing)

Spectral method for nonlinear stochastic partial differential equations of elliptic type. (English summary)

Numer. Math. Theory Methods Appl. **4** (2011), *no.* 1, 38–52.

Summary: "This paper is concerned with the numerical approximations of semi-linear stochastic partial differential equations of elliptic type in multi-dimensions. Convergence analysis and error estimates are presented for the numerical solutions based on the spectral method. Numerical results demonstrate the good performance of the spectral method."

MR2847118 65N35 41A05 41A30

Cheng, A. H.-D. (1-MS-SEN; University, MS)

Multiquadric and its shape parameter—a numerical investigation of error estimate, condition number, and round-off error by arbitrary precision computation. (English summary)

Eng. Anal. Bound. Elem. **36** (2012), *no.* 2, 220–239.

Summary: "Hardy's multiquadric and its related interpolators have been found to be highly efficient for interpolating continuous, multivariate functions, as well as for the solution of partial differential equations. Particularly, the interpolation error can be dramatically reduced by varying the shape parameter to make the interpolator optimally flat. This improvement of accuracy is accomplished without reducing the fill distance of collocation points, that is, without the increase of computational cost. There exist a number of mathematical theories investigating the multiquadric family of radial basis functions. These theories are often not fully tested due to the computation difficulty associated with the ill-conditioning of the interpolation matrix. This paper overcomes this difficulty by utilizing arbitrary precision arithmetic in the computation. The issues investigated include conditional positive definiteness, error estimate, optimal shape parameter, traditional and effective condition numbers, round-off error, derivatives of interpolator, and the edge effect of interpolation."

MR2843284 65N35 33C45 35J25

Wang, Zhong-Qing (PRC-SNO; Shanghai)**; Wu, Jing-Xia** (PRC-SGH-SCP; Shanghai)

Generalized Jacobi rational spectral methods with essential imposition of Neumann boundary conditions in unbounded domains. (English summary)

Discrete Contin. Dyn. Syst. Ser. B **17** (2012), *no.* 1, 325–346.

In this interesting paper, the authors focus on Neumann problems in unbounded domains, using the generalized Jacobi rational spectral method with essential imposition of Neumann boundary conditions. They establish some basic results on the generalized Jacobi rational approximations. They propose some related spectral schemes for one- and two-dimensional problems and they also prove their convergence. Instead of the full stiffness matrices encountered in the classical rational spectral method, they employ

some band stiffness matrices by choosing appropriate base functions with zero slopes at the ends. *Eid Hassan Doha*

MR2895495 65N38 41A55 65D30
Aimi, A. (I-PARM; Parma)**; Diligenti, M. [Diligenti, Mauro]** (I-PARM; Parma)**; Guardasoni, C. [Guardasoni, Chiara]** (I-PARM; Parma)
Numerical integration schemes for applications of energetic Galerkin BEM to wave propagation problems. (English summary)
Riv. Math. Univ. Parma (*N.S.*) **2** (2011), *no.* 1, 147–187.
Summary: "Here we consider wave propagation problems with vanishing initial and mixed boundary condition reformulated as space-time boundary integral equations. The energetic Galerkin boundary element method used in the discretization phase, after a double analytic integration in time variables, has to deal with weakly singular, singular and hypersingular double integrals in space variables. Efficient numerical quadrature schemes for evaluation of these integrals are here proposed. Several numerical results are presented and discussed."

MR2847105 65N38 74F25 74S15
Guo, Li (PRC-SEU-EMC; Nanjing)**; Chen, Tang** (PRC-SEU-EMC; Nanjing)**; Gao, Xiao-Wei** (PRC-DUT-SAI; Dalian)
Transient meshless boundary element method for prediction of chloride diffusion in concrete with time dependent nonlinear coefficients. (English summary)
Eng. Anal. Bound. Elem. **36** (2012), *no.* 2, 104–111.
Summary: "Chloride-induced corrosion of steel reinforcements has been identified as one of the main causes of deterioration of concrete structures. A feasible numerical method is required to predict chloride penetration in concrete structures. A transient meshless boundary element method is proposed to predict chloride diffusion in concrete with time dependent nonlinear coefficient. Taking Green's function as the weighted function, the weighted residue method is adopted to transform the diffusion equation into equivalent integral equations. By the coupling of radial integral method and radial basis function approximation, the domain integrals in equivalent control equations are transformed into boundary integrals. Following the general procedure of boundary element meshing and traditional finite difference method, a set of nonlinear algebraic equations are constructed and are eventually solved with the modified Newtonian iterative method. Several numerical examples are provided to demonstrate the effectiveness and efficiency of the developed model. A comparison of the simulated chloride concentration with the corresponding reported experimental data in a real marine structure indicates the high accuracy and advantage of the time dependent coefficient and nonlinear model over the conventional constant coefficient model."

MR2847120 65N38 76Q05
Wu, Haijun [Wu, Hai Jun[1]] (PRC-JTU-MSV; Shanghai)**; Liu, Yijun [Liu, Yi Jun[1]]** (1-CINC-ME; Cincinnati, OH)**; Jiang, Weikang [Jiang, Wei-kang]** (PRC-JTU-MSV; Shanghai)
Analytical integration of the moments in the diagonal form fast multipole boundary element method for 3-D acoustic wave problems. (English summary)
Eng. Anal. Bound. Elem. **36** (2012), *no.* 2, 248–254.
Summary: "A diagonal form fast multipole boundary element method (BEM) is presented in this paper for solving 3-D acoustic wave problems based on the Burton-Miller boundary integral equation (BIE) formulation. Analytical expressions of the moments in the diagonal fast multipole BEM are derived for constant elements, which are shown

to be more accurate, stable and efficient than those using direct numerical integration. Numerical examples show that using the analytical moments can reduce the CPU time by a lot as compared with that using the direct numerical integration. The percentage of CPU time reduction largely depends on the proportion of the time used for moments calculation to the overall solution time. Several examples are studied to investigate the effectiveness and efficiency of the developed diagonal fast multipole BEM as compared with earlier p^3 fast multipole method BEM, including a scattering problem of a dolphin modeled with 404,422 boundary elements and a radiation problem of a train wheel track modeled with 257,972 elements. These realistic, large-scale BEM models clearly demonstrate the effectiveness, efficiency and potential of the developed diagonal form fast multipole BEM for solving large-scale acoustic wave problems."

MR2877951 65N50

Bois, Richard (3-LVL-MS; Quebec, QC)**; Fortin, Michel** (3-LVL-MS; Quebec, QC)**; Fortin, André** (3-LVL-MS; Quebec, QC)

A fully optimal anisotropic mesh adaptation method based on a hierarchical error estimator. (English summary)

Comput. Methods Appl. Mech. Engrg. **209/212** (2012), 12–27.

Summary: "We present a new two-dimensional mesh adaptation method which produces optimal meshes for all quadratic functions, positive definite or indefinite. The method also leads naturally, and without any specific modification, to anisotropic meshes when the solution allows it. In its simplest form, the method starts with a linear finite element solution and requires the recovery of its gradient which is used to build a new quadratic reinterpolation of the solution. The error is estimated as the difference between the linear solution and its quadratic reinterpolation. *Our method does not depend, a priori, on the partial differential equation at hand in contrast to residual methods. It however strongly depends on the quality of the gradient recovery.* The method is also easily generalized to higher order finite element solution which is also an improvement over most metric based adaptation methods. This estimated error is used to govern local modifications of the mesh in order to attain a prescribed level of error in L^2-norm or a prescribed number of nodes. The H^1-seminorm of the estimated error is then minimized in order to get an optimal mesh. We also show that the optimal mesh depends only on the solution itself and very little on the differential operator of the problem at hand. Numerical examples are presented and discussed."

MR2862229 65N50

Stadler, Domen (SV-TURBI; Ljubljana)**; Kosel, Franc** (SV-LJUBME; Ljubljana)**; Čelič, Damjan** (SV-TURBI; Ljubljana)**; Lipej, Andrej** (SV-TURBI; Ljubljana)

Mesh deformation based on artificial neural networks. (English summary)

Int. J. Comput. Fluid Dyn. **25** (2011), *no.* 8, 439–448.

Summary: "In the article a new mesh deformation algorithm based on artificial neural networks is introduced. This method is a point-to-point method, meaning that it does not use connectivity information for calculation of the mesh deformation. Two already known point-to-point methods, based on interpolation techniques, are also presented. In contrast to the two known interpolation methods, the new method does not require a summation over all boundary nodes for one displacement calculation. The consequence of this fact is a shorter computational time of mesh deformation, which is proven by different deformation tests. The quality of the deformed meshes with all three deformation methods was also compared. Finally, the generated and the deformed three-dimensional meshes were used in the computational fluid dynamics numerical analysis of a Francis water turbine. A comparison of the analysis results was made to

prove the applicability of the new method in every day computation."

MR2861652 65N55 65F10 65Y05
Baker, Allison H. (1-LLL-AC; Livermore, CA)**;**
Falgout, Robert D. (1-LLL-AC; Livermore, CA)**;**
Kolev, Tzanio V. (1-LLL-AC; Livermore, CA)**;**
Yang, Ulrike Meier [Meier Yang, Ulrike] (1-LLL-AC; Livermore, CA)
Multigrid smoothers for ultraparallel computing. (English summary)
SIAM J. Sci. Comput. **33** (2011), *no.* 5, 2864–2887.
This work concerns the scalability of various algebraic multigrid smoothers with potentially millions of processors. First, using the two-grid theory, the authors identify some smoothers that are practical on ultraparallel computers. The analyses are done either by studying the smoothing properties of the smoothers or by comparing smoothers to others with well-known smoothing properties. These findings are verified numerically; the authors show that the Chebyshev and the ℓ_1 smoothers are robust with respect to different scaling and parallelism. *Leevan Ling*

MR2861645 65N55 65F08 65N22 65N30
Brunner, Thomas A. (1-LLL-WCX; Livermore, CA)**;**
Kolev, Tzanio V. (1-LLL-AC; Livermore, CA)
Algebraic multigrid for linear systems obtained by explicit element reduction. (English summary)
SIAM J. Sci. Comput. **33** (2011), *no.* 5, 2706–2731.
In this paper the authors consider a linear system of the form

$$Ax = b$$

in which A is a very large sparse matrix, resulting from a finite element discretisation of a partial differential equation, which is symmetric and positive (semi-)definite. Some unknowns are eliminated in order to reduce the size of A with the intention of increasing computational efficiency. To achieve this a set of "interior" degrees of freedom is eliminated. The elimination is undertaken in such a way that it results in a reduced memory requirement and an algebraic problem that can be solved efficiently. The authors therefore propose a general element reduction approach with the aim of maintaining sparsity of the Schur complement. They also investigate the application of the Algebraic Multigrid (AMG) approach to the reduced problem and discuss the influence of local elimination on solver-related properties of the matrix and availability of state subspace decompositions. The approach is tested on selected problems. The authors' observation is that a combination of appropriately chosen local elimination with solvers like the BoomerAMG leads to significant improvements in overall solution time.
Mapundi K. Banda

MR2861655 65N55 60J22 65C40 65F10
Treister, Eran (IL-TECH-C; Haifa)**; Yavneh, Irad** (IL-TECH-C; Haifa)
On-the-fly adaptive smoothed aggregation multigrid for Markov chains. (English summary)
SIAM J. Sci. Comput. **33** (2011), *no.* 5, 2927–2949.
Algebraic multigrid methods are used to numerically solve linear systems and partial differential equations. There are adaptive multigrid methods, quite general ones like Petrov-Galerkin smoothed aggregation [H. Guillard, A. Janka and P. Vaněk, Appl. Numer. Math. **58** (2008), no. 12, 1861–1874; MR2464817 (2010g:65047)] and more specific ones like the Exact Interpolation Scheme (EIS) [A. E. Brandt and D. Ron, in *Multilevel*

optimization in VLSICAD, 1–69, Comb. Optim., 14, Kluwer Acad. Publ., Dordrecht, 2003; MR2021995]. Here a new adaptive algebraic multigrid method is presented that is tailored towards the solution of Markov chains. For an irreducible sparse column-stochastic matrix B it computes the principal eigenvector of B, i.e., the unique vector x that satisfies $Bx = x$. The adaptive scheme interleaves classical multigrid methods with an EIS scheme. Classical algorithms use fixed restriction (that transforms the problem into a coarse-grid problem of smaller dimension) and fixed prolongation (that transforms the coarse-grid problem back into the original problem). EIS adapts restriction and prolongation in each round, which is computationally very costly. The new scheme starts with an EIS setup and then interleaves solution and EIS cycles. Since solution cycles are considerably faster the idea is to use operators that yield worse convergence factors in a single round and make up for this by having multiple solution rounds in the same time yielding an overall better convergence factor.

The new method is developed step-wise and presented clearly. Also implementations that do not require recurrent and frequent communication and are thus suitable for distributed-memory parallel computations are discussed. Based on average convergence factors and computational cost for both kinds of cycles, a qualitative analysis is presented. Moreover, the approach is empirically evaluated using three example problems, namely a tandem queue Markov chain, a random walk on a nonsymmetric random planar graph, and a random walk on a triangular lattice. *Thomas Jansen*

MR2836694 65N80 31B35

Langston, M. Harper (1-NY-X; New York, NY)**;**
Greengard, Leslie [Greengard, Leslie F.] (1-NY-X; New York, NY)**;**
Zorin, Denis (1-NY-X; New York, NY)

A free-space adaptive FMM-based PDE solver in three dimensions. (English summary)

Commun. Appl. Math. Comput. Sci. **6** (2011), *no.* 1, 79–122.

Summary: "We present a kernel-independent, adaptive fast multipole method (FMM) of arbitrary order accuracy for solving elliptic PDEs in three dimensions with radiation and periodic boundary conditions. The algorithm requires only the ability to evaluate the Green's function for the governing equation and a representation of the source distribution (the right-hand side) that can be evaluated at arbitrary points. The performance is accelerated in three ways. First, we construct a piecewise polynomial approximation of the right-hand side and compute far-field expansions in the FMM from the coefficients of this approximation. Second, we precompute tables of quadratures to handle the near-field interactions on adaptive octree data structures, keeping the total storage requirements in check through the exploitation of symmetries. Third, we employ shared-memory parallelization methods and load-balancing techniques to accelerate the major algorithmic loops of the FMM. We present numerical examples for the Laplace, modified Helmholtz and Stokes equations."

MR2864660 65N99

Kumar, Manoj [Kumar, Manoj[1]] (6-MNNIT; Allahabad)**;**
Joshi, Pratibha (6-MNNIT; Allahabad)

Some numerical techniques for solving elliptic interface problems. (English summary)

Numer. Methods Partial Differential Equations **28** (2012), *no.* 1, 94–114.

Summary: "Many physical phenomena can be modeled by partial differential equations with singularities and interfaces. The standard finite difference and finite element methods may not be successful in giving satisfactory numerical results for such problems.

Hence, many new methods have been developed. Some of them are developed with the modifications in the standard methods, so that they can deal with the discontinuities and the singularities. In this article, a survey has been done on some recent efficient techniques to solve elliptic interface problems."

65P Numerical problems in dynamical systems

MR2821359 65P10 37M15 65L05
Brugnano, Luigi (I-FRNZ; Florence); **Trigiante, Donato** (I-FRNZ-EG; Florence)
Energy drift in the numerical integration of Hamiltonian problems. (English summary)
JNAIAM J. Numer. Anal. Ind. Appl. Math. **4** (2009), *no.* 3-4, 153–170.
In the numerical integration of differential equations arising in autonomous reversible Hamiltonian problems, the presence of a drift in the numerical values of the Hamiltonian function has been reported, even when reversible integrators are used. The present paper sheds additional light on this phenomenon by considering a restrictive notion of time reversal symmetry for both the continuous formulation and its discrete counterpart. In the continuous case this more precise definition applies only to periodic trajectories. Here the important point is the distinction between the symmetry of the underlying equations and the symmetry of the solution (which depends, in particular, on the initial condition). It is shown that time symmetric Hamiltonians discretized by a symmetric integration method (i.e., an integrator which is identical to its adjoint) with a sufficiently small time step h do not present a drift in the numerical value of the energy, but this drift may be observed when the discrete periodic orbits occur only in correspondence of isolated values of h. Several numerical examples illustrate the different possibilities arising and the theoretical results. *Fernando Casas*

MR2833601 65P10 65L05
Celledoni, E. (N-NUST; Trondheim);
McLachlan, R. I. [**McLachlan, Robert I.**] (NZ-MASS-FS; Palmerston North);
Owren, B. (N-NUST; Trondheim);
Quispel, G. R. W. [**Quispel, Gilles Reinout Willem**] (5-LTRB; Bundoora)
On conjugate B-series and their geometric structure. (English summary)
JNAIAM. J. Numer. Anal. Ind. Appl. Math. **5** (2010), *no.* 1-2, 85–94.
Summary: "The characterizations of B-series of symplectic and energy preserving integrators are well-known. The graded Lie algebra of B-series of modified vector fields include the Hamiltonian and energy preserving cases as Lie subalgebras, these spaces are relatively well understood. However, two other important classes are the integrators which are conjugate to Hamiltonian and energy preserving methods respectively. The modified vector fields of such methods do not form linear subspaces and the notion of a grading must be reconsidered. We suggest to study these spaces as filtrations, and viewing each element of the filtration as a vector bundle whose typical fiber replaces the graded homogeneous components. In particular, we shall study properties of these fibers, a particular result is that, in the energy preserving case, the fiber of degree n is a direct sum of the nth graded component of the Hamiltonian and energy preserving space. We also give formulas for the dimension of each fiber, thereby providing insight into the range of integrators which are conjugate to symplectic or energy preserving." *Luis Rández*

MR2908509 65P10 35Q55 65M06
Chen, Ya-Ming [Chen, Yaming] (PRC-NUDT-MSS; Changsha);
Zhu, Hua-Jun [Zhu, Hua Jun] (PRC-NUDT-MSS; Changsha);
Song, Song-He (PRC-NUDT-MSS; Changsha)
Multi-symplectic splitting method for two-dimensional nonlinear Schrödinger equation. (English summary)
Commun. Theor. Phys. (*Beijing*) **56** (2011), *no.* 4, 617–622.
Summary: "Using the idea of splitting numerical methods and the multi-symplectic methods, we propose a multi-symplectic splitting (MSS) method to solve the two-dimensional nonlinear Schrödinger equation (2D-NLSE) in this paper. It is further shown that the method constructed in this way preserve the global symplecticity exactly. Numerical experiments for the plane wave solution and singular solution of the 2D-NLSE show the accuracy and effectiveness of the proposed method."

MR2812323 65P10
Chen, Yao (PRC-ASBJ-AMS; Beijing);
Sun, Yajuan [Sun, Ya Juan] (PRC-ASBJ-AMS; Beijing);
Tang, Yifa [Tang, Yi-Fa] (PRC-ASBJ-AMS; Beijing)
Energy-preserving numerical methods for Landau-Lifshitz equation. (English summary)
J. Phys. A **44** (2011), *no.* 29, 295207, 16 *pp.*
Summary: "In this paper, we construct the energy-preserving numerical algorithms for the multisymplectic Hamiltonian system with nonconstant structures. We apply the algorithms to the Landau-Lifshitz equation, which is expressed as the multisymplectic Hamiltonian system with constraint [J. Frank, Appl. Numer. Math. **48** (2004), no. 3-4, 307–322; MR2056920 (2005b:82084)]. We compare the five numerical algorithms applied to the Landau-Lifshitz equation and present the numerical experiment by simulating one and two solitons motion."

65Q Difference and functional equations, recurrence relations

MR2864662 65Q99 34A25
Aslan, İsmail (TR-IIT-DM; Urla)
The discrete (G'/G)-expansion method applied to the differential-difference Burgers equation and the relativistic Toda lattice system. (English summary)
Numer. Methods Partial Differential Equations **28** (2012), *no.* 1, 127–137.
Summary: "We introduce the discrete (G'/G)-expansion method for solving nonlinear differential-difference equations (NDDEs). As illustrative examples, we consider the differential-difference Burgers equation and the relativistic Toda lattice system. Discrete solitary, periodic, and rational solutions are obtained in a concise manner. The method is also applicable to other types of NDDEs."

65R Integral equations, integral transforms

MR2854161 65R20 45E05 65N38

Bremer, James [Bremer, James C.] (1-CAD; Davis, CA)

On the Nyström discretization of integral equations on planar curves with corners. (English summary)

Appl. Comput. Harmon. Anal. **32** (2012), *no.* 1, 45–64.

In the Nyström method, a Fredholm integral equation of the second kind, $u + Ku = f$, with a continuous kernel, $K(x, y)$, is discretized as $u_i + \sum_{j=1}^{n} K_{ij} w_j u_j = f_i$, $i = 1, 2, \ldots, n$, where $u_i = u(x_i)$, $f_i = f(x_i)$, $K_{ij} = K(x_i, x_j)$, and x_j and w_j are the nodes and weights, respectively, of a quadrature rule. Here, the author starts by noting that it is advantageous to solve the modified system $v_i + \sum_{j=1}^{n} K_{ij} \sqrt{w_i w_j}\, v_j = g_i$, $i = 1, 2, \ldots, n$, where $v_i = u_i \sqrt{w_i}$ and $g_i = f_i \sqrt{w_i}$. This observation is developed in the context of the interior Neumann problem for Laplace's equation in two dimensions. The results of many numerical experiments are presented. *Paul Andrew Martin*

MR2856672 65R20 35J05 94A08

Chen, K. [Chen, Ke[1]] (4-LVRP-NDM; Liverpool)

Efficient iterative methods for fast solution of integral operators related problems.

Integral methods in science and engineering, 79–90, *Birkhäuser/Springer*, *New York*, 2011.

Introduction: "The discretization of integral operator related problems inevitably leads to some kind of linear system involving dense matrices. Such large scale systems can be prohibitively expensive to solve.

"In this paper, we shall first review various works that aimed to solve such systems effectively. We start from the solution of the boundary integral equation for the exterior Helmholtz problem with smooth boundaries for low and medium wavenumbers, solved by conjugate gradients and multigrid methods. We discuss the importance of effective preconditioning in the contexts of fast multipole methods and wavelet methods.

"Then we present some recent work on restoring images in the framework of inverse deconvolution, where the integral operator induced dense matrix, though structured, can be generated but cannot be computed due to extremely large sizes. No optimal solvers exist for this problem if the nonlinear total-variation semi-norm based regularizer is used. An effective optimization based multilevel method, using the idea of fast multipole like methods, is developed and presented here. Various numerical experiments are also reported. Finally a brief discussion of open challenges is given."

{For the entire collection see MR2848605 (2012h:74004).}

MR2907186 65R20 45D05

Maksimov, V. I. [Maksimov, Vyacheslav I.]

On an algorithm for solving an integral equation of the second kind. (Russian. English and Russian summaries)

Izv. Ural. Gos. Univ. Mat. Mekh. Inform. No. 11(58) (2008), 106–116, 168.

Consider the following equation:

$$Mu(t) + \int_{t_0}^{t} K(t, s)u(s)\, ds = f_1(t),$$

where $t \in [t_0, \nu]$, $u: t \to \mathbb{R}^r$ is an unknown function, M is an $r \times r$ matrix, and K is a known continuous kernel which is continuously differentiable with respect to the second argument. The function $f_1(t)$ is known approximately; namely, only approximations of

its integrals $\int_{t_0}^{\tau_i} f_1(\tau)\,d\tau$ are given for discrete moments $\tau_i = t_0 + ih$, $i = 1, \ldots, n$, $h = (\nu - t_0)/n$.

The article proposes a stable algorithm for approximately solving the problem considered. *Aleksander Denisiuk*

MR2870050 65R20

Parand, K. [**Parand, Kourosh**] (IR-SHBHM-CS; Tehran)**;**
Rad, J. A. [**Amani Rad, Jamal**] (IR-SHBHM-CS; Tehran)

Numerical solution of nonlinear Volterra-Fredholm-Hammerstein integral equations via collocation method based on radial basis functions. (English summary)

Appl. Math. Comput. **218** (2012), *no.* 9, 5292–5309.

Summary: "A numerical technique based on the spectral method is presented for the solution of nonlinear Volterra-Fredholm-Hammerstein integral equations. This method is a combination of collocation method and radial basis functions (RBFs) with the differentiation process (DRBF), using zeros of the shifted Legendre polynomial as the collocation points. Different applications of RBFs are used for this purpose. The integrals involved in the formulation of the problems are approximated based on Legendre-Gauss-Lobatto integration rule. The results of numerical experiments are compared with the analytical solution in illustrative examples to confirm the accuracy and efficiency of the presented scheme."

MR2869644 65R20 45E05 45E10

Rostamy, D. [**Rostamy Varnos Fadrani, D.**] (IR-IKIUS-M; Qazvin)

Hybrid of sigmoidal transformations and collocation method for a generalized airfoil equation. (English summary)

J. Numer. Math. Stoch. **3** (2011), *no.* 1, 80–95.

The author considers a second-kind integral equation over the interval, where the integral operator is the sum of a weakly singular, a Cauchy singular, and a hypersingular operator. He formulates a smoothness result for integrable solutions to the integral equation with a smooth right-hand side. Using the Euler-Maclaurin formula, he gives error estimates for the quadrature of the integral operators over non-uniform sets of quadrature knots, which are generated by the sigmoidal transform of uniform grids. Finally, the author proposes a collocation method based on splines, resp. trigonometric polynomials, and on non-uniform collocation points. Simple numerical examples show fast convergence.

Unfortunately, important details of the numerical scheme, like the quadrature discretization of the collocation matrix or the structure of the employed preconditioner, are not mentioned. Furthermore, the notation and the arguments in the proofs of the presented results are not very clear. For example, the author claims in the proof of Proposition 2.1 that a hypersingular operator is invertible in L^∞. In order to estimate the condition numbers, he simply claims that the norm of the inverse discretized operator is close to the norm of the inverse integral operator. In other words, the most important parts of a convergence analysis are missing. *Andreas Rathsfeld*

MR2863103 65R20 45J05 65L60
Wei, Yunxia [Wei, Yun Xia] (PRC-ZHO-SMC; Guangzhou)**;**
Chen, Yanping [Chen, Yan Ping[1]] (PRC-SCN-SM; Guangzhou)
Convergence analysis of the Legendre spectral collocation methods for second order Volterra integro-differential equations. (English summary)
Numer. Math. Theory Methods Appl. **4** (2011), *no.* 3, 419–438.
Summary: "A class of numerical methods is developed for second order Volterra integro-differential equations by using a Legendre spectral approach. We provide a rigorous error analysis for the proposed methods, which shows that the numerical errors decay exponentially in the L^∞-norm and L^2-norm. Numerical examples illustrate the convergence and effectiveness of the numerical methods."

65T Numerical methods in Fourier analysis

MR2895843 65T50 35Q60 78A45 78A50
Hansen, Thorkild B.
Spherical near-field scanning with higher-order probes. (English summary)
IEEE Trans. Antennas and Propagation **59** (2011), *no.* 11, 4049–4059.
Summary: "A general method for higher-order probe correction in spherical scanning is obtained from a renormalized least-squares approach. The renormalization causes the normal matrix of the least-squares problem to closely resemble the identity matrix when most of the energy of the probe pattern resides in the first-order modes. The normal equation can be solved either with a linear iterative solver (leading to an iterative scheme), or with a Neumann series (leading to a direct scheme). The computation scheme can handle non-symmetric probes, requires only the output of two independent ports of a dual-polarized probe, and works for both ϕ and θ scans. The probe can be characterized either by a complex dipole model or by a standard spherical-wave representation. The theory is validated with experimental data."

MR2839799 65T50 94A12 94A20 94A34
Rao, K. R. [Rao, Kamisetty Ramamohan] (1-TXA-EE; Arlington, TX)**;**
Kim, D. N. [Kim, Do Nyeon] (1-TXA-EE; Arlington, TX)**;**
Hwang, J. J. (KR-KUN-SEI; Kunsan)
★**Fast Fourier transform: algorithms and applications.**
Signals and Communication Technology.
Springer, *Dordrecht*, 2010. *xviii*+423 *pp.* $99.00. *ISBN* 978-1-4020-6628-3
This volume of the Springer Series Signal and Communication Technologies offers an account of the Discrete Fourier Transform (DFT) and its implementation, including the Fast Fourier Transform (FFT). The target audience is clearly instructors and students in engineering rather than mathematicians. However, the great amount of exercises and projects in Matlab makes it worth considering this book as a supplemental text in applied mathematics as well. The main emphasis of the book is on the accurate description of algorithms for the DFT/FFT.

Any comprehensive presentation of the DFT/FFT contains a progression through a definition of the DFT, its implementation, including the FFT, and finally applications. This book follows this path in seven chapters.

Chapter 2 introduces the DFT, Inverse DFT and the variant called the z-transform. The linear transforms corresponding to these algorithms are explained in great detail.

The authors move on in Chapter 3 to the central section of the book, devoted to the great variety of implementation algorithms for the FFT. Practical implementation is

extensively detailed. We are here on the edge between computer science and applied mathematics. The authors succeed in the difficult task of giving a precise account of the computer algebra for coding the FFT. This is illustrated by two kinds of pictures: First, detailed flow charts are provided describing how the algorithms work. Second, the matrices involved in linear algebra operations are displayed. Using this kind of visualizations, radix-2, radix-3, and radix-4 algorithms are presented using both Decimation in Time (DIT) and Decimation in Frequency (DIF). This is particularly useful for students doing practical projects. The chapter finally also gives a description of the Winograd variant of the FFT algorithm and of the Hartley transform (cosine and sine transforms). This chapter is very informative for mathematicians interested in further studies in FFT.

Chapter 4 is devoted to the Integer Fourier Transform. Even for readers not interested in the fixed-point arithmetic implementation of the FFT, this chapter is interesting because it gives a good introduction to the lifting scheme, which is an important technique in wavelet algorithms.

Chapter 5 and Chapter 6 parallel Chapter 2 and Chapter 3 for the two-dimensional DFT. A first flavor of applications for image filtering and its statistical aspects is given in Chapter 5.

After describing the variant of the nonequispaced DFT in Chapter 7 along with its fast calculation, Chapter 8 provides a broad series of Applications of the DFT and the FFT. Theses applications cover domains like image processing (compression, rotation), ear modeling, watermarking (image and audio), acoustic signal processing with applications in music.

The FFT has been one of the cornerstone in advanced computer science for real world application. Classic books on the FFT at the interface of applied mathematics, computer science, and approximations of partial differential equations include [C. F. Van Loan, *Computational frameworks for the fast Fourier transform*, Frontiers Appl. Math., 10, SIAM, Philadelphia, PA, 1992; MR1153025 (93a:65186); W. L. Briggs and V. E. Henson, *The DFT*, SIAM, Philadelphia, PA, 1995; MR1322049 (96c:65216); W. M. Pickering, *An introduction to fast Fourier transform methods for partial differential equations, with applications*, Electron. Electric. Engrg. Res. Stud. Appl. Engrg. Math. Ser., 4, Res. Stud. Press, Chichester, 1986; MR0868280 (88e:65166)]. Replacing them in classrooms is clearly not the role of the present volume. However, this book gives an excellent opportunity to applied mathematicians interested in refreshing their teaching to enrich their presentation of the DFT/FFT with modern applications. The exercises and projects (thoroughly described in several annexes) are one of the most important feature of this volume. This is in itself a clear motivation to strongly recommend this volume and to stress that teaching DFT and FFT should maintain a prominent place in any mathematics curriculum. *Jean-Pierre Croisille*

MR2895925 65T60

Han, Chun Mei (PRC-ITSTI; Shanghai)

A de-interlacing technique with motion estimation and hybrid median filter in wavelet domains. (Chinese. English and Chinese summaries)

Commun. Appl. Math. Comput. **24** (2010), *no.* 2, 124–128.

Summary: "A novel de-interlacing algorithm with motion estimation and hybrid median filter is introduced. The novel method employs the wavelet analysis firstly to distinguish the high and low frequency handled using different median filter, and then gets the value of the ME and MF. It utilizes the correlative information of space and time of the video signal. Experimental results show that the proposed method gives better quantitative

and a better visual performance than the traditional median filter method."

Guohui Song

65Y Computer aspects of numerical algorithms

MR2832696 65Y10 65F08 65N22 65N55

Knibbe, H. (NL-DELFEM-IA; Delft)**; Oosterlee, C. W.** (NL-DELFEM-IA; Delft)**; Vuik, C. [Vuik, Cornelis]** (NL-DELFEM-IA; Delft)

GPU implementation of a Helmholtz Krylov solver preconditioned by a shifted Laplace multigrid method. (English summary)

J. Comput. Appl. Math. **236** (2011), *no.* 3, 281–293.

A two-dimensional Helmholtz equation is solved by Krylov subspace methods which are preconditioned by a shifted Laplace multigrid method. The main contribution of this paper is a detailed comparison of the GPU (graphics processing unit) and CPU (central processing unit) implementations of all particular steps of the solution procedure: Krylov solver iterations, coarse grid correction and smoothing. Using GPU in all steps clearly appears to be the most advantageous. *Ivana Pultarová*

MR2776495 65Y20 34C14 68Q25

Chèze, Guillaume (F-TOUL3-IM; Toulouse)

Computation of Darboux polynomials and rational first integrals with bounded degree in polynomial time. (English summary)

J. Complexity **27** (2011), *no.* 2, 246–262.

This paper deals with the complexity of algorithms for the computation of Darboux polynomials of planar polynomial differential systems. Polynomial-time algorithms are given for the computation of both Darboux polynomials and rational first integrals.

Guoting Chen

MR2846702 65Y20 65D30

Plaskota, L. (PL-WASWMI; Warsaw)**; Wasilkowski, G. W.** (1-KY-C; Lexington, KY)

Tractability of infinite-dimensional integration in the worst case and randomized settings. (English summary)

J. Complexity **27** (2011), *no.* 6, 505–518.

Summary: "We consider approximation of weighted integrals of functions with infinitely many variables in the worst case deterministic and randomized settings. We assume that the integrands f belong to a weighted *quasi*-reproducing kernel Hilbert space, where the weights have product form and satisfy $\gamma_j = \mathcal{O}(j^{-\beta})$ for $\beta > 1$. The cost of computing $f(\mathbf{x})$ depends on the number $\mathrm{Act}(\mathbf{x})$ of active coordinates in $\mathbf{x}$ and is equal to $\$(\mathrm{Act}(\mathbf{x}))$, where $\$$ is a given cost function. We prove, in particular, that if the corresponding univariate problem admits algorithms with errors $\mathcal{O}(n^{-\kappa/2})$, where n is the number of function evaluations, then the ∞-variate problem is polynomially tractable with the tractability exponent bounded from above by $\max(2/\kappa, 2/(\beta-1))$ for all cost functions satisfying $\$(d) = \mathcal{O}(\mathrm{e}^{k\cdot d})$, for any $k \geq 0$. This bound is sharp in the worst case setting if β and κ are chosen as large as possible and $\$(d)$ is at least linear in d. The problem is weakly tractable even for a larger class of cost functions including $\$(d) = \mathcal{O}(\mathrm{e}^{\mathrm{e}^{k\cdot d}})$. Moreover, our proofs are constructive."

MR2895194 65Y99 68W30
Bright, Curtis (3-WTRL-SC; Waterloo, ON);
Storjohann, Arne (3-WTRL-SC; Waterloo, ON)
Vector rational number reconstruction. (English summary)
ISSAC 2011—*Proceedings of the* 36*th International Symposium on Symbolic and Algebraic Computation*, 51–57, *ACM*, *New York*, 2011.
Summary: "The final step of some algebraic algorithms is to reconstruct the common denominator d of a collection of rational numbers $(n_i/d)_{1\le i\le n}$ from their images $(a_i)_{1\le i\le n}$ mod M, subject to a condition such as $0 < d \le N$ and $|n_i| \le N$ for a given magnitude bound N. Applying elementwise rational number reconstruction requires that $M \in \Omega(N^2)$. Using the gradual sublattice reduction algorithm of M. van Hoeij and A. Novocin [in *LATIN 2010: theoretical informatics*, 539–553, Lecture Notes in Comput. Sci., 6034, Springer, Berlin, 2010; MR2673291 (2012c:94083)], we show how to perform the reconstruction efficiently even when the modulus satisfies a considerably smaller magnitude bound $M \in \Omega(N^{1+1/c})$ for c a small constant, for example $2 \le c \le 5$. Assuming $c \in O(1)$ the cost of the approach is $O(n(\log M)^3)$ bit operations using the original LLL lattice reduction algorithm, but is reduced to $O(n(\log M)^2)$ bit operations by incorporating the L^2 variant of P. Q. Nguyễn and D. Stehlé [SIAM J. Comput. **39** (2009), no. 3, 874–903; MR2538842 (2010i:11187)]. As an application, we give a robust method for reconstructing the rational solution vector of a linear system from its image, such as obtained by a solver using p-adic lifting."
{For the entire collection see MR2895188 (2012j:68010).}

Items with secondary classifications in Section 65

MR2854075 05C50 05C76 65F15
Kaveh, A. [**Kaveh, Ali**] (IR-IUST-STE; Tehran);
Fazli, H. [**Fazli, Hadi**] (IR-IUST-STE; Tehran)
Approximate eigensolution of Laplacian matrices for locally modified graph products. (English summary)
J. Comput. Appl. Math. **236** (2011), *no.* 6, 1591–1603.
Summary: "Laplacian matrices and their spectrum are of great importance in algebraic graph theory. There exist efficient formulations for eigensolutions of the Laplacian matrices associated with a special class of graphs called product graphs. In this paper, the problem of determining a few approximate smallest eigenvalues and eigenvectors of large scale product graphs modified through the addition or deletion of some nodes and/or members, is investigated. The eigenproblem associated with a modified graph model is reduced using the set of master eigenvectors and linear approximated slave eigenvectors from the original model. Implicitly restarted Lanczos method is employed to obtain the required eigenpairs of the reduced problem. Examples of large scale models are included to demonstrate the efficiency of the proposed method compared to the direct application of the IRL method."

MR2871127 05C85 65K05 68R10 90C39

Ito, Takehiro (J-TOHOEI-NDM; Sendai); **Nishizeki, Takao** (J-KWANS-SST; Sanda); **Schröder, Michael [Schröder, Michael[1]]; Uno, Takeaki** (J-NIIF; Tokyo); **Zhou, Xiao [Zhou, Xiao[1]]** (J-TOHOEI-NDM; Sendai)

Partitioning a weighted tree into subtrees with weights in a given range. (English summary)

Algorithmica **62** (2012), *no.* 3-4, 823–841.

Summary: "Assume that each vertex of a graph G is assigned a nonnegative integer weight and that l and u are given integers such that $0 \leq l \leq u$. One wishes to partition G into connected components by deleting edges from G so that the total weight of each component is at least l and at most u. Such a partition is called an (l, u)-partition. We deal with three problems to find an (l, u)-partition of a given graph: the minimum partition problem is to find an (l, u)-partition with the minimum number of components; the maximum partition problem is defined analogously; and the p-partition problem is to find an (l, u)-partition with a given number p of components. All these problems are NP-hard even for series-parallel graphs, but are solvable in linear time for paths. In this paper, we present the first polynomial-time algorithm to solve the three problems for arbitrary trees."

MR2781416 11K45 65C10

Gyarmati, Katalin (H-EOTVO-ALN; Budapest); **Mauduit, Christian** (F-CNRS-IML; Marseille); **Sárközy, András** (H-EOTVO-ALN; Budapest)

Measures of pseudorandomness of binary lattices, III (Q_k, correlation, normality, minimal values). (English summary)

Unif. Distrib. Theory **5** (2010), *no.* 2, 183–207.

In two earlier papers [Part I, Acta Arith. **144** (2010), no. 3, 295–313; MR2672292 (2012a:11111); Part II, Ramanujan J. **25** (2011), no. 2, 155–178; MR2800603] the authors introduced various measures of pseudorandomness of binary lattices. In the present paper they introduce correlation measures, measures of normality and related quantities. In two dimensions, the minima of these measures are estimated. This extends a famous result of K. F. Roth [Acta Arith. **9** (1964), 257–260; MR0168545 (29 #5806)]. The proof depends on elementary harmonic analysis. Furthermore, the connection between the correlation measures of order two and three of binary lattices is also studied. A list of open problems is included. *Robert F. Tichy*

MR2896601 15A06 65F30

Liang, Kai Fu (PRC-XIA-SMC; Xiangtan); **Liu, Jian Zhou** (PRC-XIA-SMC; Xiangtan)

The least squares symmetric-skew symmetric solution of the generalized coupled Sylvester matrix equations. (Chinese. English and Chinese summaries)

Math. Appl. (*Wuhan*) **24** (2011), *no.* 4, 746–753.

Summary: "In this paper, an iterative method is proposed for solving the minimum residual $\left\| \begin{pmatrix} A_1XB_1+C_1YD_1 \\ A_2XB_2+C_2YD_2 \end{pmatrix} - \begin{pmatrix} M_1 \\ M_2 \end{pmatrix} \right\| = \min$ over X symmetric-Y skew symmetric. First, it is obtained that the normal equations equivalent to the minimum residual problem, and then an iterative algorithm is presented for solving the normal matrix equations. By using the iterative method, the least squares symmetric-skew symmetric solution can be got within finite iteration steps in the absence of roundoff errors for any initial symmetric-skew symmetric matrix pair (X_0, Y_0). Moreover, the least squares symmetric-skew symmetric solution with minimum norm can be got by choosing a special kind of initial matrix."

MR2853003 15A18 15A12 65F35

Armentia, Gorka (E-PAMP-EMI; Pamplona);
Gracia, Juan-Miguel (E-EHUPH-AOR; Vitoria);
Velasco, Francisco E. (E-EHUPH-AOR; Vitoria)

Derivatives of the diameter and the area of a connected component of the pseudospectrum. (English summary)

Electron. J. Linear Algebra **22** (2011), 1004–1019.

The ε-pseudospectrum $\Lambda_\varepsilon(A)$ of a complex square matrix A is defined as the set of eigenvalues of all matrices X in an ε neighborhood of A, i.e. $\|X - A\|_2 \leq \varepsilon$.

The authors fix an eigenvalue λ of A and consider the connected component of $\Lambda_\varepsilon(A)$ around λ. For this component, they view the diameter and the area as functions of ε and determine expressions for the right-hand derivatives at $\varepsilon = 0$. Depending on the index of λ, the derivatives are functions of the Hölder condition number of λ. Examples on normal matrices, Jordan blocks, and 2×2 matrices illustrate the expressions for the diameter, area and their derivatives. *Ilse C. F. Ipsen*

MR2869490 15A18 15A12 65F15

Karow, Michael (D-TUB-RCM; Berlin)

Structured pseudospectra for small perturbations. (English summary)

SIAM J. Matrix Anal. Appl. **32** (2011), *no.* 4, 1383–1398.

In this paper, the author considers the shape and growth of structured pseudospectra for small matrix perturbations of a special form. It is shown that the properly scaled pseudospectra components converge to nontrivial limit sets. The relationship of these limit sets with μ-values and structured eigenvalue condition numbers for multiple eigenvalues is studied. The results are interesting. The proofs are well written.

Zheng Sheng Wang

MR2854123 15A21 15A23 65F25

Vandebril, Raf (B-KUL-C; Leuven (Heverlee));
Del Corso, Gianna M. (I-PISA-IF; Pisa)

A unification of unitary similarity transforms to compressed representations. (English summary)

Numer. Math. **119** (2011), *no.* 4, 641–665.

This paper deals with unitary similarity transformation of a complex $n \times n$ matrix A to a matrix H in upper Hessenberg form. The twist here is that A and H are expressed in factored form, that is, as a product of a unitary with upper triangular matrices. From a QR decomposition $A = QR$ the authors compute a QR decomposition $H = Q_H R_H$. The matrix Q is given as a product of $n(n-1)/2$ Givens rotations, while Q_H is produced as a product of $n-1$ rotations. The main idea is that the same unitary matrix can be factored differently into products of different sequences of Givens rotations.

The approach is extended to Hessenberg-like matrices (inverses of Hessenberg matrices), generalized Hessenberg matrices (with more than one subdiagonal), and mixed structures (sums of generalized Hessenberg matrices).

Finally, similarity transformations to Hessenberg-like form are related to QR factorizations of certain Krylov matrices formed from powers of A^{-1} and to Ritz values.

Ilse C. F. Ipsen

MR2871861 15A22 15A18 65F15

Hochstenbach, Michiel E. (NL-EIND; Eindhoven)

Fields of values and inclusion regions for matrix pencils. (English summary)

Electron. Trans. Numer. Anal. **38** (2011), 98–112.

The author uses a field-of-values approach to obtain inclusion regions for the eigenvalues of matrix pencils. In particular, two families of inclusion regions depending on a shifting parameter τ are given. A method for automatically selecting τ and computing an approximate inclusion region is proposed. The strategy of approximation is based on the use of low-dimensional Krylov spaces. *Enrico Bozzo*

MR2884289 15A23 65F05

Li, Lin [Li, Lin[7]] (PRC-AFEU-DMP; Xi'an)**;**
Yuan, Xiu Jiu (PRC-AFEU-DMP; Xi'an)**; Zhao, Xue Jun** (PRC-AFEU-DMP; Xi'an)

Triangular factorization of the Cauchy matrix and its application. (Chinese. English summary)

Numer. Math. J. Chinese Univ. **33** (2011), *no.* 1, 90–96.

Summary: "In this paper, a new method for triangular factorization of the Cauchy matrix is proposed by decomposing the Cauchy matrix and its inverse into the product of some sparse lower and upper triangular matrices. This provides a theoretic foundation for further study of the fast algorithm of the numerical solutions of linear equations with the Cauchy matrix as its coefficient matrix. The method does not depend on the selection of the pivot and its arithmetic operations is $O(n^2)$ which is fewer than the existing algorithms."

MR2810806 15A23 65F15

Sidje, Roger B. (1-AL; Tuscaloosa, AL)

On the simultaneous tridiagonalization of two symmetric matrices. (English summary)

Numer. Math. **118** (2011), *no.* 3, 549–566.

Summary: "We discuss congruence transformations aimed at simultaneously reducing a pair of symmetric matrices to tridiagonal-tridiagonal form under the very mild assumption that the matrix pencil is regular. We outline the general principles and propose a unified framework for the problem. This allows us to gain new insights, leading to an economical approach that only uses Gauss transformations and orthogonal Householder transformations. Numerical experiments show that the approach is numerically robust and competitive."

MR2807142 15A24 65F30

Guo, Chun-Hua (3-RGN; Regina, SK)**; Kuo, Yueh-Cheng [Kuo, Yueh-Cheng[1]];**
Lin, Wen-Wei [Lin, Wen Wei] (RC-NTAI; Taipei)

Complex symmetric stabilizing solution of the matrix equation $X + A^{\mathsf{T}}X^{-1}A = Q$. (English summary)

Linear Algebra Appl. **435** (2011), *no.* 6, 1187–1192.

Summary: "We study the matrix equation $X + A^{\mathsf{T}}X^{-1}A = Q$, where A is a complex square matrix and Q is complex symmetric. Special cases of this equation appear in Green's function calculation in nano research and also in the vibration analysis of fast trains. In those applications, the existence of a unique complex symmetric stabilizing solution has been proved using advanced results on linear operators. The stabilizing solution is the solution of practical interest. In this paper we provide an elementary proof of the existence for the general matrix equation, under an assumption that is satisfied for the two special applications. Moreover, our new approach here reveals that

the unique complex symmetric stabilizing solution has a positive definite imaginary part. The unique stabilizing solution can be computed efficiently by the doubling algorithm."

MR2872151 15A24 15B57 65F30

Krishnaswamy, D. (6-ANNA; Annamalainagar)**;**
Punithavalli, G. (6-ANNA-NDM; Annamalainagar)

The skew-symmetric ortho-symmetric solutions of the matrix equations $A^*XA = D$. (English summary)

Int. J. Algebra **5** (2011), *no.* 29-32, 1489–1504.

Summary: "In this paper, the following problems are discussed. Problem 1. Given matrices $A \in C^{n\times m}$ and $D \in C^{m\times m}$, find $X \in SSC_p^n$ such that $A^*XA = D$, where $SSC_p^n = \{X \in SSC^{n\times n}/PX \in SC^{n\times n}$ for given $P \in OC^{n\times n}$ satisfying $P^* = P\}$.

"Problem 2. Given a matrix $\widetilde{X} \in C^{n\times n}$, find $\widehat{X} \in S_E$ such that

$$\|\widetilde{X} - \widehat{X}\| = \inf_{X\in S_E} \|\widetilde{X} - X\|,$$

where $\|\cdot\|$ is the Frobenius norm, and S_E is the solution set of problem 1.

"Expressions for the general solution of problem 1 are derived. Necessary and sufficient conditions for the solvability of Problem 1 are determined. For problem 2, an expression for the solution is given."

MR2870079 15A24 65F30

Wang, Xiang [Wang, Xiang^3] (PRC-NCH; Nanchang)**;**
Dai, Lin (PRC-NCH; Nanchang)**; Liao, Dan** (PRC-NCH; Nanchang)

A modified gradient based algorithm for solving Sylvester equations. (English summary)

Appl. Math. Comput. **218** (2012), *no.* 9, 5620–5628.

Summary: "In this paper a modified gradient based algorithm for solving Sylvester equations is presented. Different from the gradient based method introduced by F. Ding and T. Chen [IEEE Trans. Automat. Control **50** (2005), no. 8, 1216–1221; MR2156053 (2006c:65032)] and the relaxed gradient based algorithm proposed by Q. Niu, X. Wang and L. Z. Lu [Asian J. Control **13** (2011), no. 3, 461–464; MR2830148 (2012h:65081)], the information generated in the first half-iterative step is fully exploited and used to construct the approximate solution. Theoretical analysis shows that the new method converges under certain assumptions. Numerical results are given to verify the efficiency of the new method."

MR2844961 15A24 65F30

Yuan, Yongxin (PRC-UJS-SMP; Zhenjiang)**;**
Jiang, Jiashang (PRC-UJS-SMP; Zhenjiang)

Iterative solutions to the linear matrix equation $AXB + CX^TD = E$. (English summary)

Int. J. Comput. Math. Sci. **6** (2012), 39–42.

Summary: "In this paper the gradient based iterative algorithm is presented to solve the linear matrix equation $AXB + CX^TD = E$, where X is unknown matrix, A, B, C, D, E are the given constant matrices. It is proved that if the equation has a solution, then the unique minimum norm solution can be obtained by choosing a special kind of initial matrices. Two numerical examples show that the introduced iterative algorithm is quite efficient."

MR2856063 15A42 65F15

Nakatsukasa, Yuji (4-MANC-SM; Manchester)

Eigenvalue perturbation bounds for Hermitian block tridiagonal matrices. (English summary)

Appl. Numer. Math. **62** (2012), *no.* 1, 67–78.

Some perturbation bounds for eigenvalues of Hermitian matrices with 2-by-2 block structure and block tridiagonal structure are given. Two examples are presented to demonstrate the sharpness of the approach. *Wen Li*

MR2844786 15A69 15A23 65F05

Oseledets, Ivan [Oseledets, Ivan V.] (RS-AOS-NU; Moscow);
Tyrtyshnikov, Eugene [Tyrtyshnikov, Eugene E.] (RS-AOS-NU; Moscow);
Zamarashkin, Nickolai [Zamarashkin, N. L.] (RS-AOS-NU; Moscow)

Tensor-train ranks for matrices and their inverses. (English summary)

Comput. Methods Appl. Math. **11** (2011), *no.* 3, 394–403.

The authors are concerned with the tensor-train (TT) decompositions of matrices and TT ranks for matrices and their inverses. They prove that the TT decompositions can be derived from certain recursive Kronecker-product representations. Then the authors show that the TT ranks of matrices are intimately related to those of their inverses. In particular, for a banded Toeplitz matrix, they establish an elegant upper bound for the TT ranks of its inverse by using the lower and upper bandwidths of the matrix.

Zhongxiao Jia

MR2835584 15B52 60B20 65F30 68W20

Tropp, Joel A. (1-CAIT-CPM; Pasadena, CA)

Improved analysis of the subsampled randomized Hadamard transform. (English summary)

Adv. Adapt. Data Anal. **3** (2011), *no.* 1-2, 115–126.

Summary: "This paper presents an improved analysis of a structured dimension-reduction map called the subsampled randomized Hadamard transform. This argument demonstrates that the map preserves the Euclidean geometry of an entire subspace of vectors. The new proof is much simpler than previous approaches, and it offers—for the first time—optimal constants in the estimate on the number of dimensions required for the embedding." *Rajat Subhra Hazra*

MR2854878 15B99 15A21 65D17 65F05

Barreras, A. (E-ZRGZ-AMM; Zaragoza);
Peña, J. M. [Peña, Juan Manuel] (E-ZRGZ-AMM; Zaragoza)

Characterizations of Jacobi sign regular matrices. (English summary)

Linear Algebra Appl. **436** (2012), *no.* 2, 381–388.

In this very interesting paper, the authors propose several characterizations of Jacobi nonsingular sign regular (SR) matrices. Specifically, after providing the necessary preliminary results, the authors prove that a nonsingular nonnegative Jacobi matrix A is SR if and only if A is totally positive (TP) of order $n-1$. Thereby they establish that if A is a Jacobi nonsingular matrix, then A is SR if and only if A or $-A$ is TP of order $n-1$.

The main result of the paper provides equivalent characterizations of nonsingular nonnegative Jacobi SR matrices A in terms of properties of specific submatrices of A, and also in terms of the pivots appearing after application of Gaussian elimination (GE) on A. To demonstrate the last argument, the authors take advantage of the fact that the pivot elements appearing after application of GE without pivoting are

given as appropriately selected quotients of leading principal minors of the intermediate matrices that occur during the elimination process when GE can be preformed without row exchanges. Examples indicate that the conditions used in this characterization are optimal, i.e., cannot be improved.

Finally, a computationally cheap algorithm is presented to check if a Jacobi nonsingular matrix is SR. The algorithm utilizes the theoretical results and is robust.

Christos Kravvaritis

MR2848520 26D15 26A45 65D30

Heljiu, Marius Nicolae

On Newton's quadrature formula for mappings of bounded variation. (English summary)

Transylv. J. Math. Mech. **2** (2010), *no.* 2, 153–158.

The author considers a quadrature formula for mappings of bounded variation. An estimation of the remainder for Newton's quadrature formula for mappings of bounded variation is established. Some applications to special means are given.

Allaberen Ashyralyev

MR2871867 26D15 65D30

Masjed-Jamei, Mohammad (IR-KNTU; Tehran)

A linear constructive approximation for integrable functions and a parametric quadrature model based on a generalization of Ostrowski-Grüss type inequalities. (English summary)

Electron. Trans. Numer. Anal. **38** (2011), 218–232.

The author generalizes the Ostrowski-Grüss inequalities by introducing a parameter λ and gives parametric quadrature models with their error bounds. Indeed, let $f(t)$ be a function differentiable in a given interval including $[a,b]$ and let $\lambda \in [1/2,1]$ be a parameter. Let A and B be given by the formulas

$$A = \frac{a+(2\lambda-1)b}{2\lambda} \quad \text{and} \quad B = \frac{b+(2\lambda-1)a}{2\lambda}.$$

The author shows that $f(x)$, where $x \in [A,B] \subset [a,b]$, is approximated by

$$\frac{f(b)-f(a)}{b-a}x + \frac{1}{b-a}\left(\int_a^b f(t)dt + Af(a) - Bf(b)\right)$$

with the error being bounded by

$$\frac{\beta-\alpha}{4(b-a)}\frac{\lambda^2+(1-\lambda)^2}{\lambda}[(x-a)^2+(x-b)^2],$$

where α and β are constants such that $\alpha \le f'(t) \le \beta$ $(t \in [a,b])$. Three cases of $\lambda = 1/2$, $1/\sqrt{2}$ and 1 are studied, respectively, and a sharper version of the inequality given by X.-L. Cheng [Comput. Math. Appl. **42** (2001), no. 1-2, 109–114; MR1834470 (2002e:26018)] is derived from the case $\lambda = 1$. The paper ends with the exhibition of four types of quadrature rules, namely, midpoint, trapezoidal and Simpson rules as well as a rule with a minimal error bound among all cases of λ. *Takemitsu Hasegawa*

MR2821870 26D15 65D30

Vong, Seak Weng [Vong, Seak-Weng]

A note on some Ostrowski-like type inequalities. (English summary)

Comput. Math. Appl. **62** (2011), *no.* 1, 532–535.

In this article Vong improves and extends some recent results of Vu Nhat Huy and Q. A.

Ngô [Appl. Math. Lett. **22** (2009), no. 9, 1345–1350; MR2536811 (2010e:26023); Comput. Math. Appl. **59** (2010), no. 9, 3045–3052; MR2610536 (2011d:26049)]. In general, to evaluate the integral $\int_a^b f(t)dt$ numerically over a real interval $[a,b]$, we consider the values of f at some points $\xi_1,\dots,\xi_n$ on $[a,b]$, and then the integral can be approximated by $\frac{b-a}{n}\sum_{i=1}^n f(\xi_i)$. The relative coordinates of the points $\xi_1,\dots,\xi_n$ are referred to as "knots", i.e., for a point $\xi_i = a + x_i(b-a) \in [a,b]$, x_i is then called the knot [see op. cit.; MR2610536 (2011d:26049)]. By choosing the knots to satisfy $\sum_{i=1}^n x_i^j = \frac{n}{j+1}$, for some integer j, Huy and Ngô [op. cit.; MR2536811 (2010e:26023); op. cit.; MR2610536 (2011d:26049)] discussed a new way to think about some Ostrowski-like type inequalities by enlarging the number of knots involved, and they proved

$$\left|\int_a^b f(x)dx - \frac{b-a}{n}\sum_{i=1}^n f(a+x_i(b-a))\right| \le \frac{2m+5}{4}\frac{(b-a)^{m+1}}{(m+1)!}\left[\sup_{x\in[a,b]} f^{(m)}(x) - \inf_{x\in[a,b]} f^{(m)}(x)\right],$$

provided that $f\colon [a,b]\to\mathbb{R}$ is an m-th differentiable function and $x_1,\dots,x_n$ satisfy $\sum_{i=1}^n x_i^j = \frac{n}{j+1}$, for $j = 1,\dots,m$.

However, Vong improves the above inequality as follows:

$$\left|\int_a^b f(x)dx - \frac{b-a}{n}\sum_{i=1}^n f(a+x_i(b-a))\right| \le \frac{(b-a)^{m+1}}{(m+1)!}\left[\sup_{x\in[a,b]} f^{(m)}(x) - \inf_{x\in[a,b]} f^{(m)}(x)\right].$$

It is easy to see that for any $m \ge 1$ the constant $\frac{2m+5}{4} > 1$, which gives an improvement of the Huy–Ngô inequality.

Finally, an extension of a Huy–Ngô–Ostrowski-like type inequality involving the L_p-norm is also considered. *Mohammad W. Alomari*

MR2846046 30B40 65J20

Xiong, Xiangtuan [Xiong, Xiang Tuan] (PRC-NWNU; Lanzhou)**;**
Zhu, Liqin (PRC-NWNU; Lanzhou)**; Li, Ming** (PRC-TYUT-M; Taiyuan)

Regularization methods for a problem of analytic continuation. (English summary)

Math. Comput. Simulation **82** (2011), *no.* 2, 332–345.

Summary: "In this paper, we prove a sharp stability estimate for the problem of analytic continuation. Based on the obtained stability estimate, a generalized Tikhonov regularization is provided and the corresponding error estimate is obtained. Moreover, we give many other regularization methods. For illustration, a numerical experiment is constructed to demonstrate the feasibility and efficiency of the proposed method."

MR2811951 31C15 31C20 45A05 49J30 65R20

Of, G. [Of, Günther] (A-TGRZ-NM; Graz)**;**
Wendland, W. L. [Wendland, Wolfgang L.] (D-STGT-ANS; Stuttgart)**;**
Zorii, N. [Zoriĭ, N. V.] (UKR-AOS; Kiev)

On the numerical solution of minimal energy problems. (English summary)

Complex Var. Elliptic Equ. **55** (2010), *no.* 11, 991–1012.

Summary: "We study the constructive and numerical solution of minimizing the energy for the Gauss variational problem involving the Newtonian potential. As a special case,

we also treat the corresponding condenser problem. These problems are considered for two two-dimensional compact, disjoint Lipschitz manifolds $\Gamma_j \subset \mathbb{R}^3$, $j = 1, 2$, charged with measures of opposite sign. Since this minimizing problem over an affine cone of Borel measures with finite Newtonian energy can also be formulated as the minimum problem over an affine cone of surface distributions belonging to the Sobolev-Slobodetski space $H^{-\frac{1}{2}}(\Gamma)$, $\Gamma := \Gamma_1 \cup \Gamma_2$, which allows the application of simple layer boundary integral operators on Γ, a penalty approximation for the Gauss variational problem can be used. The numerical approximation is based on a Galerkin-Bubnov discretization with piecewise constant boundary elements. To the discretized problem, the projection-iteration is applied where the matrix times vector operations are executed with the fast multipole method. For the condenser problem, we solve the dual problem which reduces in our case to solving two linear boundary integral equations. Here the fast multipole method provides an efficient solution algorithm. We finally present some convergence studies and error estimates."

MR2863511 33C45 42A10 42C05 65D20

Orel, Bojan (SV-LJUBC; Ljubljana)**; Perne, Andrej** (SV-LJUBELE; Ljubljana)

Computations with half-range Chebyshev polynomials. (English summary)

J. Comput. Appl. Math. **236** (2012), *no.* 7, 1753–1765.

Half-range Chebyshev polynomials of the first kind $\{T_k^h(x)\}$ satisfy the following relations:

$$\int_0^1 T_k^h(x) x^l \frac{1}{\sqrt{1-x^2}}\, dx = 0, \quad l = 0, \ldots, k-1,$$
$$\frac{4}{\pi} \int_0^1 (T_k^h(x))^2 \frac{1}{\sqrt{1-x^2}}\, dx = 1.$$

In other words, these polynomials are orthogonal with respect to the weight $\frac{1}{\sqrt{1-x^2}}$ on the half-interval $[0, 1]$; classical Chebyshev polynomials of the first kind are orthogonal with respect to the same weight, but on the interval $[-1, 1]$. Half-range Chebyshev polynomials of the second kind $\{U_k^h(x)\}$ satisfy the same relations with $\sqrt{1-x^2}$ instead of $\frac{1}{\sqrt{1-x^2}}$. Note that after a linear change of variable, these polynomials are essentially orthogonal polynomials for modified Jacobi weight functions of the form $h(z)(1-z)^\alpha(1+z)^\beta$.

In this paper the authors describe the particularization to these polynomials of an efficient algorithm due to J. C. Wheeler for computing orthogonal polynomials [Rocky Mountain J. Math. **4** (1974), 287–296; MR0334466 (48 #12785)].

In [SIAM J. Numer. Anal. **47** (2010), no. 6, 4326–4355; MR2585189 (2010m:42004)] D. Huybrechs discussed the following problem: given a function $f \in L^2_{[-1,1]}$, find the best approximation to f in $L^2_{[-1,1]}$ by 4-periodic functions of the form

$$\frac{a_0}{2} + \sum_{k=1}^{n} \left(a_k \cos \frac{\pi k x}{2} + b_k \sin \frac{\pi k x}{2} \right).$$

For a fixed n, the solution comes in terms of half-range Chebyshev-Fourier truncated series, that is,

$$g_n(x) = \sum_{k=0}^{n} a_k T_k^h(\cos \frac{\pi x}{2}) + \sum_{k=0}^{n-1} b_k U_k^h(\cos \frac{\pi x}{2}) \sin \frac{\pi x}{2}.$$

Motivated by the construction of spectral methods for the solution of differential equations using half-range Chebyshev polynomials, the authors are interested in the deriv-

atives and multiplications of these truncated series. They find that, given g_n as before with coefficients $u = (a_0, \dots, a_n, b_0, \dots, b_{n-1})^T$, its derivative is another truncated series with coefficients $u' = (a'_0, \dots, a'_n, b'_0, \dots, b'_{n-1})^T$. The authors find a matrix relation $u' = Du$, where D is block antidiagonal:

$$D = \frac{\pi}{2} \begin{bmatrix} 0 & H_1 \\ H_2 & 0 \end{bmatrix},$$

H_1 and H_2 being explicitly given $(n+1) \times n$ and $n \times (n+1)$ matrices, respectively. A matrix expression is given also for the coefficients of a product of two such truncated series. *Mario Pérez Riera*

MR2863528 33E05 33F05 65D20

Fukushima, Toshio (J-NAOJ; Mitaka)

Precise and fast computation of a general incomplete elliptic integral of third kind by half and double argument transformations. (English summary)

J. Comput. Appl. Math. **236** (2012), *no.* 7, 1961–1975.

This paper shows a method to compute Legendre's incomplete elliptic integral of the third kind,

$$\Pi(\varphi, n|m) \equiv \int_0^{\varphi} \frac{d\theta}{(1 - n\sin^2\theta)\sqrt{1 - m\sin^2\theta}},$$

where φ, n, m are the amplitude, characteristic, and parameter, respectively. $\Pi(\varphi, n|m)$ appears in describing gravitational and/or electromagnetic fields. A calculation problem—a round-off error— exists when $|m|$ and/or $|n|$ are small.

The author introduces a linear combination of two integrals in place of $\Pi(\varphi, n|m)$ itself:

$$J(\varphi, n|m) \equiv \frac{\Pi(\varphi, n|m) - F(\varphi|m)}{n} = \int_0^{\varphi} \frac{\sin^2\theta d\theta}{(1 - n\sin^2\theta)\sqrt{1 - m\sin^2\theta}},$$

where

$$F(\varphi|m) \equiv \int_0^{\varphi} \frac{d\theta}{\sqrt{1 - m\sin^2\theta}}.$$

If $F(\varphi|m)$ and $J(\varphi, n|m)$ are known, $\Pi(\varphi, n|m)$ is computable from them without suffering from the smallness of $|n|$:

$$\Pi(\varphi, n|m) = F(\varphi|m) + nJ(\varphi, n|m).$$

In past studies there have been formulations of calculating the associated integral $J(\varphi, n|m)$ such as "Bulirsch's procedure", "Carlson's formulation" and so on. However, these methods also have the round-off error problem and/or computational time problem. The author develops a new method to overcome these problems, in which key techniques are (i) the combination of half argument formulas of the sine and cosine amplitude functions, (ii) the truncated Maclaurin series expansion of the integral with respect to the sine amplitude, and (iii) the double argument formula of the integral. The new procedure is precise in the sense that the maximum relative errors are less than 20 machine epsilons and 1.5–3.7 times faster than Carlson's one. *Ben T. Nohara*

MR2869045 33E05 33F05 65D20

Fukushima, Toshio (J-NAOJ; Mitaka)

Series expansions of symmetric elliptic integrals. (English summary)

Math. Comp. **81** (2012), *no.* 278, 957–990.

The aim of this article is to resolve the issue of slow convergence of series expansions

of elliptic integrals. The author develops several new series expansions by using the symmetric nature of Carlson's elliptic integrals. In Section 2 several aspects are treated: (1) 15 series expansions are provided. Four of them are essentially the same as given in the literature and the other eleven are new. In Section 3, the effectiveness of these series expansions is discussed. (2) Four appropriate expansions are chosen among the 30 obtained and the rule to select the best series expansion is specified analytically from the four candidates. (3) An effective approach is shown to compute the complete integrals by way of the incomplete ones. (4) Algorithms are presented to evaluate the complete and incomplete integrals, respectively. Finally, in Section 4 some results of numerical experiments to confirm the effectiveness of the developed series expansions are given. *Daniele Ritelli*

MR2855280 33E10 26D15 33E20 40A25 65B15

Zastavnyĭ, V. P. (UKR-DONE; Donetsk)

Inequalities for Mathieu series and positive definiteness. (Russian. English and Russian summaries)

Anal. Math. **37** (2011), *no.* 4, 289–318.

Consider the series

$$S_\mu(t,u)=\sum_{k=1}^{\infty}{}'\frac{2(k+u)}{((k+u)^2+t^2)^{\mu+1}},$$

where $\mu>0$, $u,t\in\mathbb{R}$. Prime means that for $-u\in\mathbb{N}$ the term for $k=-u$ in the sum is omitted. The results of the paper are certain inequalities for $s_\mu(t,u)$ valid for all $t>0$. Specifically, estimates for $|S_\mu(t,u)-\frac{1}{\mu(p^2+t^2)^\mu}|$ and $(\mu S_\mu(t,u))^{-1/\mu}-t^2$ are given.

Aleksander Denisiuk

MR2862672 33E30 33C47 41A30 65N35

Zhang, Jing (SGP-NANT-MPM; Singapore)**;**
Wang, Li-Lian (SGP-NANT-MPM; Singapore)

On spectral approximations by generalized Slepian functions. (English summary)

Numer. Math. Theory Methods Appl. **4** (2011), *no.* 2, 296–318.

In this paper, the authors explore a generalization of the prolate spheroidal wave (or Slepian, according to the authors) functions [D. Slepian, Bell System Tech. J. **43** (1964), 3009–3057; MR0181766 (31 #5993)]. These functions form a complete orthogonal system in $L^2_\omega(-1,1)$, where $\omega(x)=(1-x)^\alpha$, $\alpha>-1$.

The authors present various analytic properties and study spectral approximations by such functions. *Diego E. Dominici*

MR2882293 34A08 37M99 65L05

Wang, Mao [Wang, Mao^2] (PRC-HIT-SCN; Harbin)**;**
Sun, Guang Hui (PRC-HIT-SCN; Harbin)**; Wei, Yan Ling** (PRC-HIT-SCN; Harbin)

Limitations of frequency domain approximation in the calculation of fractional-order chaotic systems. (Chinese. English and Chinese summaries)

J. Harbin Inst. Tech. **43** (2011), *no.* 5, 8–12.

This paper is concerned with frequency domain analysis of fractional chaotic systems. Based on the frequency response of the fractional integral operator, the authors analyze the limitations of the frequency domain approximation algorithm in the calculation of fractional chaotic systems and show that the frequency domain approximation algorithm can approach the original system in the desired frequency band, but in the low- and high-frequency bands there are large errors, which limits its applications in the calculation

of fractional chaotic systems. The effectiveness of the result is illustrated on simulation examples. The problem of how to overcome the limitations of the frequency domain approximation algorithm applied to fractional chaotic systems remains open.

Shu Rong Sun

MR2855624 34A08 26A33 45J05 65L05

Xu, Yufeng (PRC-CSU-AM; Changsha)**;**
He, Zhimin [He, Zhi Min[1]] (PRC-CSU-AM; Changsha)

The short memory principle for solving Abel differential equation of fractional order. (English summary)

Comput. Math. Appl. **62** (2011), *no.* 12, 4796–4805.

Existence and uniqueness theorems for first-order initial value problems for ordinary differential equations of the type

$$y' = f(x, y), \quad y(x_0) = y_0$$

are well known. In this paper, besides discussing numerical approximate solutions, the authors discuss existence and uniqueness theorems for initial value problems for fractional differential equations of the type

$${}_aD_x^{\alpha} y(x) = f(x, y), \quad D_0^{\alpha-k} y(0) = b_k, \quad k = 0, 1, 2, \ldots, m-1.$$

In particular they employ the short-memory principle (SMP) for numerically solving the Abel fractional differential equation of order α, $0 < \alpha < 1$, viz. $D^{\alpha} y(x) = ay^3 + by^2 + cy + d$, $y(0) = 0$, where a, b, c, d are analytic functions of x, and D^{α} is the fractional derivative in the sense of Grünwald-Letnikov:

$${}_aD_x^{\alpha} f(x) = \lim_{N\to\infty} \frac{1}{\alpha^k} \sum_{k=0}^{N} (-1)^k \binom{\alpha}{k} f(x - kh_N),$$

where $h_N = (k-a)/N$, $\alpha > 0$, $f \in C^m[a, b]$, $a < x < b$ and m is the smallest natural number larger than α.

The term SMP means taking into account the behaviour of $y(x)$ in the recent past. The principle is similar to the principle of initialisation discussed by C. F. Lorenzo and T. T. Hartley in their paper [Int. J. Appl. Math. **3** (2000), no. 3, 249–265; MR1783745 (2001i:26004)], where they took into account the behaviour of $y(x)$ from $-\infty$ to c, the point of initialisation. To illustrate the numerical procedure and its efficiency, four examples are given using Matlab.

This is a beautiful paper on the latest trend in fractional calculus. *B. P. Parashar*

MR2869043 34A09 65L80 94C05 94C15

Iwata, Satoru (J-KYOT-R; Kyoto)**; Takamatsu, Mizuyo** (J-CHUO-IS; Bunkyo)**;**
Tischendorf, Caren (D-KOLN; Cologne)

Tractability index of hybrid equations for circuit simulation. (English summary)

Math. Comp. **81** (2012), *no.* 278, 923–939.

Summary: "Modern modeling approaches for circuit simulation such as the modified nodal analysis (MNA) lead to differential-algebraic equations (DAEs). The index of a DAE is a measure of the degree of numerical difficulty. In general, the higher the index is, the more difficult it is to solve the DAE.

"In this paper, we consider a broader class of analysis methods called the hybrid analysis. For nonlinear time-varying circuits with general dependent sources, we give a structural characterization of the tractability index of DAEs arising from the hybrid analysis. This enables us to determine the tractability index efficiently, which helps to avoid solving higher index DAEs in circuit simulation." *Kai Bittner*

MR2864505 34B20 34A55 34L40 65L09

Fritzsche, B. (D-LEIPMI-MI; Leipzig);
Kirstein, B. [**Kirstein, Bernd**] (D-LEIPMI-MI; Leipzig);
Roitberg, I. Ya. [**Roitberg, Inna**] (D-LEIPMI-MI; Leipzig);
Sakhnovich, A. L. (A-WIENM; Vienna)

Recovery of the Dirac system from the rectangular Weyl matrix function. (English summary)

Inverse Problems **28** (2012), *no.* 1, 015010, 18 *pp.*

The authors consider the Dirac-type system

$$y' = i\{zJ + JV(x)\}y,$$

on the half-line $[0, \infty)$, where

$$J = \begin{pmatrix} I_{m_1} & 0 \\ 0 & -I_{m_2} \end{pmatrix}, \quad V(x) = \begin{pmatrix} 0 & v(x) \\ v^*(x) & 0 \end{pmatrix},$$

I_{m_k} is the $m_k \times m_k$ identity matrix, v is the $m_1 \times m_2$ matrix with entries from the space of measurable and locally summable functions, $y = y(x, z)$ is an $(m_1 + m_2) \times (m_1 + m_2)$ matrix and z is the spectral parameter.

Weyl theory and spectral theory of such a system have been well studied in the case $m_1 = m_2$. In this paper, the authors investigate the case $m_1 \neq m_2$. It is proved that the Weyl function of the Dirac system, which is analytic and non-expansive on $\mathbf{C}_+$, is well defined and the potential v is uniquely reconstructed from the Weyl function.

The authors also give conditions which are sufficient for a non-expansive and analytic matrix function on $\mathbf{C}_+$ to be the Weyl function of the Dirac system with some potential v. *Michiyuki Watanabe*

MR2895768 34K07 26E25 34K28 65M99

Devi, J. Vasundhara [**Vasundhara Devi, J.**] (6-GVPCE-IAS; Visakhapatnam);
Naidu, Ch. Appala

Approximate and Euler solutions for set differential equation involving causal operators with memory. (English summary)

Dyn. Contin. Discrete Impuls. Syst. Ser. A Math. Anal. **18** (2011), *no.* 6, 783–795.

Set differential equations generalize the concept of ordinary differential equations. Their solutions are set-valued functions defined from a real interval into the metric space of compact subsets of $\mathbb{R}^n$ such that their Hukuhara derivative satisfies the set differential equation.

The authors consider approximate solutions and Euler trajectories of set differential equations with memory involving nonanticipative operators, where the Euler trajectories are defined as uniform limits of polygonal arcs. *Janosch Rieger*

MR2867994 35-02 35A02 35J57 65N30 74A45 74F05 74R10

Yosibash, Zohar (IL-BGUN-ME; Be'ér Sheva')

★**Singularities in elliptic boundary value problems and elasticity and their connection with failure initiation.**

Interdisciplinary Applied Mathematics, 37.
Springer, *New York*, 2012. *xxii*+459 *pp.* €96.25. *ISBN* 978-1-4614-1507-7

This book deals with the singularities of two-dimensional elliptic problems and linear elasticity, occurring in the vicinity of nonsmooth boundary points, namely crack-tip singularities and multi-material interfaces; see Chapter 1 for an overview. The solution is uniquely characterized by an asymptotic series of eigenfunctions and associated coefficients called eigenvalues. Usually, the computation of these eigenpairs and the

derived generalized intensity factors cannot be carried out by means of analytical techniques. This major drawback is overcome by numerical computations based on the *p*-version of the finite element method; see Chapter 2. A comparison between the numerical coefficients and experimental observations proves that the procedure is efficient and accurate.

Chapter 2 provides all the necessary material about *p*- and *hp*-versions of the finite element method, which will be used in the sequel to compute eigenpairs and generalized flux and stress intensity factors that characterize the asymptotic expansions.

Chapters 3 and 5 discuss the asymptotic solution of linear second-order elliptic partial differential equations in the vicinity of singular points. Numerical procedures are developed to compute the characteristic unknowns, the so-called eigenpairs. The method discussed in Chapter 3, namely the modified Steklov method, is general, that is, applicable to singularities associated with corners and anisotropic, multi-material interfaces. Singular points associated with the linear theories of heat transfer and elasticity are discussed in Chapters 3 and 5 respectively. Exact solutions for model problems consisting of crack tips, wedge corners of different angles and materials, and internal multi-material interfaces in isotropic and anisotropic materials are described in detail. Both the generalized flux and stress intensity factors and the eigenfunctions are explicitly presented in Chapters 4 and 5 respectively. The efficiency, robustness and accuracy of new numerical methods derived from the *p*-version of the finite element method are proved on the basis of the benchmark problems.

Chapter 6 presents a method for the extraction of the coefficients of the asymptotic expansion, namely the generalized stress intensity factors (GSIFs), once the eigenpairs are available; see Chapter 5. The stress intensity factors in the two-dimensional linear theory of elasticity are related to the amount of energy residing in the natural straining modes. In Chapter 6, it is shown that accurate computation of stress intensity factors is possible using a post-processing scheme over a small subdomain. It is proved that by using the weak complementary formulation, the Steklov method and the *p*-version of the finite element method, the GSIFs can be computed with high accuracy. The contour integral method is presented in §6.1. This efficient superconvergent procedure is based on the construction of a path independent contour integral and on the orthogonality of dual and primal eigenfunctions. The complementary energy method of §6.2 provides an alternative. Numerical examples are worked out in §6.3 on the basis of three model problems, namely a crack in an isotropic material in §6.3.1, a crack between two different materials in §6.3.2 where complex eigenpairs appear, and a nearly incompressible L-shaped domain in §6.3.3.

Chapter 7 deals with thermal generalized stress intensity factors (TGSIFs) in two-dimensional domains. The TGSIFs in linear thermo-elastic two-dimensional problems are computed when the steady-state temperature distribution is complicated by singular points. In the vicinity of the singular points, the stress tensor displays singular behaviour manifested by the strength of the singularity and the associated thermal generalized stress intensity factors. As explained in §7.1, the temperature field is computed by the *p*-version of the finite element method. The resulting singular fluxes are used as thermal loading in the elasticity analysis to get the required TGSIFs. This post-processing technique is based on the complementary weak formulation combined with Richardson extrapolation. Numerical examples for crack-tip singularities and singularities associated with multi-material interfaces are presented in §7.2. All experiments allow one to extract accurate TGSIFs, although the integration radii may be large. Moreover, it does not require strong mesh refinement around the singularity point, which proves the efficiency of the numerical method.

Chapter 8 addresses the problem of failure criteria for brittle elastic materials. In

§8.1, the validity of several known failure criteria under mode I loading is examined. The failure criterion proposed by Novozhilov (1969) and expanded by Seweryn (1994) is reviewed in §8.1.1. It suggests considering the average normal stress along the anticipated path of the failure. More recently, the Novozhilov-Seweryn failure criterion has been extended to mixed mode failure by Seweryn and Łukasiewicz (2002), the validity of which compared to other failure criteria in predicting the failure load and direction is demonstrated when compared with experimental observations. Leguillon (2001, 2002) proposed a criterion for a failure initiation crack at a sharp V-notch based on the combination of the Griffith energy criterion for a crack and the strength criterion for a straight edge; see §8.1.2. Dunn et al. (1997) proposed using the V-notch generalized stress intensity factor as the single parameter to be correlated to failures. The proposed SED criterion of §8.1.4 is more similar to the Dunn criteria of §8.1.3 in terms of the needed values of the critical SED for a large range of opening angles. Since V-notched reentrant corners are an unrealistic model, the author follows a detailed experimental procedure, focusing on the dependence upon V-notch tip radii. Under the assumption that the V-notch is sharp, it is shown in §8.3 that some failure criteria provide a reasonably good prediction of experimental observations, although corrections are needed to take into account the realistic radius at the notch tip. A cause of this discrepancy can be that a small notch tip radius blunts the sharp corner. It is analysed in §8.4 by means of matched asymptotics at the rounded V-notch tip involving two small parameters, namely a micro-crack increment length and the notch tip radius. This analysis provides also the threshold value of the V-notch tip radius that does not influence the failure criteria. Without new developments, it allows the stress intensity factor at the tip of a short crack emanating from a sharp or a rounded V-notch to be determined.

Chapter 9 deals with thermo-mechanical failures occurring in the passivation layer of micro-electronic devices initiated by cracks at keyhole corners. In §9.1 a strain energy density criterion based on an average value of the elastic strain energy in the vicinity of a reentrant corner at any angle is described. Prior to the validation of the failure criterion by a test in §9.3, the parameters and material properties are analysed in §9.2, namely the passivation thickness in §9.2.1 and metal lines height in §9.2.2. The computation of the SED criterion in §9.3 requires the construction of a p-FEM method; see §9.3.1.

Chapter 10 is concerned with the resolution of the scalar heat conduction equation in polyhedral domains. Along any given edge, singular solutions are characterized by an exponent α from a discrete set of eigenvalues depending on the geometry of the domain and featuring the non-smoothness of the singularity, an associated eigenfunction. Notice that in the local cylindrical coordinates, eigenpairs are independent of coordinate x_3 along the edge as solutions of an equivalent two-dimensional problem; see §10.1. The dependence of the singularity along the edge is taken into account by a multiplying function defined along the edge called the edge-flux-intensity function (EFIF). From the physical point of view, it represents the contribution of the singularity to the local amount of energy. The complete expansion of the solution in the vicinity of an edge is described in §10.2 as a combination of eigenfunctions and their shadows; see §10.2.1. These shadows are new functions characteristic of three-dimensional domains and having no counterpart in the two-dimensional case in the heat conduction problem under consideration. There exists also a sequence of dual eigenfunctions and their dual shadows; see §10.2.2–§10.2.3 and §10.3 for the Dirichlet and Neumann boundary conditions respectively. Their explicit knowledge is required in the quasi-dual function method for the computation of the EFIFs; see below.

Chapter 11 addresses the problem of extracting EFIFs associated with polyhedral domains. The asymptotic expansion of the solution to the Laplace operator in three-dimensional domains is performed in the vicinity of straight edges. It involves eigen-

pairs with their coefficients representing EFIFs. A method based on L^2-projection and Richardson extrapolation is presented in §11.1 for point-wise extraction of EFIFs from p-finite element solutions (see §11.1.1) and illustrated by numerical experiments in §11.1.2. Similarly but more efficiently, the energy projection method of §11.2 requires integration over a one-dimensional circular arc, unlike the above-mentioned L^2-projection method running with two-dimensional integration. The explicit structure of the solution in the vicinity of the edge is used in §11.3 to extract the EFIFs by a new method, namely the quasi-dual function method, which may be interpreted as an extension of the dual function contour method in two-dimensional domains and involves the computation of a surface integral $J[R]$ along a cylindrical surface of radius R away from the edge as presented in §11.3.1. To that aim, the surface integral $J[R]$ uses a special class of extraction polynomials (see §11.3.2) together with the dual eigenfunctions. This method provides a polynomial approximation of any EFIF along the edge at adaptively high order. It is implemented as a post-solution operation in conjunction with the p-version finite element method. Analytical solutions of §11.3.3 are used as a benchmark in subsequent numerical experiments of §11.3.4–§11.3.6.

Chapter 12 deals with vertex singularities for the three-dimensional Laplace equation. The analytical solution is first computed in the vicinity of axisymmetric conical points for the canonical Dirichlet and Neumann problems with a graph describing the behaviour of the eigenvalues for different opening angles ω. The modified Steklov method is presented in §12.2 in the context of two-dimensional problems for the computation of eigenpairs associated with vertex singularities of the Laplace equation. The resulting numerical methods are compared with the analytical solutions for conical vertices of §12.1 to determine their convergence rate. In §12.2, the weak formulation of the eigenvalue problem, that is, the so-called weak Steklov problem, is addressed to be suitable for p- and spectral finite element discretization. This method is aimed at computing the eigenpairs in a very efficient and accurate manner and may be generalized for multi-material interfaces and elasticity operators; see §12.4. Numerical examples are considered in §12.3. More precisely, two problems are first considered in §12.3.1 and §12.3.2 for which eigenpairs were provided in §12.1 to demonstrate the accuracy and efficiency of the numerical methods under consideration. Two more complicated example problems follow in §12.3.3 and §12.3.4 for which analytical results are unavailable.

In the vicinity of an edge where two flat planes intersect, therefore allowing one to define local plane cylindrical coordinates (r, θ, x_3) and expand the solution in powers of the radial coordinate r where exponents are called the eigenvalues with associated eigenfunction depending on the angular coordinate and defined in the local plane $x_3 = 0$. As the vertical coordinate x_3 varies, the eigenpair is multiplied by a coefficient called the edge stress intensity factor (ESIF). Note that this ESIF is actually normalized with respect to the local plane $x_3 = 0$. The three-dimensional case is more involved as each eigenvalue is characterized by an eigenpair and an additional shadow function. Chapter 13 is devoted to the computation of edge eigenpairs in three-dimensional linear elasticity, especially extracting edge stress intensity functions along a given straight edge, possibly including anisotropic, multi-material interfaces.

Using the numerically computed eigen- and shadow functions as well as their duals, the author uses the functional $J[R]$ to compute the ESIF explicitly as a function of the x_3 coordinate along the edge. The $J[R]$ computation is a post-processing step in a p-version finite element code. The accuracy and efficiency of the extraction are verified in two numerical examples in a cracked and in a V-notched domain respectively. Finally, an engineering example is considered for which a description of a so-called compact tension specimen is required.

The problem is complicated by considerations of anisotropic and multi-material in-

terfaces. Indeed, a new extraction method, namely the quasi-dual function method, is applied to perform the polynomial approximation of the complex ESIFs and eventually complete the mathematical algorithm for the construction of the asymptotic solution in the vicinity of an edge. The quasi-dual function method extends to the three-dimensional case the already known dual function method, which is valid in two dimensions. Two numerical examples are displayed. The first one deals with the interface of two isotropic materials and is based on the analytical computation of the dual eigenfunctions and their dual shadows. In the second, anisotropic example, the compact tension specimen is described. As the eigenfunctions, their shadows and the dual eigen- and shadow functions cannot be computed analytically, numerical methods are required, namely p-FEMs, to take advantage of the symmetry and of the exponential convergence rate.

Chapter 14 deals with recent results about three-dimensional circular edges. The axisymmetric Laplace problem is handled first because the geometrical assumption avoids otherwise tedious computations. The elasticity and the general Laplace problem are more involved and therefore treated afterwards. The last paragraph deals with open questions both in the theoretical and engineering fields.

Appendices A to F are devoted to some useful mathematical material, namely, in Appendix A, the norm-based Sobolev functional framework is chosen in accordance with energetic considerations, the need for statically admissible spaces and the computational requirements of the FEM method. Analytical solutions to scalar elliptic problems in plane anisotropic domains are computed in Appendix B with an insight into coupled materials. The influence of the boundary conditions must be analysed. The developments of Appendix B are illustrated by an example. In Appendix C the plane Laplace problem at the intersection of circular edges classically leads to an asymptotic study with respect to a smoothing parameter. In Appendix D the eigenvalues of scalar anisotropic elliptic boundary value problems with constant coefficients are proved to be real. They are orthogonally distributed in the two-dimensional general scalar case as shown in Appendix E, where a path-independent integral is also introduced. Appendix F deals with the energy release rate method based on both the energy and the potential energy, thus introducing the Griffith energy criterion, which is classically involved in the failure of brittle materials. The relation with stress-intensity factors is discussed under various assumptions on loading, namely, symmetric loading, antisymmetric loading and their combination. The stiffness derivative method is developed with a special insight into the three-dimensional case. To conclude Appendix F, the J-integral is revisited in connection with the above-mentioned energy release rate method to generalize the concept, which was developed in 1967 by Cherepanov and in 1968 by Jim Rice independently.

Isabelle Gruais

MR2861243 35B27 35J25 65M60 65N30

Owhadi, Houman (1-CAIT-CPM; Pasadena, CA)**;**
Zhang, Lei [Zhang, Lei[13]] (4-OX; Oxford)

Localized bases for finite-dimensional homogenization approximations with nonseparated scales and high contrast. (English summary)

Multiscale Model. Simul. **9** (2011), *no.* 4, 1373–1398.

Summary: "We construct finite-dimensional approximations of solution spaces of divergence-form operators with L^∞-coefficients. Our method does not rely on concepts of ergodicity or scale-separation, but on the property that the solution space of these operators is compactly embedded in H^1 if source terms are in the unit ball of L^2 instead of the unit ball of H^{-1}. Approximation spaces are generated by solving elliptic PDEs on localized subdomains with source terms corresponding to approximation

bases for H^2. The H^1-error estimates show that $\mathcal{O}(h^{-d})$-dimensional spaces with basis elements localized to subdomains of diameter $\mathcal{O}(h^\alpha \ln \frac{1}{h})$ (with $\alpha \in [\frac{1}{2}, 1)$) result in an $\mathcal{O}(h^{2-2\alpha})$ accuracy for elliptic, parabolic, and hyperbolic problems. For high-contrast media, the accuracy of the method is preserved, provided that localized subdomains contain buffer zones of width $\mathcal{O}(h^\alpha \ln \frac{1}{h})$, where the contrast of the medium remains bounded. The proposed method can naturally be generalized to vectorial equations (such as elasto-dynamics)."

MR2860412 35B27 35J25 65N30 74Q05

Schweizer, Ben (D-DTUM; Dortmund)**; Veneroni, Marco** (3-MGL; Montreal, QC)

The needle problem approach to non-periodic homogenization. (English summary)

Netw. Heterog. Media **6** (2011), *no.* 4, 755–781.

Summary: "We introduce a new method to homogenization of non-periodic problems and illustrate the approach with the elliptic equation $-\nabla \cdot (a^\varepsilon \nabla u^\varepsilon) = f$. On the coefficients a^ε we assume that solutions u^ε of homogeneous ε-problems on simplices with average slope $\xi \in \mathbb{R}^n$ have the property that flux-averages $\fint a^\varepsilon \nabla u^\varepsilon \in \mathbb{R}^n$ converge, for $\varepsilon \to 0$, to some limit $a^*(\xi)$, independent of the simplex. Under this assumption, which is comparable to H-convergence, we show the homogenization result for general domains and arbitrary right hand side. The proof uses a new auxiliary problem, the *needle problem*. Solutions of the needle problem depend on a triangulation of the domain, they solve an ε-problem in each simplex and are affine on faces." *Srinivasan Natesan*

MR2843918 35J05 31B35 35A35 41A30 65N99

Moiola, A. [**Moiola, Andrea**] (CH-ETHZ-AM; Zürich)**;**
Hiptmair, R. [**Hiptmair, Ralf**] (CH-ETHZ-AM; Zürich)**; Perugia, I.** (I-PAVI; Pavia)

Plane wave approximation of homogeneous Helmholtz solutions. (English summary)

Z. Angew. Math. Phys. **62** (2011), *no.* 5, 809–837.

The authors study the approximation of solutions of the homogeneous Helmholtz equation $\Delta u + \omega^2 u = 0$ in $\mathbb{R}^N$ with constant coefficients and wave number $\omega > 0$ by linear combinations of plane waves with different directions. They combine approximation estimates for homogeneous Helmholtz solutions by generalized harmonic polynomials with approximation estimates of generalized harmonic polynomials by plane waves. The first estimates are obtained by using Vekua's theory and the second ones by establishing best approximation error estimates in Sobolev norms, which are explicit in terms of the degree of the generalized polynomial to be approximated, the domain size, and the number of plane waves used in the approximations. *Michele Campiti*

MR2806074 35J20 35B25 35B65 65N99

Blass, Timothy (1-TX; Austin, TX)**; de la Llave, Rafael** (1-TX; Austin, TX)

Perturbation and numerical methods for computing the minimal average energy. (English summary)

Netw. Heterog. Media **6** (2011), *no.* 2, 241–255.

Summary: "We investigate the differentiability of minimal average energy associated to the functionals $S_\varepsilon(u) = \int_{\mathbb{R}^d} \frac{1}{2}|\nabla u|^2 + \varepsilon V(x,u)\,dx$, using numerical and perturbative methods. We use the Sobolev gradient descent method as a numerical tool to compute solutions of the Euler-Lagrange equations with some periodicity conditions; this is the cell problem in homogenization. We use these solutions to determine the average minimal energy as a function of the slope. We also obtain a representation of the solutions to the Euler-Lagrange equations as a Lindstedt series in the perturbation parameter ε ,

and use this to confirm our numerical results. Additionally, we prove convergence of the Lindstedt series."

MR2863477 35J25 35A35 35B20 35J05 65N99
Di Costanzo, E. (I-ROME-BAE; Rome)**;**
Marasco, A. [**Marasco, Addolorata**] (I-NAPL-AM; Naples)
Approximate analytic solution of the Dirichlet problems for Laplace's equation in planar domains by a perturbation method. (English summary)
Comput. Math. Appl. **63** (2012), *no.* 1, 60–67.

Summary: "In this paper, we propose a regular perturbation method to obtain approximate analytic solutions of exterior and interior Dirichlet problems for Laplace's equation in planar domains. This method, starting from a geometrical perturbation of these planar domains, reduces our problems to a family of classical Dirichlet problems for Laplace's equation in a circle. Numerical examples are given and comparisons are made with the solutions obtained by other approximation methods."

MR2839012 35J25 35A35 35B51 65N15
Pauly, Dirk (D-DUES2-NDM; Essen)**;**
Repin, Sergei [**Repin, S. I.**] (RS-AOS2; St. Petersburg)
Functional a posteriori error estimates for elliptic problems in exterior domains. (English summary)
Problems in mathematical analysis. No. 42.
J. Math. Sci. (N. Y.) **162** (2009), *no.* 3, 393–406.

Summary: "This paper is concerned with the derivation of computable and guaranteed upper bounds of the difference between the exact and approximate solutions of an exterior domain boundary value problem for a linear elliptic equation. Our analysis is based upon purely functional argumentation and does not attract specific properties of an approximation method. Therefore, the estimates derived in the paper at hand are applicable to any approximate solution that belongs to the corresponding energy space. Such estimates (also called error majorants of functional type) were derived earlier for problems in bounded domains of RN."

MR2906229 35J65 35J05 65R20
Cheng, Pan (PRC-CQJU-SSC; Chongqing)**;**
Huang, Jin [**Huang, Jin[1]**] (PRC-EST-SM; Chengdu)**;**
Wang, Zhu [**Wang, Zhu[2]**] (PRC-EST-SM; Chengdu)
Mechanical quadrature methods and extrapolation for solving nonlinear boundary Helmholtz integral equations. (English summary)
Appl. Math. Mech. (English Ed.) **32** (2011), *no.* 12, 1505–1514.

Summary: "This paper presents mechanical quadrature methods (MQMs) for solving nonlinear boundary Helmholtz integral equations. The methods have high accuracy of order $O(h^3)$ and low computation complexity. Moreover, the mechanical quadrature methods are simple without computing any singular integration. A nonlinear system is constructed by discretizing the nonlinear boundary integral equations. The stability and convergence of the system are proved based on an asymptotical compact theory and the Stepleman theorem. Using the h^3-Richardson extrapolation algorithms (EAs), the accuracy to the order of $O(h^5)$ is improved. To solve the nonlinear system, the Newton iteration is discussed extensively by using the Ostrowski fixed point theorem. The efficiency of the algorithms is illustrated by numerical examples."

MR2850433 35K20 35L20 65M60
He, Siriguleng (PRC-INMO-SM; Hohhot)**;**
Li, Hong [Li, Hong[7]] (PRC-INMO-SM; Hohhot)**; Liu, Yang** (PRC-INMO-SM; Hohhot)
The time discontinuous finite element method for evolution equations. (Chinese. English and Chinese summaries)
Adv. Math. (*China*) **40** (2011), *no.* 5, 513–530.
Summary: "Unifying the space and time variables, space-time finite element method overcomes the low order accuracy in traditional finite element method caused by the difference discrete in time. This method has high-order accuracy in space and time directions, good dissipation on unstructured mesh, unconditional stability. Thus it becomes an efficiency method for the problems dependent on time. In this paper, the basic conceptions and formulations of the space-time finite element method, discontinuous in time and continuous in space, are given by a general parabolic model problem. The numerical simulation results for parabolic equations, integral-differential equations, hyperbolic problems, Sobolev equations and other high order equations are given to illustrate the stability and accuracy. The development and applied foreground are discussed for the time discontinuous space-time finite element method."

MR2846183 35K40 35K55 65N08
Ševčovič, Daniel (SK-KMSKMI-IM; Bratislava)**;**
Yazaki, Shigetoshi (J-MYZE-NDM; Miyazaki)
Evolution of plane curves with a curvature adjusted tangential velocity. (English summary)
Jpn. J. Ind. Appl. Math. **28** (2011), *no.* 3, 413–442.
Summary: "We study evolution of a closed embedded plane curve with the normal velocity depending on the curvature, the orientation and the position of the curve. We propose a new method of tangential redistribution of points by curvature adjusted control in the tangential motion of evolving curves. The tangential velocity may not only distribute grid points uniformly along the curve but also produce a suitable concentration and/or dispersion depending on the curvature. Our study is based on solutions to the governing system of nonlinear parabolic equations for the position vector, tangent angle and curvature of a curve. We furthermore present a semi-implicit numerical discretization scheme based on the flowing finite volume method. Several numerical examples illustrating capability of the new tangential redistribution method are also presented in this paper."

MR2861584 35K51 35B35 35K91 35Q91 65M60 91D10 92C17
Burger, Martin (D-MUNS-NAM; Münster)**;**
Markowich, Peter Alexander (4-CAMB-A; Cambridge)**;**
Pietschmann, Jan-Frederik (4-CAMB-A; Cambridge)
Continuous limit of a crowd motion and herding model: analysis and numerical simulations. (English summary)
Kinet. Relat. Models **4** (2011), *no.* 4, 1025–1047.
This paper considers the crowd motion model

$$\begin{cases} \rho_t = \Delta\rho - \nabla\cdot(k_D\rho(1-\rho)\nabla D), \\ D_t = \kappa\Delta D - \delta D + \rho(1-\rho), \end{cases}$$

with no-flux boundary condition for D, zero Neumann boundary condition for ρ on the boundary of walls and out-flux boundary condition for ρ on the boundary of doors, where ρ denotes the population density, D is the dynamic floor field which accounts for the effect of herding, and $k_D > 0$, $\kappa > 0$ and $\delta > 0$ are parameters. This model corresponds

to the well-known volume-filling Keller-Segel model with the signal production term ρ replaced by $\rho(1-\rho)$ in the second equation. The authors first derive the above macroscopic model from the discrete model [A. Sopasakis and M. A. Katsoulakis, SIAM J. Appl. Math. **66** (2006), no. 3, 921–944; MR2216726 (2007b:90026); M. J. Simpson, B. D. Hughes and K. A. Landman, Australas. J. Eng. Educ. **15** (2009), no. 2, 59–67]. Then they perform some linear stability analysis, and they study the stationary states which imply the formation of clusters. Finally, they give some simulations to confirm the emergence of plateau solutions. *Youshan Tao*

MR2868921 35K57 35K20 65M99

Huber, Christian (1-GAIT-AS; Atlanta, GA)**;**
Dufek, Josef (1-GAIT-AS; Atlanta, GA)**; Chopard, Bastien** (CH-GENV-C2; Carouge)

A simple algorithm to enforce Dirichlet boundary conditions in complex geometries. (English summary)

Internat. J. Modern Phys. C **22** (2011), *no.* 10, 1093–1105.

Summary: "We present a new algorithm to implement Dirichlet boundary conditions for diffusive processes in arbitrarily complex geometries. In this approach, the boundary conditions around the diffusing object is replaced by the fictitious phase transition of a pure substance where the energy cost of the phase transition largely overwhelms the amount of energy stored in the system. The computing cost of this treatment of the boundary condition is independent of the topology of the boundary. Moreover, the implementation of this new approach is straightforward and follows naturally from enthalpy-based numerical methods. This algorithm is compatible with a wide variety of discretization methods, finite differences, finite volume, lattice Boltzmann methods and finite elements, to cite a few. We show, here, using both lattice Boltzmann and finite-volume methods that our model is in excellent agreement with analytical solutions for high symmetry geometries. We also illustrate the advantages of the algorithm to handle more complex geometries."

MR2861746 35K70 35A01 35A02 35D30 65M06 65M15 76S05

Fan, Y. [Fan, Yabin] (NL-EIND; Eindhoven)**; Pop, I. S.** (NL-EIND; Eindhoven)

A class of pseudo-parabolic equations: existence, uniqueness of weak solutions, and error estimates for the Euler-implicit discretization. (English summary)

Math. Methods Appl. Sci. **34** (2011), *no.* 18, 2329–2339.

The authors investigate a class of pseudo-parabolic equations which model two-phase flow in porous media where dynamic effects are included in the capillary pressure. They employ the Rothe method (based on Euler-implicit time stepping) for proving the existence of a solution, and use a Green function approach for the uniqueness. Error estimates for an Euler-implicit scheme are obtained. In the last part of the paper, the theoretical estimates are confirmed by some numerical experiment for which the explicit solution is known. *Andrea Pascucci*

MR2895971 35K91 35B40 35B50 35K20 35K67 65M06

Boni, Théodore K. [Boni, Théodore Kouassi] (IV-INPHB; Yamoussoukro)**;**
N'gohisse, Firmin K. (IV-ABIDS-MI; Abidjan)

Quenching for discretizations of a localized semilinear parabolic equation with Neumann boundary condition. (English summary)

An. Univ. Vest Timiş. Ser. Mat.-Inform. **48** (2010), *no.* 3, 3–18.

Summary: "This paper concerns the study of the numerical approximation for the

following boundary value problem

$$\begin{cases} u_t(x,t) = u_{xx}(x,t) = -u^{-p}(0,t),\ x \in (-1,1),\ t \in (0,T), \\ u_x(-1,t) = 0,\ u_x(1,t) = 0,\ t \in (0,T), \\ u(x,0) = u_0(x) > 0,\ x \in [-1,1], \end{cases}$$

where $p > 0,\ u_0 \in C^2([-1,1]),\ u_0'(-1) = 0,\ u_0'(1) = 0,\ u_0(x)$ is symmetric for $x \in [-1,1],\ u_0'(x) \le 0,\ x \in [-1,0],\ u_0''(x) - u_0^{-p}(0) < 0,\ x \in [-1,1]$. We find some conditions under which the solution of a discrete form of the above problem quenches in a finite time and estimate its numerical quenching time. We also prove that the numerical quenching time converges to the real one when the mesh size goes to zero. Finally, we give some numerical results to illustrate our analysis."

MR2895977 35K91 35B44 35K20 65M06

Nabongo, Diabate (IV-ABIDS-MI; Abidjan)**;**
Boni, Théodore K. [Boni, Théodore Kouassi]

An adaptive scheme to handle the phenomenon of blow-up for a localized semilinear heat equation with Neumann boundary conditions. (English summary)

An. Univ. Vest Timiş. Ser. Mat.-Inform. **48** (2010), *no.* 3, 105–123.

Summary: "This paper concerns the study of the numerical approximation for the following initial-boundary value problem

$$\begin{cases} u_t(x,t) = u_{xx}(x,t) + f(u(\frac{1}{2},t)),\ (x,t) \in (0,1) \times (0,T), \\ u_x(0,t) = 0,\ u_x(1,t) = 0,\ t \in (0,T), \\ u(x,0) = u_0(x),\ x \in [0,1], \end{cases}$$

where $f\colon [0,\infty) \to [0,\infty)$ is a C^1 convex, nondecreasing function, $\int^{\infty} \frac{d\sigma}{f(\sigma)} < \infty$. The initial data $u_0 \in C^0([0,1]),\ u_0(x) \ge 0,\ x \in [0,1]$. Under some assumptions, we prove that the solution of a discrete form of the above problem blows up in a finite time and estimate its numerical blow-up time. We also show that the numerical blow-up time in certain cases converges to the real one when the mesh size tends to zero. Finally, we give some numerical experiments to illustrate our analysis."

MR2852914 35L65 35L45 35L67 65M06 76M20

Ran, Zheng (PRC-SGH-AMM; Shanghai)

Galilean invariance and the conservative difference schemes for scalar laws. (English summary)

Adv. Difference Equ. **2011,** 2011:53, 16 *pp.*

Summary: "Galilean invariance for general conservative finite difference schemes is presented in this article. Two theorems have been obtained for first- and second-order conservative schemes, which demonstrate the necessity conditions for Galilean preservation in the general conservative schemes. Some concrete application has also been presented."

MR2783227 35P25 35J05 65N12 76Q05 78A45 78M25

Kalvin, Victor [Kal′vin, V. O.] (FIN-JVS-MIT; Jyväskylä)

Perfectly matched layers for diffraction gratings in inhomogeneous media. Stability and error estimates. (English summary)

SIAM J. Numer. Anal. **49** (2011), *no.* 1, 309–330.

In this paper, the author analyzes the scattering of acoustic or electromagnetic waves by diffraction gratings in inhomogeneous media. In particular, the perfectly matched layer (PML) method is investigated for 2-D periodic gratings in media that can be

inhomogeneous up to infinity (gradient-index media).

Time-harmonic acoustic and electromagnetic waves in gradient-index media are described by a function u satisfying the Dirichlet boundary value problem

$$(1) \qquad \begin{aligned} (\Delta + n^2(y,t)k^2)u(y,t) = 0, \quad (y,t) \in \mathcal{P}, \\ u(y,t) = 0, \quad (y,t) \in \partial\mathcal{P}, \end{aligned}$$

where $\mathcal{P} \subset \mathbb{R}^2$ denotes the upper periodic half-plane (above the grating) with 2π-periodic boundary $\partial\mathcal{P}$. The homogeneous Dirichlet boundary condition corresponds to an acoustically soft grating, or to the transverse magnetic case of a perfectly conducting electromagnetic grating. The refractive index $n(y,t)$ is subject to the conditions: (i) it stabilizes to 1 as the vertical distance t to the grating tends to infinity; (ii) it is a 2π-periodic function of the horizontal distance y and possesses a certain dilation analytic property with respect to t.

By using the limiting absorption principle, the author proves that problem (1) has a unique (outgoing) solution. The utilized techniques rely on the analysis of a non-self-adjoint problem, which is actually a problem with a PML of infinite length. Outgoing solutions of the original problem locally coincide with solutions of the infinite-PML problem.

Furthermore, problem (1) is modelled with a PML of finite length. The infinite-PML is truncated at a finite distance and the Dirichlet boundary condition is imposed on the boundary of truncation. Solutions to the finite-PML problem approximate outgoing solutions of the original problem. The author proves that the finite-PML problem is uniquely solvable and that the error of the approximation tends to zero with an exponential rate as the PML length increases. The proof is based on variational statements of problems in weighted Sobolev spaces and on a modification of the compound expansion method.

At the end of the paper, the derived results on the convergence of the PML method are compared with the respective results of [Z. M. Chen and H. J. Wu, SIAM J. Numer. Anal. **41** (2003), no. 3, 799–826; MR2005183 (2004k:65215); É. Bécache, A.-S. Bonnet-Ben Dhia and G. Legendre, SIAM J. Numer. Anal. **42** (2004), no. 1, 409–433; MR2051072 (2005c:65094)]. Also, the contribution of the problem's eigenvalues and resonances to the error of the approximation is examined. Finally, the author points out that the approach can be extended for Neumann boundary conditions and for scattering of transverse electric waves. *Nikolaos L. Tsitsas*

MR2847242 35Q35 35B40 65M06 65M12 76Z05 92C99

Holmes, William R. [Holmes, William Robert] (1-IN; Bloomington, IN)**;**
Jolly, Michael [Jolly, Michael S.] (1-IN; Bloomington, IN)**;**
Rubinstein, Jacob (1-IN; Bloomington, IN)

Hydro-elastic waves in a cochlear model: numerical simulations and an analytically reduced model. (English summary)

Confluentes Math. **3** (2011), *no.* 3, 523–541.

In this article the author studies a three-dimensional model of hydro-elastic waves associated with the mammalian cochlea fluid behavior. In the problem, the fluid is considered to be incompressible and inviscid and the fluid model to be linear. The work has nine sections. The first section introduces the problem. The second section is dedicated to the formulation of the model and the boundary conditions. In order to make numerical solutions simpler, Section 3 deals with reformulating the model using a Dirichlet-to-Neumann operator. In Section 4 a numerical scheme is presented. Section 5 discusses the convergence of the numerical solutions for different initial data, Δt and discretization of the domain. Section 6 discusses a reduced model. Section 7 presents

simulations of the full cochlear model to validate the asymptotic reduction formulated in Section 6. Section 8 discusses a relation between the aspect ratio and the size of the hearing band. Conclusions are given in Section 9. *Sandro M. Guzzo*

MR2821579 35Q53 35A35 35B10 35C10 65M60

Kapitula, Todd [Kapitula, Todd M.] (1-CLVN-MS; Grand Rapids, MI)**;**
De Jong, Nate (1-CLVN-MS; Grand Rapids, MI)**;**
Plaisier, Katelyn (1-CLVN-MS; Grand Rapids, MI)

Wave dynamics in the extended forced Korteweg-de Vries equation. (English summary)

SIAM J. Appl. Math. **71** (2011), *no.* 3, 811–828.

Summary: "The extended forced Korteweg-de Vries equation (efKdV) is a mathematical model for simulating the interaction of a shallow layer of fluid with external forcing agents. Herein we consider the dynamics of the efKdV when the forcing is assumed to be small and spatially periodic with a time-periodic variation of the phase. We show that a good heuristic understanding of the dynamics for a certain class of initial data can be found by studying a one-degree-of-freedom Hamiltonian system. One feature associated with this Hamiltonian system is that if the phase varies slowly with time, then to leading order the dynamics for the resonant solutions are governed by the forced nonlinear pendulum equation. Furthermore, we show that resonant solutions can correspond to waves which are trapped, i.e., waves which do not travel but instead oscillate. The theory is illustrated by numerical simulations." *Ademir Pastor Ferreira*

MR2863559 35Q55 35A01 35A02 35B30 65M06

Comech, A. (1-TXAM; College Station, TX)**;**
Komech, A. [Komech, Alexander Ilich] (A-WIENM; Vienna)

Well-posedness and the energy and charge conservation for nonlinear wave equations in discrete space-time. (English summary)

Russ. J. Math. Phys. **18** (2011), *no.* 4, 410–419.

In this paper, the authors consider the discretization of U(1)-invariant nonlinear wave equations of the form

$$\partial_{tt}\psi(x,t) = \Delta\psi(x,t) - 2\partial_\lambda v(x,|\psi(x,t)|^2)\psi(x,t), \quad x \in \mathbb{R}^n,$$

where Δ is the Laplace operator, $\psi \in \mathbb{C}^n$, $n \geq 1$, $v(x,\lambda)$ is such that $v \in C(\mathbb{R}^n \times \mathbb{R})$ and $v(x,\cdot) \in C^2(\mathbb{R})$ for each $x \in \mathbb{R}^n$. They show that the classical finite-difference scheme used by W. A. Strauss and L. Vázquez Martínez [J. Comput. Phys. **28** (1978), no. 2, 271–278; MR0503140 (58 #19970)] conserves the positive-definite discrete analog of the energy if the grid ratio satisfies $dt/dx \leq 1/\sqrt{n}$, where dt and dx are the mesh sizes of the time and space variables and n is the spatial dimension. They also obtain a discrete analog of the charge which is conserved if the grid ratio is $dt/dx = 1/\sqrt{n}$. Next, they prove the existence and uniqueness of solutions to the discrete Cauchy problem. Finally, using the energy conservation they obtain a priori bounds for finite energy solutions, showing that the Strauss–Vázquez Martínez finite-difference scheme for the nonlinear Klein-Gordon equation with positive nonlinear term in the Hamiltonian is conditionally stable. *Luiz Gustavo Farah*

MR2863068 35Q83 35B35 35M31 65M70 76X05

Balmforth, N. J. [Balmforth, Neil J.] (3-BC; Vancouver, BC)

BGK states from the bump-on-tail instability. (English summary)

Commun. Nonlinear Sci. Numer. Simul. **17** (2012), *no.* 5, 1989–1997.

Summary: "Numerical computations are presented of the BGK-like states that emerge

beyond the saturation of the bump-on-tail instability in the Vlasov-Poisson system. The stability of these states towards subharmonic perturbations is explored in order to gauge whether the primary bump-on-tail instability always suffers a secondary instability that precipitates wave mergers and coarsening of the BGK pattern. Because the onset of the bump-on-tail instability occurs at finite wavenumber, and the spatially homogeneous state is not itself unstable to spatial subharmonics, it is demonstrated that mergers and coarsening do not always occur, and the dynamics displays a richer spatio-temporal complexity."

MR2883145 35R10 35B35 35K51 65M06 65M12

Jaruszewska-Walczak, Danuta (PL-GDAN; Gdańsk)

Stability of difference problems generated by infinite systems of quasilinear parabolic functional differential equations. (English summary)

Bull. Belg. Math. Soc. Simon Stevin **18** (2011), *no.* 3, 517–536.

Summary: "The paper deals with infinite weakly coupled systems of quasilinear parabolic differential functional equations. Initial boundary conditions of the Robin type are considered. We construct an explicit Euler type approximation method based on an infinite system of difference functional equations. Next we apply the truncation method to obtain a finite difference scheme corresponding to the original differential problem. We present a complete convergence analysis for the methods. The results are based on a comparison technique with nonlinear estimates of the Perron type for given functions."

MR2869039 35R30 65N21 78A46

Ammari, Habib (F-ENS-DAM; Paris)**; Kang, Hyeonbae** (KR-INHA; Inchon)**; Kim, Eunjoo** (KR-EWHA-IM; Seoul)**; Lee, June-Yub** (KR-EWHA-IM; Seoul)

The generalized polarization tensors for resolved imaging Part II: Shape and electromagnetic parameters reconstruction of an electromagnetic inclusion from multistatic measurements. (English summary)

Math. Comp. **81** (2012), *no.* 278, 839–860.

Summary: "This paper deals with the problem of reconstructing the electromagnetic parameters and the shape of a target from multi-static response matrix measurements at a single frequency. The target is of characteristic size less than the operating wavelength. Using small-volume asymptotic expansions of the measurements of high-order, we show how the electromagnetic parameters and the equivalent ellipse of the target can be reconstructed. The asymptotic expansions of the measurements are written in terms of the new concept of frequency dependent polarization tensors. Moreover, we extend the optimization approach proposed in Part I [H. Ammari et al., Math. Comp. **81** (2012), no. 277, 367–386; MR2833499 (2012f:35570)] to image geometric details of an electromagnetic target that are finer than the equivalent ellipse. The equivalent ellipse still provides a good initial guess for the optimization procedure. However, compared to the conductivity case in Part I, the cost functional measures the discrepancy between the computed and measured high-order frequency dependent polarization tensors rather than between the generalized polarization tensors. The main reason for such a modification of the cost functional is the fact that the (measured) frequency dependent polarization tensors can be easily obtained from multistatic measurements by solving a linear system while the derivation of the generalized polarization tensors from measurements requires more delicate treatment. The proposed methods are numerically implemented to demonstrate their validity and efficiency."

MR2853113 35R30 35L20 65M32
Boumenir, Amin (1-WGA; Carrollton, GA)**;**
Tuan, Vu Kim [Vu Kim Tuan] (1-WGA; Carrollton, GA)
An inverse problem for the wave equation. (English summary)
J. Inverse Ill-Posed Probl. **19** (2011), *no.* 4-5, 573–592.
Summary: "In the first part of this article, we show that we can recover the coefficient q in the one-dimensional wave equation from a finite number of special lateral measurements. Moreover, if some estimates on the size of q are available, then q can be recovered from a single boundary measurement. In the second part we treat the multidimensional case and show how we can reconstruct the coefficient q from a sequence of boundary measurements taken at one point only."

MR2805355 35R30 35A02 35B35 65N21
Caro, Pedro (E-MADA; Madrid)
On an inverse problem in electromagnetism with local data: stability and uniqueness. (English summary)
Inverse Probl. Imaging **5** (2011), *no.* 2, 297–322.
Summary: "In this paper we prove a stable determination of the coefficients of the time-harmonic Maxwell equations from local boundary data. The argument—due to Isakov—requires some restrictions on the domain."

MR2805358 35R30 31B20 35J25 65N21 78A70
Delbary, Fabrice (DK-TUD-IMM; Lyngby)**; Kress, Rainer** (D-GTN-N; Göttingen)
Electrical impedance tomography using a point electrode inverse scheme for complete electrode data. (English summary)
Inverse Probl. Imaging **5** (2011), *no.* 2, 355–369.
Summary: "For the two dimensional inverse electrical impedance problem in the case of piecewise constant conductivities with the currents injected at adjacent point electrodes and the resulting voltages measured between the remaining electrodes, in [J. Integral Equations Appl. **22** (2010), no. 2, 193–216; MR2661719 (2011m:35415)] the authors proposed a nonlinear integral equation approach that extends a method that has been suggested by Kress and W. Rundell [Inverse Problems **21** (2005), no. 4, 1207–1223; MR2158105 (2006e:45010)] for the case of perfectly conducting inclusions. As the main motivation for using a point electrode method we emphasized on numerical difficulties arising in a corresponding approach by H. Eckel and Kress [Inverse Problems **23** (2007), no. 2, 475–491; MR2309659 (2008a:78036); Appl. Anal. **87** (2008), no. 10-11, 1267–1288; MR2477607 (2010e:45008)] for the complete electrode model. Therefore, the purpose of the current paper is to illustrate that the inverse scheme based on point electrodes can be successfully employed when synthetic data from the complete electrode model are used."

MR2872349 35R30 35J25 65N21
Li, Xiao-Xiao [Li, Xiao Xiao[1]] (PRC-LNUT-SSC; Lanzhou)**;**
Guo, Heng Zhen (PRC-LZCU-IED; Lanzhou)**; Wan, Shi Min** (PRC-TJUPD; Tianjin)**;**
Yang, Fan [Yang, Fan[6]] (PRC-LNUT-SSC; Lanzhou)
Inverse source identification by the modified regularization method on Poisson equation. (English summary)
J. Appl. Math. **2012,** *Art. ID* 971952, 13 *pp.*
Summary: "This paper deals with an inverse problem for identifying an unknown source which depends only on one variable in two-dimensional Poisson equation, with the aid of an extra measurement at an internal point. Since this problem is illposed, we

obtain the regularization solution by the modified regularization method. Furthermore, we obtain the Hölder-type error estimate between the regularization solution and the exact solution. The numerical results show that the proposed method is stable and the unknown source is recovered very well."

MR2883220 35R30 35A02 35B30 35Q60 65M32 78A46
Romanov, V. G. [Romanov, Vladimir Gavrilovich] (RS-AOSSI; Novosibirsk)
A stability estimate for a solution of an inverse problem of electrodynamics. (Russian. Russian summary)
Sibirsk. Mat. Zh. **52** (2011), *no.* 4, 861–875; *translation in Sib. Math. J.* **52** (2011), *no.* 4, 682–695.

The paper deals with the system of integro-differential equations

$$\frac{\partial}{\partial t}\left[\varepsilon_0(x)E(x,t)+\int_{-\infty}^{t}\varepsilon(x,t-s)E(x,s)ds\right]=$$
$$\operatorname{rot} H(x,t)-j(x,t),$$
$$\frac{\partial}{\partial t}H(x,t)+\operatorname{rot} E(x,t)=0,$$

for $t>0$ and $x\in\mathbb{R}^3$, which describes the propagation of electromagnetic waves in a dispersive medium. The dielectric permittivity $\varepsilon(x,t)$ is assumed to have the form $\varepsilon(x,t)=k(t)p(x)$. The paper addresses the inverse problem, where the spatial part of the dielectric permittivity, $p(x)$, is to be determined from the field measurements on the boundary of the spatial domain containing the support of $p(x)$. Assuming that the measurements are made during a sufficiently long time, a stability estimate for the solution of the inverse problem is obtained. As a consequence, a uniqueness theorem is established. *Dmitry G. Shepelsky*

MR2754313 37B55 37C60 39A22 65L07
Pötzsche, Christian (D-MUTU-ZMG; Garching)
Nonautonomous continuation of bounded solutions. (English summary)
Commun. Pure Appl. Anal. **10** (2011), *no.* 3, 937–961.

In this paper the author proves the persistence of hyperbolic bounded solutions to nonautonomous difference and retarded functional differential equations under parameter perturbation, where hyperbolicity is expressed in terms of an exponential dichotomy in variation. The approach proposed by the author uses a formulation of the dynamical systems as operator equations in certain sequence or function spaces. The main results are illustrated in an interesting application concerning the behavior of hyperbolic solutions and stable manifolds for ODEs under numerical discretization with varying step sizes. *Bogdan Sasu*

MR2873189 37D45 65G20 65G30 65P20
Goldsztejn, Alexandre (F-NANT-LIN; Nantes)**;**
Hayes, Wayne (1-CA3-NDM; Irvine, CA)**;**
Collins, Pieter [Collins, Pieter J.] (NL-MST-NDM; Maastricht)
Tinkerbell is chaotic. (English summary)
SIAM J. Appl. Dyn. Syst. **10** (2011), *no.* 4, 1480–1501.

Summary: "Shadowing is a method of backward error analysis that plays a important role in hyperbolic dynamics. In this paper, the shadowing by containment framework is revisited, including a new shadowing theorem. This new theorem has several advantages with respect to existing shadowing theorems: It does not require injectivity or

differentiability, and its hypothesis can be easily verified using interval arithmetic. As an application of this new theorem, shadowing by containment is shown to be applicable to infinite length orbits and is used to provide a computer assisted proof of the presence of chaos in the well-known noninjective Tinkerbell map." *Jiri Fiser*

MR2834447 37M15 65P10 70H15

Ruzzon, A. (F-PROV-TB; Marseille)**; Elskens, Y.** (F-PROV-TB; Marseille)**;**
Doveil, F. [Doveil, Fabrice] (F-PROV-TB; Marseille)

A symplectic, symmetric algorithm for spatial evolution of particles in a time-dependent field. (English summary)

Commun. Nonlinear Sci. Numer. Simul. **17** (2012), *no.* 2, 769–779.

There are problems related with the study of particle motion in a space-time dependent field where it is convenient to use a space dimension, rather than time, as the independent variable. One such instance is the propagation of a beam of electrons in a traveling wave tube, where it is more natural to sample particles at given positions along the tube. In this case it might be of interest to design numerical integration methods for the resulting differential equations which preserve as much of the qualitative properties of the Hamiltonian system as possible, in particular their symplectic structure. To this end, the authors consider a symplectic Euler implicit method as a first-order approximation and then compose it with its adjoint to get a second-order symmetric scheme. Then, by applying well-known composition methods, it is possible to construct higher-order approximations. Even though the first-order method is implicit, the resulting algebraic equation can be solved either exactly or by the Newton method when only one space dimension is considered. The methods thus constructed are tested by analyzing the dynamics of a beam of electrons injected in a single wave and also in two waves. Although only one dimension is considered in the paper, extending the approach to three space dimensions is straightforward when the particles stream along a single coordinate. *Fernando Casas*

MR2805916 41A05 41A10 65D05

Palacios-Quiñonero, F. (E-UPB-A3M; Manresa)**;**
Rubió-Díaz, P. [Rubió i Díaz, Pedro] (E-UPB-A3M; Manresa)**;**
Díaz-Barrero, J. L. [Díaz-Barrero, José Luis] (E-UPB-A3M; Manresa)**;**
Rossell, J. M. [Rossell i Garriga, Josep Maria] (E-UPB-A3M; Manresa)

Order regularity for Birkhoff interpolation with lacunary polynomials. (English summary)

Math. Æterna **1** (2011), *no.* 3-4, 129–135.

Using certain definitions and earlier results, the authors mainly prove the following result:

Theorem 1 (resp. 1′). Let E be an interpolation matrix that satisfies the Pólya K-condition and the upper (resp. lower) K-inclusive property. If E contains no odd upper (resp. lower) K-supported sequences, then E is order K-regular on $[0,\infty)$ (resp. $(-\infty,0]$).

The authors claim these two theorems are generalizations of Atkinson and Sharma's theorem (1969).

Based on these theorems, sufficient conditions for the order regularity problem in Birkhoff interpolation with lacunary polynomials $\sum_{j=1}^{n} a_j(x^{k_j}/k_j!)$ are established. The proofs are quite technical. The generalized Pólya condition is used to characterize conditionally regular interpolation matrices, which is simpler than Pólya's condition for algebraic Birkhoff interpolation and it is equivalent to Pólya's condition when $k_j = j - 1$.

The reader should be warned about numerous typos. *Kewal Krishna Mathur*

MR2843040 41A05 41A30 41A63 47B06 65D05

Pazouki, Maryam (D-GTN-N; Göttingen)**; Schaback, Robert** (D-GTN-N; Göttingen)

Bases for kernel-based spaces. (English summary)

J. Comput. Appl. Math. **236** (2011), *no.* 4, 575–588.

This paper provides a general framework for the discussion of alternate bases for computation on reproducing kernel Hilbert spaces with kernel K. It is well known that the standard basis consisting of "translates" $K(\cdot, x_j)$ of the kernel to a finite set of centers $\{x_1, \dots, x_N\} \subseteq \Omega$ often is unstable, i.e., it leads to an ill-conditioned system matrix $A = (K(x_j, x_k))_{1 \le j,k \le N}$. On the other hand, the function space spanned by the standard basis has perfectly good approximation properties. The situation of piecewise polynomial splines, for which truncated power functions are a much less stable basis than B-splines, may serve as a well-known illustration of this phenomenon.

The kernel bases discussed in this paper are all interpreted in terms of standard matrix factorizations of the system matrix A, such as Cholesky (leading to a "Newton" basis), QR and SVD. In contrast to these data-dependent bases the authors also discuss the data-independent basis of eigenfunctions of the kernel. An interpretation of the SVD basis as a discretized (via numerical integration techniques) version of the eigenfunction basis is also provided.

The "Newton" basis receives special attention. Two iterative center selection algorithms are discussed for it. The first is a generic version that does not take into account the given data. This algorithm is akin to a column-pivoted Cholesky factorization and leads to a center distribution (design) that is relatively uniform and uses the power function as a point selection criterion. The second algorithm is a version of orthogonal matching pursuit and takes into account the given function values and therefore adapts to special features in the function. For example, centers will be clustered along derivative singularities as illustrated numerically in the paper.

Other theoretical aspects of the various bases, such as duality or orthonormality, are also easily accessible through the framework provided here. For example, the standard basis of kernel translates and the Lagrange basis are shown to be dual to each other, or orthonormal bases (in the reproducing kernel Hilbert space sense) are shown to be self-dual. The "Newton" basis is shown to be such a self-dual orthonormal basis.

Gregory E. Fasshauer

MR2869036 41A10 41A25 41A63 65N15 65N35

Chernov, Alexey (D-BONN-CM; Bonn)

Optimal convergence estimates for the trace of the polynomial L^2-projection operator on a simplex. (English summary)

Math. Comp. **81** (2012), *no.* 278, 765–787.

The author studies convergence of the L^2-projections onto the spaces of polynomials up to degree p defined on a simplex in $\mathbb{R}^d$, $d \ge 2$, as $p \to \infty$. Based on the collapsed coordinate transform and the expansion into various polynomial bases involving Jacobi polynomials, the optimal error estimates are established in the case of Sobolev regularity.

Mao Dong Ye

MR2875913 41A15 65D05 65D07

Delgado-Gonzalo, R. [**Delgado-Gonzalo, Ricard**] (CH-LSNP-BI; Lausanne)**;**
Thévenaz, P. [**Thévenaz, Philippe**] (CH-LSNP-BI; Lausanne)**;**
Unser, M. [**Unser, Michael A.**] (CH-LSNP-BI; Lausanne)

Exponential splines and minimal-support bases for curve representation. (English summary)

Comput. Aided Geom. Design **29** (2012), *no.* 2, 109–128.

Summary: "Our interest is to characterize the spline-like integer-shift-invariant bases capable of reproducing exponential polynomial curves. We prove that any compact-support function that reproduces a subspace of the exponential polynomials can be expressed as the convolution of an exponential B-spline with a compact-support distribution. As a direct consequence of this factorization theorem, we show that the minimal-support basis functions of that subspace are linear combinations of derivatives of exponential B-splines. These minimal-support basis functions form a natural multiscale hierarchy, which we utilize to design fast multiresolution algorithms and subdivision schemes for the representation of closed geometric curves. This makes them attractive from a computational point of view. Finally, we illustrate our scheme by constructing minimal-support bases that reproduce ellipses and higher-order harmonic curves."

MR2894255 41A15 65D07 70E55

Jakubiak, Janusz (PL-WROCT-CEN; Wrocław)

Path planning for a double pendulum using natural splines on the torus. (English summary)

Mathematical papers in honour of Fátima Silva Leite, 31–41, *Textos Mat. Sér. B*, 43, *Univ. Coimbra*, *Coimbra*, 2011.

Summary: "In this paper we present an algorithm to generate splines on a torus. In the task solved it is assumed that the splines connect points with given velocities in boundary positions. Results are adapted to a double pendulum robotic arm, illustrated by computer simulations and compared with regular cubic interpolation and X-splines. This paper is an extended version of the work presented at Controlo 2010."

{For the entire collection see MR2894252 (2012i:70004).}

MR2853516 41A15 14Q10 65D07

Lai, Yisheng (PRC-HGSU-ICS; Hangzhou)**; Wang, Renhong** (PRC-DUT-IM; Dalian)**;**
Wu, Jinming (PRC-HGSU-ICS; Hangzhou)

Solving parametric piecewise polynomial systems. (English summary)

J. Comput. Appl. Math. **236** (2011), *no.* 5, 924–936.

Piecewise polynomial systems have many applications in various academic and industrial domains, such as CAD, CAM, CAE and image processing. Many problems, in both practice and theory (for example, the construction of explicit interpolation schemes for spline spaces on a given partition, blending curves and surfaces and computer graphics), can be reduced to problems of solving parametric piecewise polynomial systems. It is obvious that the parametric piecewise polynomial system is also a kind of generalization of the parametric semi-algebraic system.

Lazard and Rouillier recently proposed a new framework for studying the basic constructible set and the basic semi-algebraic set, using a discriminant variety of the basic constructible set.

Based on this discriminant variety method, the authors show that solving a parametric piecewise polynomial system $\mathcal{Z}(f_1, \ldots, f_n)$ is reduced to the computation of the discriminant variety of $\mathcal{Z}$. The variety can then be used to solve the parametric piece-

wise polynomial system. In this context, the authors present theoretical and algorithmic results. More precisely, this paper proposes a general method to classify the parameters of $\mathcal{Z}(f_1, \ldots, f_n)$ and an algorithm that answers the following question:

Given a parametric piecewise polynomial system $\mathcal{Z}(f_1, \ldots, f_n)$ and integers $N_1, \ldots, N_m$, does there exist an open set $\mathcal{O}$ in the parameter space such that for all $p_0 \in \mathcal{O}$, the zero-dimensional non-parametric piecewise polynomial system $\mathcal{Z}_{p_0}(f_1, \ldots, f_n)$ obtained by specializing at point p_0 has exactly $N_1, \ldots, N_m$ distinct torsion-free real zeros in the n-dimensional cells $\sigma_1, \ldots, \sigma_m$, respectively?

In the affirmative case, the authors give explicitly a point $a \in \mathcal{O}$. Several experimental results are included to illustrate the theoretical and algorithmic results. *Juana Sendra*

MR2869040 41A25 33C45 41A58 65D05

Wang, Haiyong (PRC-CSU-AMS; Changsha)**;**
Xiang, Shuhuang [Xiang, Shu Huang] (PRC-CSU-AMS; Changsha)

On the convergence rates of Legendre approximation. (English summary)

Math. Comp. **81** (2012), *no.* 278, 861–877.

For the class of functions f, $f', \ldots, f^{(k-1)}$ absolutely continuous on $[-1, 1]$ with $\|f^{(k)}\|_T$ finite (here $\|u\|_T = \int_{-1}^{1} (|u'(x)|/\sqrt{1-x^2})\, dx$), upper bounds on the coefficients of the Legendre series are obtained. Also, bounds of the same coefficients are given for functions analytic inside and on the Bernstein ellipse. For the latter class of functions the bounds are better than the bounds given in [P. J. Davis, *Interpolation and approximation*, Dover, New York, 1975; MR0380189 (52 #1089)]. The decay rates of the Legendre coefficients are shown to be comparable to those of the Chebyshev coefficients, although the latter are somewhat faster. These decay rates are then used to give error bound estimates for Legendre series approximations for the above classes of functions.

Finally, explicit values for the barycentric weights are given for barycentric Lagrange interpolation formulas using the Gauss-Legendre points. An error bound for this interpolant is also given for the concerned classes of functions. Several examples are also provided. *James R. Angelos*

MR2875252 41A30 41A05 65D10

Lee, Mun Bae (KR-KOKU; Seoul)**; Lee, Yeon Ju** (KR-AIST2; Taejŏn)**;**
Yoon, Jungho (KR-EWHA; Seoul)

Sobolev-type L_p-approximation orders of radial basis function interpolation to functions in fractional Sobolev spaces. (English summary)

IMA J. Numer. Anal. **32** (2012), *no.* 1, 279–293.

The authors give a Sobolev-type L_p-approximation estimation for some radial basis functions in a fractional Sobolev space. The results are valid for conditional positive (negative) radial basis functions (see chapter 8 in [H. Wendland, *Scattered data approximation*, Cambridge Monogr. Appl. Comput. Math., 17, Cambridge Univ. Press, Cambridge, 2005; MR2131724 (2006i:41002)] for a definition) on bounded domain Ω with a Lipschitz boundary.

Let $W^{k,p}(\Omega)$ be a Sobolev space on $\mathbb{R}^d$ associated with (semi-)norms

$$|f|^p_{W^{k,p}(\Omega)} := \sum_{|\alpha|_1 = k} \|D^\alpha f\|^p_{L_p(\Omega)}$$

and

$$\|f\|^p_{W^{k,p}(\Omega)} := \sum_{|\alpha|_1 \le k} \|D^\alpha f\|^p_{L_p(\Omega)},$$

where $\alpha = (\alpha_1, \alpha_1, \ldots, \alpha_d) \in \mathbb{Z}^d_+$ is a multi-index, $|\alpha|_1 = \sum_{j=1}^d \alpha_j$, and $D^\alpha f \in L_p(\Omega)$

are distributional (weak) derivatives. For the case $p = 2$, and any $\tau > 0$, one can define a norm of the Sobolev space $W^{\tau,p}(\mathbb{R}^d)$ as

$$\|f\|_{W^{\tau,2}(\mathbb{R}^d)} := \left(\int_{\mathbb{R}^d} (1 + |\theta|^2)^{\tau} |\widehat{f}(\theta)|^2 d\theta \right)^{1/2}. \tag{1}$$

For a non-negative integer k, $0 < \mu < 1$ and $1 \le p \le \infty$, the fractional Sobolev spaces $W^{k+\mu,p}(\Omega)$ consist of all the functions f with the following norm being finite:

$$\|f\|^p_{W^{k+\mu,p}(\Omega)} := \|f\|^p_{W^{k,p}(\Omega)} + \sum_{|\beta|_1 = k} \int_{\Omega} \left\| \frac{D^\beta f(\cdot) - D^\beta f(x)}{|\cdot - x|^{d/p+\mu}} \right\|^p_{L_p(\Omega)} dx.$$

For $p = 2$ and $\tau = k + \mu$, the latter norm is equivalent to the norm in (1).

Let ν be a real number satisfying $d/2 \le \nu \le \tau$, where τ is a parameter depending on the related radial basis function, and let $S_X f$ be the radial basis function interpolant of a function f. The authors show that

$$\|f - S_X f\|_{W^{|\alpha|_1,p}(\Omega)} \le c h^{\nu - |\alpha|_1 - \max\{d(1/2-1/p),0\}} \|f\|_{W^{\nu,2}(\Omega)},$$

for $|\alpha|_1 \le \lceil \nu_0 \rceil$ with $\nu_0 = \nu - \max\{d(1/2 - 1/p), 0\}$, where h is the so-called *fill distance*.

This result has a statement that is similar to Theorem 6.1 of [R. Arcangéli, M. C. López de Silanes and J. J. Torrens, Numer. Math. **107** (2007), no. 2, 181–211; MR2328845 (2008f:46039)] but generalizes that result to a larger fractional Sobolev space. The proof itself is also related to the sampling inequalities in Theorem 4.1 of [R. Arcangéli, M. C. López de Silanes and J. J. Torrens, op. cit.]. *Shengxin Zhu*

MR2871668 41A30 41A05 41A63 65D05

Luh, Lin-Tian (RC-PU-M; Taichung)

The shape parameter in the Gaussian function. (English summary)

Comput. Math. Appl. **63** (2012), *no.* 3, 687–694.

This paper discusses the optimal choice of the parameter $\beta > 0$ in the Gaussian function $h(x) = e^{-\beta|x|^2}$ for radial basis function interpolations. Let $s(x) = \sum_{i=1}^N c_i h(x - x_i)$ be an h-spline interpolant of data (x_i, y_i), $i = 1, 2, \ldots, N$. From the interpolation error bound, a MIN function is derived from which criteria to choose an optimal value of the parameter β are proposed. *Falai Chen*

MR2812528 41A35 41A55 41A63 42C25 65D15

Michel, Volker (D-SGN-GMG; Siegen)

Optimally localized approximate identities on the 2-sphere. (English summary)

Numer. Funct. Anal. Optim. **32** (2011), *no.* 8, 877–903.

The paper deals with the construction of optimally localized approximate identities on the three-dimensional sphere. The differential in the paper is how optimal localization is found in the optimization problem, with a functional that keeps a balance between bad localization and deviation from an approximate identity. The part that controls localization includes a weight function that can be conveniently chosen. For each choice, the author proves the existence and uniqueness of the optimal kernel and shows how to generate an approximate identity in the band limited case. The paper includes results of numerical tests. *Valdir A. Menegatto*

MR2832720 41A46 42C40 65T60

Kutyniok, Gitta (D-OSNB-IM; Osnabrück)**; Lim, Wang-Q** (D-OSNB-IM; Osnabrück)

Compactly supported shearlets are optimally sparse. (English summary)

J. Approx. Theory **163** (2011), *no.* 11, 1564–1589.

The authors identify optimally sparse approximations of cartoon-like images, i.e., C^2 functions which are smooth apart from a C^2 discontinuity curve, up to a log-factor with the same exponent as in the curvelet-, contourlet-, and (band-limited) shearlet-approximation rates, by using a particular class of directional representation systems, consisting of compactly supported elements. This class is chosen as a subset of (non-tight) shearlet frames with shearlet generators having compact support and satisfying some weak directional vanishing moment conditions. This proof is different from previous ones since it extensively exploits the fact that the shearlet generators are compactly supported and the lack directional vanishing moments. The directional representation system of shearlets has recently gained attention because, in contrast to other such systems, shearlets provide a unified treatment of the continuum and digital worlds, similar to wavelets, due to the fact that the shearing operator, a means for deriving directionality, leaves the digital grid invariant. *Rémi Vaillancourt*

MR2908113 41A50 41A55 65D30

Perić, I. [**Perić, Ivan**] (CT-ZAGRFB; Zagreb)

Frequency variant of Euler type identities and the problem of sign-constancy of the kernel in associated quadrature formulas. (English summary)

J. Math. Inequal. **5** (2011), *no.* 4, 565–579.

Summary: "In the recent years many authors used extended Euler identities to obtain generalizations of some classical quadrature formulas with the best possible error estimates. The main step in obtaining the best possible error estimates was to control zeros of the kernel in the error term which consists of the affine combinations of the translates of periodic Bernoulli polynomials. This was done for some low degrees of Bernoulli polynomials. The main goal of this paper is to consider a general case. The frequency variant of extended Euler identities is found to be more tractable for this problem."

MR2905968 41A55 65D30

Boltaev, A. K.

On an extremal function for an optimal quadrature formula. (Russian. English, Russian and Uzbek summaries)

Vopr. Vychisl. Prikl. Mat. No. 125 (2010), 32–42, 173.

Summary: "In the present paper in the $W_2^{P_3}(0,1)$ Hilbert space the first part of the problem of construction of optimal quadrature formulas is solved, i.e. norm of the error functional of optimal quadrature formulas in the $W_2^{P_3}(0,1)$ space is calculated."

MR2905973 41A55 41A05 65D30

Mamatova, N. Kh.

Construction of quadrature formulas using an optimal interpolation formula. (Russian. English, Russian and Uzbek summaries)

Vopr. Vychisl. Prikl. Mat. No. 125 (2010), 83–91, 174.

Consider the space $\widetilde{L}_2^m(0,1)$ of 1-periodic functions $\varphi\colon \mathbb{R} \to \mathbb{R}$ endowed with the seminorm

$$\|\varphi\|_{\widetilde{L}_2^m(0,1)} := \Big(\int_0^1 (\varphi^{(m)}(x))^2 dx\Big)^{1/2}.$$

The author studies quadrature formulas of the form

$$\int_0^1 p(x)\varphi(x)dx \approx \sum_{k=1}^{N} c_k \varphi(\tfrac{k}{N}).$$

For $\varphi \in \widetilde{L}_2^m(0,1)$, let the map $\varphi \mapsto P(\varphi, x)$ be defined by

$$P(\varphi, x) := \sum_{k=1}^{N} c_k(x)\varphi(x_k).$$

The error functional at a point z can be represented by

$$\varphi(z) - P(\varphi, z) := \langle l_z, \varphi\rangle = \int_0^1 \Big[(\delta(x-z) - \sum_{k=1}^{N} c_k(z)\delta(x-x_k)) * \phi_0(x)\Big]\varphi(x)dx,$$

where $\delta(x)$ is the delta function, $\phi_0(x) := \sum_{k\in\mathbb{Z}} \delta(x-k)$. Let $\widetilde{L}_2^{m*}(0,1)$ be the space of functionals l_z of the form above such that $\langle l_z, 1\rangle = 0$. An "optimal interpolation formula" is that whose error functional has the minimal L_2-norm over all choices of $c_k(z) \in \mathbb{R}$, with N and $x_k = k/N$ being fixed. Using optimal interpolation formulas the author establishes several quadrature formulas.

It is shown that if $p(x) \equiv 1$ then there is a unique quadrature formula of such type with the coefficients $c_k = N^{-1}$, $1 \le k \le N$. In the case $p(x) = e^{2\pi i p x}$, $p \in \mathbb{Z}$, it is shown that the coefficients are

$$c_k = \frac{N^{-1}e^{2\pi i p x}}{p^{2m}\sum_{k\in\mathbb{Z}} \frac{N^{-2m}}{(k-pN^{-1})^{2m}}}, \quad 1 \le k \le N,\ 1 \le p \le N-1.$$

If $p(x) = x^\alpha$, then

$$c_k = N^{-1}\left(\frac{1}{\alpha+1} - \sum_{s\in\mathbb{Z},\ sN^{-1}\notin\mathbb{Z}} \sum_{n=0}^{\alpha-1} \frac{\alpha! e^{2\pi i s k N^{-1}}}{(\alpha-n)! k^{2m}(2\pi i k)^{n+1} L(k)}\right),$$

where

$$L(k) = N^{-2m}\sum_s (s - kN^{-1}), \quad 1 \le k \le N,\ N = 2, 3, \ldots.$$

Alexander K. Kushpel′

MR2843703 41A55 33C45 42C05 65D30

Milovanović, Gradimir V.

Numerical quadratures and orthogonal polynomials. (English summary)

Stud. Univ. Babeş-Bolyai Math. **56** (2011), *no.* 2, 449–464.

The construction of quadrature formulae of the maximal, or nearly maximal, algebraic degree of exactness for integrals involving a positive measure $d\sigma$ is closely connected to orthogonal polynomials on the real line with respect to the inner product

$$(f, g) = (f, g)_{d\sigma} = \int_{\mathbb{R}} f(t)g(t)d\sigma(t) \quad (f, g \in L^2(d\sigma)).$$

This paper discusses different types of quadrature formulae such as Gauss-Christoffel quadratures, quadratures with multiple nodes, and Birkhoff-Young quadratures. For example, the Gauss-Christoffel quadrature formula is defined as follows: Let $\mathcal{P}_n$ be the set of all algebraic polynomials of degree at most n and $d\sigma$ be a finite positive Borel measure on the real line $\mathbb{R}$ such that its support $\mathrm{supp}(d\sigma)$ is an infinite set, and all

its moments $\mu_k = \int_{\mathbb{R}} t^k d\sigma(t)$, $k = 0, 1, \ldots$, exist and are finite. The n-point quadrature formula

$$\int_{\mathbb{R}} f(t)d\sigma(t) = \sum_{k=1}^{n} \sigma_k f(\tau_k) + R_n(f),$$

which is exact on the set $\mathcal{P}_{2n-1}$, is known as the Gauss-Christoffel quadrature formula. It is a quadrature formula of the maximal algebraic degree of exactness, i.e. $R_n(\mathcal{P}_{d_{\max}}) = 0$, where $d_{\max} = 2n - 1$. In the same manner, other types of quadratures, such as quadratures with multiple nodes and Birkhoff-Young quadratures, are presented. This paper gives an account of some important connections between orthogonal polynomials and Gaussian quadratures, as well as several types of generalized orthogonal polynomials and corresponding types of quadratures with simple and multiple nodes.

The paper has 4 sections. The introduction is presented in Section 1. In Section 2 quadratures of Gaussian type (with maximal or nearly maximal degree of exactness) and quasi-orthogonal polynomials are considered. Section 3 is devoted to presenting a connection between s- and σ-orthogonal polynomials and quadratures with multiple nodes. Finally, in Section 4 multiple orthogonal polynomials and two applications are presented. *Mohammad R. Eslahchi*

MR2871785 41A60 41A65 65Y20

Weimar, Markus (D-FSU-MI; Jena)

Tractability results for weighted Banach spaces of smooth functions. (English summary)

J. Complexity **28** (2012), *no.* 1, 59–75.

Let $f\colon [0,1]^d \to \mathbb{R}$ be a bounded function belonging to a Banach function space $\mathcal{F}_d$, endowed with the L_∞-norm. The author considers the worst case error

$$e^{\mathrm{wor}}(A_{n,d}; \mathcal{F}_d) = \sup_{\|f\| \le 1} \|f - A_{n,d}(f)\|_{L_\infty([0,1]^d)},$$

for the algorithms $A_{n,d} \in \mathcal{A}_n$. These algorithms use n pieces of information in d dimensions from a given class Λ of information. The author is interested in the nth minimal error

$$e(n, d; \mathcal{F}_d) = \inf\{e^{\mathrm{wor}}(A_{n,d}; \mathcal{F}_d)\colon\ A_{n,d} \in \mathcal{A}_n\}.$$

If the quantity $n(\varepsilon, d; \mathcal{F}_d) = \min\{n \in \mathbb{N}_0 \colon e(n, d; \mathcal{F}_d) \le \varepsilon\}$ (information complexity) depends exponentially on dimension d or ε^{-1} then the problem considered is called intractable. The problem is called weakly tractable if $\lim_{\varepsilon^{-1}+d\to\infty} \frac{\ln(n(\varepsilon,d;\mathcal{F}_d))}{\varepsilon^{-1}+d} = 0$, and polynomially tractable if there exist the constants $c, p, q > 0$ such that $n(\varepsilon, d; \mathcal{F}_d) \ge c\varepsilon^{-1}d^q$, for all $d \in \mathbb{N}$, $\varepsilon > 0$.

The author gives necessary and sufficient conditions for several kinds of tractability for a whole scale of weighted Banach spaces of smooth d-variate functions. The equivalence of weak tractability with the fact that the problem does not suffer from the "curse of dimensionality" is also proved. *Costică Mustăţa*

MR2896273 42-06 65-06 65T60

★Shearlets.

Multiscale analysis for multivariate data.

Edited by Gitta Kutyniok and Demetrio Labate.

Applied and Numerical Harmonic Analysis.

Birkhäuser/Springer, New York, 2012. *xx*+328 *pp.* €80.20. *ISBN* 978-0-8176-8315-3

Contents: Gitta Kutyniok and Demetrio Labate, Introduction to shearlets (1–38) MR2896274; Philipp Grohs, Shearlets and microlocal analysis (39–67) MR2896275;

Kanghui Guo and Demetrio Labate, Analysis and identification of multidimensional singularities using the continuous shearlet transform (69–103) MR2896276; Stephan Dahlke, Gabriele Steidl and Gerd Teschke, Multivariate shearlet transform, shearlet coorbit spaces and their structural properties (105–144) MR2896277; Gitta Kutyniok, Jakob Lemvig and Wang-Q Lim, Shearlets and optimally sparse approximations (145–197) MR2896278; Tomas Sauer, Shearlet multiresolution and multiple refinement (199–237) MR2896279; Gitta Kutyniok, Wang-Q Lim and Xiaosheng Zhuang, Digital shearlet transforms (239–282) MR2896280; Glenn R. Easley and Demetrio Labate, Image processing using shearlets (283–325) MR2896281.

{The papers are being reviewed individually.}

MR2876821 42A38 65D30 65T50

Singh, P. (SA-UKZND-SM; Durban)**;**
Singh, V. [Singh, Virath Sewnath] (SA-UKZND-SM; Durban)

A discrete Fourier transform based on Simpson's rule. (English summary)

Math. Methods Appl. Sci. **35** (2012), *no.* 2, 151–157.

Summary: "Fourier analysis plays a vital role in the analysis of continuous-time signals. In many cases, we are forced to approximate the Fourier coefficients based on a sampling of the time signal. Hence, the need for a discrete transformation into the frequency domain giving rise to the classical discrete Fourier transform. In this paper, we present a transformation that arises naturally if one approximates the Fourier coefficients of a continuous-time signal numerically using the Simpson quadrature rule. This results in a decomposition of the discrete signal into two sequences of equal length. We show that the periodic discrete time signal can be reconstructed completely from its discrete spectrum using an inverse transform. We also present many properties satisfied by this transform."

MR2861760 42C05 30G35 33C45 65D99

Brackx, F. [Brackx, Fred F.] (B-GHNTE-CRG; Ghent)**;**
De Schepper, H. [De Schepper, Hennie] (B-GHNTE-CRG; Ghent)**;**
Lávička, R. (CZ-KARLMP-MI; Prague)**; Souček, V.** (CZ-KARLMP-MI; Prague)

Gel′fand-Tsetlin bases of orthogonal polynomials in Hermitean Clifford analysis. (English summary)

Math. Methods Appl. Sci. **34** (2011), *no.* 17, 2167–2180.

Summary: "An explicit algorithmic construction is given for orthogonal bases for spaces of homogeneous polynomials, in the context of Hermitean Clifford analysis, which is a higher dimensional function theory centered around the simultaneous null solutions of two Hermitean conjugate complex Dirac operators." *Pascal Maroni*

MR2876509 42C05 26C10 33C45 65Q30

Haneczok, Maciej (B-KUL; Leuven (Heverlee))**;**
Van Assche, Walter (B-KUL; Leuven (Heverlee))

Interlacing properties of zeros of multiple orthogonal polynomials. (English summary)

J. Math. Anal. Appl. **389** (2012), *no.* 1, 429–438.

Multiple orthogonal polynomials are intimately related to Hermite-Padé approximants, so that they are also often called Hermite-Padé polynomials. There exist two types of multiple orthogonal polynomials, type I and type II [M. E.-H. Ismail, *Classical and quantum orthogonal polynomials in one variable*, Encyclopedia Math. Appl., 98, Cambridge Univ. Press, Cambridge, 2005; MR2191786 (2007f:33001)]. In this paper the authors obtain interlacing properties for the zeros of multiple orthogonal polynomials

of type II, monic polynomials of degree $|\vec{n}|$ satisfying

$$\int_{\mathbf{R}} x^k P_{|\vec{n}|}(x) d\mu_j(x) = 0, \quad 0 \le k \le n_j - 1, \quad j = 1, \dots, r,$$

with respect to r different positive Borel measures $(\mu_1, \dots, \mu_r)$ that are absolutely continuous with respect to a measure $d\mu$.

The main result is obtained for nearest neighbor recurrence relations [W. Van Assche, J. Approx. Theory **163** (2011), no. 10, 1427–1448; MR2832734 (2012h:42052)], which connect the type II multiple orthogonal polynomial $P_{\vec{n}}$ with the polynomial of degree one higher $P_{\vec{n}+\vec{e}_k}$ and all the neighbors of degree one lower $P_{\vec{n}-\vec{e}_j}$, for $j = 1, \dots, r$.

Under these conditions, the authors prove that the zeros of $P_{\vec{n}}$ and $P_{\vec{n}+\vec{e}_k}$ interlace for every k, $1 \le k \le r$, assuming that for the real recurrence coefficients $a_{\vec{n},k}$, $b_{\vec{n},k}$ one has $a_{\vec{n},j} > 0$ for all $1 \le j \le r$ and for all the multi-indices $\vec{n}$, whenever $n_j > 0$.

The positivity condition on $a_{\vec{n},j}$ to obtain interlacing properties is sufficient but not necessary, as indicated in the last section where multiple Hermite polynomials, multiple Charlier polynomials, multiple Meixner polynomials of the first and second kind, multiple Krawtchouk polynomials, and multiple Laguerre polynomials of the first and second kind are considered. *Iván Area*

MR2812539 42C40 65T60 68U10 94A08

Chen, Bo (PRC-SZU-MCP; Shenzhen)**; Chen, Wen-Sheng** (PRC-SZU-MCP; Shenzhen)

Noisy image segmentation based on wavelet transform and active contour model. (English summary)

Appl. Anal. **90** (2011), *no.* 8, 1243–1255.

Summary: "This article addresses the noisy image segmentation problems based on wavelet transform and active contour model. In order to get better results, this article proposes a new segmentation and selective smoothing algorithm. First, a new adaptive segmentation model based on grey-level image segmentation model is proposed, and this model can also be extended to the vector value image segmentation. By virtue of the prior information of regions and boundary of image, a framework is established to construct different segmentation models using different probability density functions. A segmentation model exploiting Gaussian probability density function is given in this article. A penalizing term is employed to replace the time-consuming reinitialization process. An efficient and unconditional stable algorithm based on locally one-dimensional scheme is developed and it is used to segment the grey image and the vector value image. Second, in each stage of segmentation process, wavelet denoising algorithms are employed for different sub-regions independently, so that better segmentation and smoothing results can be obtained. Comparing with existing classical model, the proposed approach gives the best performance."

MR2804724 42C40 65T60

Chuang, Zhitao [Chuang, Zhi-Tao] (PRC-NCWU-CMI; Zhengzhou)**;**
Liu, Youming (PRC-BJUT-AM; Beijing)

Spline wavelets with boundary values and vanishing moments. (English summary)

Int. J. Wavelets Multiresolut. Inf. Process. **9** (2011), *no.* 3, 501–529.

In this paper, the authors construct spline multiresolution analyses (MRA) with supports embedded in $[0, 1]$. That is, given a scaling function φ, an MRA on $\mathbb{R}$ is composed of embedded spaces $V_{j-1} \subset V_j \subset V_{j+1} \subset \cdots$ where, for $j \in \mathbb{Z}$, $V_j = \operatorname{span}\{\varphi_{j,k}, k \in \mathbb{Z}\}$, with $\varphi_{j,k}(x) = 2^{j/2}\varphi(2^j x - k)$. Here, the authors consider the MRA embedding $\tilde{V}_{j-1} \subset \tilde{V}_j \subset \tilde{V}_{j+1} \subset \cdots$ with $\tilde{V}_j = \operatorname{span}\{\varphi_{j,k}, k \in \mathbb{Z} \text{ such that } \operatorname{supp} \varphi_{j,k} \subset [0, 1]\}$.

Then, passing from $\mathbb{R}$ to $[0,1]$, the only difficulty left is the construction of boundary wavelets $\psi^{\mathrm{L}}_{j,k}$ next to 0 and $\psi^{\mathrm{R}}_{j,k}$ next to 1 respecting the number of vanishing moments of the initial wavelet ψ, and such that $\tilde{W}_j = \operatorname{span}\{\psi^{\mathrm{L}}_{j,k}\} \cup \{\psi^{\mathrm{R}}_{j,k}\} \cup \{\psi_{j,k}, k \in \mathbb{Z}, \operatorname{supp}\psi_{j,k} \subset [0,1]\}$ satisfies $\tilde{V}_{j+1} = \tilde{V}_j \oplus \tilde{W}_j$.

The authors apply this construction to a simple one-dimensional numerical experiment.

Although easy to read and understand, this work only provides a partial answer to the construction of wavelets on the interval. The absence of boundary scaling functions limits the interest of such a construction. *Erwan Deriaz*

MR2870159 42C40 41A15 65D07 65T60

Dem′yanovich, Yu. K. (RS-STPT-NDM; St. Petersburg)

On nonsmooth spline-wavelet decompositions and their properties. (Russian. English and Russian summaries)

Zap. Nauchn. Sem. S.-Peterburg. Otdel. Mat. Inst. Steklov. (*POMI*) **395** (2011), *Chislennye Metody i Voprosy Organizatsii Vychisleniĭ. XXIV*, 31–60, 173; *translation in J. Math. Sci.* (*N. Y.*) **182** (2012), *no.* 6, 761–778.

Wavelets are functions generated by translating and dilating a function. In this paper, the author gives wavelet decompositions for some nonsmooth and nonpolynomial splines. Moreover, the commutativity of the decomposition operators is established.

Paşc Găvruţa

MR2769571 42C40 65K10 65T60 94A08

Plonka, Gerlind (D-GTN-N; Göttingen)**; Ma, Jianwei** (PRC-TSI-SAE; Beijing)

Curvelet-wavelet regularized split Bregman iteration for compressed sensing. (English summary)

Int. J. Wavelets Multiresolut. Inf. Process. **9** (2011), *no.* 1, 79–110.

Summary: "Compressed sensing is a new concept in signal processing. Assuming that a signal can be represented or approximated by only a few suitably chosen terms in a frame expansion, compressed sensing allows one to recover this signal from much fewer samples than the Shannon-Nyquist theory requires. Many images can be sparsely approximated in expansions of suitable frames as wavelets, curvelets, wave atoms and others. Generally, wavelets represent point-like features while curvelets represent line-like features well. For a suitable recovery of images, we propose models that contain weighted sparsity constraints in two different frames. Given the incomplete measurements $f = \Phi u + \varepsilon$ with the measurement matrix $\Phi \in \mathbb{R}^{K \times N}$, $K \ll N$, we consider a jointly sparsity-constrained optimization problem of the form $\operatorname{argmin}_u\{\|\Lambda_c \Psi_c u\|_1 + \|\Lambda_w \Psi_w u\|_1 + \frac{1}{2}\|f - \Phi u\|_2^2\}$. Here Ψ_c and Ψ_w are the transform matrices corresponding to the two frames, and the diagonal matrices Λ_c, Λ_w contain the weights for the frame coefficients. We present efficient iteration methods to solve the optimization problem, based on Alternating Split Bregman algorithms. The convergence of the proposed iteration schemes will be proved by showing that they can be understood as special cases of the Douglas-Rachford Split algorithm. Numerical experiments for compressed sensing-based Fourier-domain random imaging show good performances of the proposed curvelet-wavelet regularized split Bregman (CWSpB) methods, where we particularly use a combination of wavelet and curvelet coefficients as sparsity constraints."

MR2804718 42C40 65T60 68T45

Sun, Yankui [Sun, Yan Kui] (PRC-TSI-CT; Beijing)**; Chen, Yong; Feng, Hao**

Two-dimensional stationary dyadic wavelet transform, decimated dyadic discrete wavelet transform and the face recognition application. (English summary)

Int. J. Wavelets Multiresolut. Inf. Process. **9** (2011), *no.* 3, 397–416.

Summary: "Currently, two-dimensional dyadic wavelet transform (2D-DWT) is habitually considered as the one presented by Mallat, which is defined by an approximation component, two detail components in horizontal and vertical directions. This paper is to introduce a new type of two-dimensional dyadic wavelet transform and its application so that dyadic wavelet can be studied and used widely furthermore. (1) Two-dimensional stationary dyadic wavelet transform (2D-SDWT) is proposed; it is defined by approximation coefficients, detail coefficients in horizontal, vertical and diagonal directions, which is essentially the extension of two-dimensional stationary wavelet transform for orthogonal/biorthogonal wavelet filters. (2) ε-decimated dyadic discrete wavelet transform (DDWT) is introduced and its relation with 2D-SDWT is given, where ε is a sequence of 0's and 1's. (3) Mallat decomposition algorithm based on dyadic wavelet is introduced as a special case of ε-decimated DDWT, and so a face recognition algorithm based on dyadic wavelet is proposed, and experimental results are given to show its effectiveness."

MR2853498 45D05 45L05 65Q20 65R20

Yang, Kai (PRC-JIL; Changchun)**; Zhang, Ran [Zhang, Ran[1]]** (PRC-JIL; Changchun)

Analysis of continuous collocation solutions for a kind of Volterra functional integral equations with proportional delay. (English summary)

J. Comput. Appl. Math. **236** (2011), *no.* 5, 743–752.

In the paper, a functional equation

$$y(t) = b(t, y(qt)) + f(t), \quad t \in (0, T),\ 0 < q < 1,$$

and its perturbation, obtained by introducing the Volterra-type integral terms,

$$y(t) = b(t, y(qt)) + f(t) + \int_0^t K_0(t, s)y(s)ds + \int_0^{qt} K_1(t, s)y(s)ds,$$

are investigated. First, the existence, uniqueness and regularity of solutions for these equations are studied. Next, the convergence of the piecewise linear collocation method applied to their approximate solution is analyzed. For illustration of the theoretical results, some numerical examples are provided. *Wojciech Mydlarczyk*

MR2764683 47A10 65J10 65N25

Boulton, Lyonell [Boulton, Lyonell S.] (4-HWAT; Edinburgh)**;**
Strauss, Michael (4-STRA-MS; Glasgow)

On the convergence of second-order spectra and multiplicity. (English summary)

Proc. R. Soc. Lond. Ser. A Math. Phys. Eng. Sci. **467** (2011), *no.* 2125, 264–284.

Summary: "The notion of second-order relative spectrum of a self-adjoint operator acting on a Hilbert space has been studied recently in connection with the phenomenon of spectral pollution in the Galerkin method. In this paper we examine how the second-order spectrum encodes precise information about the multiplicity of the isolated eigenvalues of the underlying operator. Our theoretical findings are supported by various numerical experiments on the computation of guaranteed eigenvalue inclusions via finite element bases."

MR2851909 47A10 34A55 65J22

Iantchenko, Alexei;
Korotyaev, Evgeny [Korotyaev, E. L.] (RS-STPT-NDM; St. Petersburg)

Periodic Jacobi operator with finitely supported perturbation on the half-lattice. (English summary)

Inverse Problems **27** (2011), *no.* 11, 115003, 26 *pp.*

Summary: "We consider a periodic Jacobi operator J with finitely supported perturbations on the half-lattice. We describe all eigenvalues and resonances of J and give their properties. We solve the inverse resonance problem: we prove that the mapping from finitely supported perturbations to the Jost functions is one-to-one and onto, we show how the Jost functions can be reconstructed from all eigenvalues, resonances and from the set of zeros of $S(\lambda) - 1$, where $S(\lambda)$ is the scattering matrix." *Rudi M. Brits*

MR2906701 47A52 65J20

Solodkiĭ, Sergeĭ G. (UKR-AOS; Kiev)**; Grushevaya, Anna V.** (UKR-AOS; Kiev)

On an a posteriori choice of regularization parameter in the solution of severely ill-posed problems. (Russian. English and Russian summaries)

Ukr. Mat. Visn. **8** (2011), *no.* 3, 447–457, 462; *translation in J. Math. Sci. (N. Y.)* **181** (2012), *no.* 1, 98–105.

This paper considers severely ill-posed problems of the form $Ax = y$, where $A \in \mathcal{L}(X; Y)$ is an injective linear compact infinitely smoothing operator between Hilbert spaces X and Y. It is supposed that for y only an approximation y_δ is available, satisfying the inequality $\|y - y_\delta\| \le \delta$. The problem is regularized by the Tikhonov method computing $x_\alpha^\delta = (\alpha I + A_n^* A_n)^{-1} A_n^* y_\delta$, where A_n is some finite-dimensional approximation of operator A. The regularization parameter α is chosen by the balancing principle [see S. V. Pereverzev and E. Schock, SIAM J. Numer. Anal. **43** (2005), no. 5, 2060–2076; MR2192331 (2007b:65056)]. Order-optimal error estimates are given. *Uno Hämarik*

MR2746693 47D62 34G10 65J20

Li, Miao [Li, Miao^2] (PRC-SUN; Chengdu)**;**
Morozov, Vladimir [Morozov, Vladimir A.] (RS-MOSC-C; Moscow)**;**
Piskarev, Sergey [Piskarëv, S. I.] (RS-MOSC-C; Moscow)

On the approximations of derivatives of integrated semigroups. (English summary)

J. Inverse Ill-Posed Probl. **18** (2010), *no.* 5, 515–550.

Regularized solutions to the Cauchy problem in Banach spaces for the equation $u_t'(t) = Au(t)$ with A generating a 1-time integrated semigroup are constructed. Results from [M. Li and S. I. Piskarëv, Taiwanese J. Math. **14** (2010), no. 6, 2137–2161; MR2742356 (2012b:47116)] are used to construct approximations to the integrated semigroup. Direct methods and Tikhonov's method, along with properties of integrated semigroups, are used to construct an approximate solution to the Cauchy problem via the integrated semigroup approximations. The order of convergence with respect to regularized parameters is obtained. *Irina V. Melnikova*

MR2879338 47J25 49M30 65K05 90C25

Cabot, A. [Cabot, Alexandre] (F-MONT2; Montpellier)**;**
Frankel, P. [Frankel, Pierre] (F-MONT2; Montpellier)

Alternating proximal algorithms with asymptotically vanishing coupling. Application to domain decomposition for PDE's. (English summary)

Optimization **61** (2012), *no.* 3, 307–325.

Summary: "Let $\mathcal{X}$, $\mathcal{Y}$, $\mathcal{Z}$ be real Hilbert spaces, let $f\colon \mathcal{X} \to \mathbb{R} \cup \{+\infty\}$, $g\colon \mathcal{Y} \to \mathbb{R} \cup \{+\infty\}$

be closed convex functions and let $A\colon \mathcal{X} \to \mathcal{Z}$, $B\colon \mathcal{Y} \to \mathcal{Z}$ be linear continuous operators. Given a sequence (γ_n) which increases towards infinity as $n \to +\infty$, we study the following alternating proximal algorithm:

$$(\mathcal{A}) \qquad \begin{cases} x_{n+1} = \\ \quad \operatorname{argmin}\left\{ f(\zeta) + \frac{1}{2\gamma_{n+1}}\|A\zeta - By_n\|_{\mathcal{Z}}^2 + \frac{\alpha}{2}\|\zeta - x_n\|_{\mathcal{X}}^2;\ \zeta \in \mathcal{X} \right\} \\ y_{n+1} = \\ \quad \operatorname{argmin}\left\{ g(\eta) + \frac{1}{2\gamma_{n+1}}\|Ax_{n+1} - B\eta\|_{\mathcal{Z}}^2 + \frac{\nu}{2}\|\eta - y_n\|_{\mathcal{Y}}^2;\ \eta \in \mathcal{Y} \right\}, \end{cases}$$

where α and ν are positive parameters. If the sequence (γ_n) increases *moderately slowly* towards infinity, the algorithm $(\mathcal{A})$ tends to minimize the function $(x, y) \mapsto \|Ax - By\|_{\mathcal{Z}}^2$ over the set $C = \operatorname{argmin} f \times \operatorname{argmin} g$ (assumed to be nonempty). An illustration of this result is given in the area of domain decomposition for PDE's.

MR2811225 47J25 47J20 49J40 65K15

Chidume, C. E. (I-ICTP; Trieste)**; Chidume, C. O.** (1-ABRN-S; Auburn, AL)**; Ali, Bashir** (WAN-BAY; Kano)

Convergence of hybrid steepest descent method for variational inequalities in Banach spaces. (English summary)

Appl. Math. Comput. **217** (2011), *no.* 23, 9499–9507.

Summary: "Let E be a q-uniformly smooth real Banach space with constant d_q, $q > 1$. Let $T_i\colon E \to E$, $i = 1, 2, \ldots, r$ be a finite family of nonexpansive mappings with $K := \bigcap_{i=1}^{r} Fix(T_i) \neq \varnothing$ and $K = Fix(T_rT_{r-1}\ldots T_1) = Fix(T_1T_r\ldots T_2) = \cdots = Fix(T_{r-1}T_{r-2}\ldots T_r)$. Let $G\colon E \to E$ be an η-strongly accretive map which is also κ-Lipschitzian. A hybrid steepest descent method introduced by I. Yamada [in *Inherently parallel algorithms in feasibility and optimization and their applications (Haifa, 2000)*, 473–504, Stud. Comput. Math., 8, North-Holland, Amsterdam, 2001; MR1853237 (2002j:49019)] and studied by various authors is proved to converge strongly to the unique solution of the variational inequality problem $VI(G, K)$ in q-uniformly smooth real Banach space, in particular, in L_p spaces $1 < p < \infty$."

MR2861824 47J25 49J40 52A41 65K10 90C25 90C48

Frankel, Pierre (F-MONT2; Montpellier)

Alternating proximal algorithm with costs-to-move, dual description and application to PDE's. (English summary)

Discrete Contin. Dyn. Syst. Ser. S **5** (2012), *no.* 3, 545–557.

Let $\mathcal{X}$, Y, Z be real Hilbert spaces. Given closed convex proper functions $f\colon \mathcal{X} \to \mathbb{R} \cup \{+\infty\}$, $g\colon \mathcal{Y} \to \mathbb{R} \cup \{+\infty\}$ and linear continuous operators $A\colon \mathcal{X} \to \mathcal{Z}$, $B\colon \mathcal{Y} \to \mathcal{Z}$, the author considers the convex function $\Phi\colon \mathcal{X} \times \mathcal{Y} \to \mathbb{R} \cup \{+\infty\}$ defined by

$$\Phi(x, y) = f(x) + g(y) + \frac{1}{2\gamma}\|Ax - By\|_{\mathcal{Z}}^2,$$

where γ is a positive real parameter, and studies the following alternating proximal algorithm:

$$(\mathcal{A}) \begin{cases} x_{n+1} = \operatorname{argmin}\{f(\zeta) + \frac{1}{2\gamma}\|A\zeta - By_n\|_{\mathcal{Z}}^2 + \frac{\alpha}{2}\|\zeta - x_n\|_{\mathcal{X}}^2; \zeta \in \mathcal{X}\}, \\ y_{n+1} = \operatorname{argmin}\{g(\eta) + \frac{1}{2\gamma}\|Ax_{n+1} - B\eta\|_{\mathcal{Z}}^2 + \frac{\nu}{2}\|\eta - y_n\|_{\mathcal{Y}}^2; \eta \in \mathcal{Y}\}, \end{cases}$$

where $\alpha, \nu > 0$ and $(x_0, y_0) \in \mathcal{X} \times \mathcal{Y}$. The author supposes that Φ is bounded from below and proves that any sequence (x_n, y_n) generated by $(\mathcal{A})$ weakly converges toward a minimum point of the function Φ and that the sequence of dual variables $(-\frac{1}{\gamma}(Ax_n - By_n))$ strongly converges in $\mathcal{Z}$ toward the unique minimizer of the function $z \mapsto f^*(A^*z) +$

$g^*(-B^*z) + \frac{\gamma}{2}\|z\|_Z^2$.

In the last section the author shows how algorithm $(\mathcal{A})$ can be applied so as to solve the variational problem

$$\min\left\{\frac{1}{2}\int_{\Omega_1}|\nabla u|^2 + \frac{1}{2}\int_{\Omega_2}|\nabla v|^2 + \frac{1}{2\gamma}\int_\Gamma [w]^2 - \int_\Omega hw; \right.$$
$$\left. u \in H^1(\Omega_1),\ v \in H^1(\Omega_2)\right\}$$

where

$$w = \begin{cases} u \text{ on } \Omega_1, \\ v \text{ on } \Omega_2 \end{cases}$$

and $[w]$ = jump of w through the interface Γ. *Petr Tomiczek*

MR2837793 49J20 49J15 49M05 65K10 93B11

De Los Reyes, Juan Carlos [de los Reyes, Juan Carlos]; Stykel, Tatjana (D-TUB-IM; Berlin)

A balanced truncation-based strategy for optimal control of evolution problems. (English summary)

Optim. Methods Softw. **26** (2011), *no.* 4-5, 671–692.

The authors investigate optimal control problems for nonlinear parabolic partial differential equations. They use the balanced truncation method to reduce the number of unknowns in a discretization of the equation. To solve the problem numerically, a BFGS method is used, where the gradients of the cost functional are computed by means of a reduced system. This method is used for numerical experiments. The results are compared to those obtained with gradients computed using the full discrete system. It is observed that the computing time is reduced by roughly 50% when using the reduced system, while the accuracy is comparable. *Daniel Wachsmuth*

MR2837569 49J21 49J40 49M15 65K15 90C33

De Los Reyes, Juan Carlos [de los Reyes, Juan Carlos]

Optimal control of a class of variational inequalities of the second kind. (English summary)

SIAM J. Control Optim. **49** (2011), *no.* 4, 1629–1658.

This paper is devoted to the derivation of optimality conditions for, and the numerical simulation of, solutions of an optimal control problem subject to a variational inequality of the second kind. The author describes these problems and introduces a family of regularized primal-dual problems. He proves the convergence of the solutions of these regularized problems to the solution of the original problem. This is used to obtain optimality conditions for the original control problem.

The author describes some specific cases that model the control of viscoplastic flows and of a simplified friction problem. The regularized problems involve differentiable functions, so numerical algorithms that are based on Newton type methods are proposed for approximating the solutions. Results for a numerical example are described.

Giles Auchmuty

MR2908528 49J40 65K15

Nguyen Quang Huy (VN-HPEDU2-M; Hanoi)**; Nguyen Dong Yen** (VN-HMI; Hanoi)

Minimax variational inequalities. (English summary)

Acta Math. Vietnam. **36** (2011), *no.* 2, 265–281.

Summary: "We introduce a new notion called *minimax variational inequality* (MVI).

The solution existence of nonmonotone MVIs in Euclidean spaces, pseudomonotone MVIs in reflexive Banach spaces, and strongly monotone MVIs in Hilbert spaces is studied in detail. We show that MVIs can serve as a good tool for studying minimax problems given by convex sets and differentiable functions."

MR2826667 49K20 35K05 65K05

Nazemi, A. R. [**Nazemi, Alireza**] (IR-SHUT-MSM; Shahroud)

LP modelling for the time optimal control problem of the heat equation. (English summary)

J. Math. Model. Algorithms **10** (2011), *no.* 3, 227–244.

Summary: "To find a control function which puts the heat equation in an unknown minimum time into a stationary regime is considered. Using an embedding method, the problem of finding the time optimal control is reduced to one consisting of minimizing a linear form over a set of positive measures. The resulting problem can be approximated by a finite dimensional linear programming (LP) problem. The nearly optimal control is constructed from the solution of the final LP problem. To find the lower bound of the optimal time a search algorithm is proposed. Some examples demonstrate the effectiveness of the method."

MR2843961 49M05 49M25 65K10 65N22

Borzì, A. [**Borzì, Alfio**] (I-SANE; Benevento)**;**
Schulz, V. [**Schulz, Volker H.**] (D-TRR-NDM; Trier)**;**
Schillings, C. [**Schillings, Claudia**] (D-TRR-NDM; Trier)**;**
von Winckel, G. (A-GRAZ-IMS; Graz)

On the treatment of distributed uncertainties in PDE-constrained optimization. (English summary)

GAMM-Mitt. **33** (2010), *no.* 2, 230–246.

The authors consider optimal control problems of the type $\min_{y,u} J(y,u)$ subject to the PDE constraint $c(y,u)=0$, where $y=y(u)$ is the state variable and u is the control variable. The cost functional J and the constraint function c depend also on a random variable σ, which represents "pollution" of data. A standard approach is to find

$$u_0 := \arg\min\{J(y,u,\sigma_0) \mid c(y,u,\sigma_0)=0\}, \tag{1}$$

where $\sigma_0=\mathbb{E}(\sigma)$ is the mean of σ. In the paper, the authors investigate two different formulations:

$$\overline{u} := \mathbb{E}(\arg\min\{J(y,u,\sigma) \mid c(y,u,\sigma)=0\}) \tag{2}$$

and

$$\widehat{u} := \arg\min \mathbb{E}(\{J(y,u,\sigma) \mid c(y,y,\sigma)=0\}). \tag{3}$$

In general u_0, $\overline{u}$ and $\widehat{u}$ are different. Formulation (2) is applied in a discrete setting to a parabolic optimal control with random coefficients, and formulation (3) to an aerodynamic shape optimization problem. Numerical simulations are performed in both cases. *Morgan Pierre*

MR2817312 49M15 49M27 65N30 65N55

Chang, Huibin (PRC-ECNU; Shanghai)**; Yang, Danping** (PRC-ECNU; Shanghai)

A Schwarz domain decomposition method with gradient projection for optimal control governed by elliptic partial differential equations. (English summary)

J. Comput. Appl. Math. **235** (2011), *no.* 17, 5078–5094.

A distributed optimal control problem governed by an elliptic PDE is considered. The

corresponding bounded and open domain belongs to $\mathbb{R}^n$ with $n = 1, 2, 3$. The control is constrained and the cost functional is a quadratic one. The authors propose an algorithm for the numerical approximation consisting of two iterative stages. In the inner loops, the Schwarz alternating method is used to solve the state and the adjoint variables, while in the outer loops the gradient projected algorithm is used to obtain the control variable. The convergence of the algorithm is obtained and the L^2 convergence rate for the control is derived. Numerical experiments are presented. *Viorel Arnautu*

MR2861355 49M20 65J20 65K15 90C30 94A12

Luke, D. Russell (D-GTN-N; Göttingen)

Local linear convergence of approximate projections onto regularized sets. (English summary)

Nonlinear Anal. **75** (2012), *no.* 3, 1531–1546.

In Hilbert spaces, the method of alternating projections onto two intersecting closed convex sets has been studied extensively. The main result is this area is that the alternating sequence thus produced converges weakly (strongly and even linearly if additional regularity conditions are imposed) to a point in the intersection of the sets. In the nonconvex case in Euclidean spaces, local convergence results have been established, including local linear convergence if certain regularity conditions are satisfied. In this paper, the author focuses on ill-conditioning issues that may force the intersection of the sets to fail to satisfy such regularity conditions, as in the case when the sets are based on noisy measurements in signal recovery and may even turn out to have an empty intersection. He proposes a regularization procedure that expands one of the sets in such a way as to create sufficient regularity on the intersection. Local convergence of an approximate algorithm is demonstrated and stopping rules are proposed. Applications to phase retrieval are discussed. *Patrick L. Combettes*

MR2877845 49M25 65K15 65N55

Badea, Lori (R-AOS; Bucharest)

Multigrid methods with constraint level decomposition for variational inequalities. (English summary)

Ann. Acad. Rom. Sci. Ser. Math. Appl. **3** (2011), *no.* 2, 300–331.

Summary: "In this paper we introduce four multigrid algorithms for the constrained minimization of non-quadratic functionals. These algorithms are combinations of additive or multiplicative iterations on levels with additive or multiplicative ones over the levels. The convex set is decomposed as a sum of convex level subsets, and consequently, the algorithms have an optimal computing complexity. The methods are described as multigrid V-cycles, but the results hold for other iteration types, the W-cycle iterations, for instance. We estimate the global convergence rates of the proposed algorithms as functions of the number of levels, and compare them with the convergence rates of other existing multigrid methods. Even if the general convergence theory holds for convex sets which can be decomposed as a sum of convex level subsets, our algorithms are applied to the one-obstacle problems because, for these problems, we are able to construct optimal decompositions. But, in this case, the convergence rates of the methods introduced in this paper are better than those of the methods we know in the literature."

MR2854136 49M25 65K10 65N55

Butt, M. M. (A-GRAZ-IMS; Graz); **Borzì, A.** [**Borzì, Alfio**] (D-WRZB-IM; Würzburg)

A full multigrid solution of control-constrained Cauchy-Riemann optimal control problems. (English summary)

J. Numer. Math. **19** (2011), *no.* 3, 189–214.

Summary: "The formulation as well as full-multigrid solution of a control-constrained Cauchy-Riemann optimal control problem is presented. A constrained distributed control mechanism through divergence and curl sources is considered with mixed boundary conditions. The corresponding optimal solutions are obtained by solving a Cauchy-Riemann optimality system consisting of four first-order partial differential equations and two inequality constraints. For the solution of the optimality system, staggered grids and a full-multigrid scheme are considered. The proposed full-multigrid method is based on a coarsening strategy by a factor of three that results in a nested hierarchy of staggered grids. The smoothing procedure consists of a distributed Gauss-Seidel scheme for the state and adjoint equations and a projected gradient step for the controls. Numerical results validate the effectiveness of the proposed approach." *Martin Gugat*

MR2862666 49M25 65N15 65N30

Deng, Kang (PRC-HNUST-SM; Xiangtan);
Chen, Yanping [Chen, Yan Ping[1]] (PRC-SCN-SM; Guangzhou);
Lu, Zuliang (PRC-CTGU-CMC; Chongqing)

Higher order triangular mixed finite element methods for semilinear quadratic optimal control problems. (English summary)

Numer. Math. Theory Methods Appl. **4** (2011), *no.* 2, 180–196.

In the paper, the authors investigate a priori error estimates for a quadratic optimal control problems governed by a semilinear elliptic partial differential equation when higher-order triangular mixed finite element methods are applied. The state and the co-state are approximated by order-k Raviart-Thomas mixed finite element spaces and the control is approximated by piecewise polynomials of order k ($k \geq 0$). A priori error estimates for the mixed finite element approximation are obtained. Finally, some numerical examples are presented to confirm the theoretical results. *Zhi-Gang Wu*

MR2863107 49M25 65M15 65M60

Fu, Hongfei [Fu, Hong Fei];
Rui, Hongxing [Rui, Hong Xing] (PRC-SHAN-SM; Jinan)

Finite element approximation of semilinear parabolic optimal control problems. (English summary)

Numer. Math. Theory Methods Appl. **4** (2011), *no.* 4, 489–504.

The authors study error estimates for a finite element discretization of an optimal control problem governed by a semilinear parabolic partial differential equation with a convex objective function. Convergence rates in terms of the discretization parameter are obtained. *Arnd Rösch*

MR2861641 49M25 35Q30 65N30 76D55 93E20

Gunzburger, Max [Gunzburger, Max D.] (1-FLS-SCP; Tallahassee, FL);
Ming, Ju (1-FLS-SCP; Tallahassee, FL)

Optimal control of stochastic flow over a backward-facing step using reduced-order modeling. (English summary)

SIAM J. Sci. Comput. **33** (2011), *no.* 5, 2641–2663.

This paper considers an optimal control problem involving Navier-Stokes equations with a stochastic (in time) boundary condition involving Brownian white noise. A finite

element method is presented to approximate the forward problem, and a POD method is used to produce a stochastic reduced-order model for computations. A gradient-based optimization algorithm is used to compute the optimal control, and is presented in full detail. Many computational results are given illustrating the method.

Shawn W. Walker

MR2843956 49M25 35Q93 49K20 65K10

Hinze, Michael (D-HAMB; Hamburg)**; Tröltzsch, Fredi** (D-HAMB; Hamburg)

Discrete concepts versus error analysis in PDE-constrained optimization. (English summary)

GAMM-Mitt. **33** (2010), *no.* 2, 148–162.

The paper contains a survey on discretization concepts for optimal control problems governed by partial differential equations. In particular, variational discretization, piecewise constant control discretizations, and finite-dimensional controls are discussed. The authors outline the basic ideas for deriving a priori error estimates. Numerical results illustrate the theory. *Arnd Rösch*

MR2863104 49M25 65K10 65N15 65N30

Hou, Tianliang (PRC-XIA-CPE; Xiangtan)**;**
Chen, Yanping [Chen, Yan Ping[1]] (PRC-SCN-SM; Guangzhou)**;**
Huang, Yunqing [Huang, Yun Qing] (PRC-XIA-CPE; Xiangtan)

A posteriori error estimates of mixed methods for quadratic optimal control problems governed by parabolic equations. (English summary)

Numer. Math. Theory Methods Appl. **4** (2011), *no.* 4, 439–458.

Summary: "In this paper, we discuss the a posteriori error estimates of the mixed finite element method for quadratic optimal control problems governed by linear parabolic equations. The state and the co-state are discretized by the high order Raviart-Thomas mixed finite element spaces and the control is approximated by piecewise constant functions. We derive a posteriori error estimates for both the state and the control approximation. Such estimates, which are apparently not available in the literature, are an important step towards developing reliable adaptive mixed finite element approximation schemes for the control problem."

MR2871837 49M25 49M37 65L60

Shamsi, M. (IR-AUTMC-AM; Tehran)

A modified pseudospectral scheme for accurate solution of bang-bang optimal control problems. (English summary)

Optimal Control Appl. Methods **32** (2011), *no.* 6, 668–680.

The numerical approach proposed in this paper for solving bang-bang optimal control problems belongs to the class of direct methods in optimal control. In the discretization model, on each bang-arc the control is assumed to be constant. Using Legendre polynomials with Gauss-Lobatto collocation points for both the state variables and the right-hand side function in the dynamics, the control can be piecewisely integrated and inserted into a Mayer-type objective functional. Numerical tests show how a wrong guess of the number of control switches can be detected. Heuristics are given for correction of the guess and illustrated by examples. However, there is no evidence that the method yields an accurate bang-bang structure or could exclude, e.g., singular control arcs. *Ursula Felgenhauer*

MR2872589 49M25 49K20 65N06 65N55

Vallejos, Michelle (PH-PHIL-IM; Quezon City)

Multigrid methods for elliptic optimal control problems with pointwise state constraints. (English summary)

Numer. Math. Theory Methods Appl. **5** (2012), *no.* 1, 99–109.

This paper adapts two methods (multigrid for optimization (MGOPT) and collective smoothing multigrid) for solving state-constrained elliptic optimal control problems. Even though the paper refers to elliptic problems, it actually considers just the homogeneous Laplacian. The optimal control functional is modified by adding a Lavrent′ev-type regularization term in order to better handle the state-constraints. The optimality system for collective smoothing multigrid is clearly stated and its discretization is easy to follow. A modified version of FAS is utilized for solving the control system using the MGOPT method. *Miguel A. Dumett*

MR2837792 49Q10 49M25 65N55 76D07

Antil, H. (1-RICE-CP; Houston, TX)**; Heinkenschloss, M.** (1-RICE-CP; Houston, TX)**; Hoppe, R. H. W. [Hoppe, Ronald H. W.]** (1-HST; Houston, TX)

Domain decomposition and balanced truncation model reduction for shape optimization of the Stokes system. (English summary)

Optim. Methods Softw. **26** (2011), *no.* 4-5, 643–669.

The paper is concerned with the numerical solution of a class of shape optimization problems governed by the time-dependent Stokes or the time-dependent linearized Navier-Stokes equations, of the form

$$\inf_{\theta\in\Theta} J(\theta),\ J(\theta)=\int_0^T\int_{\Omega(\theta)} l(\mathbf{v}(\theta),p(\theta),x,t)\,dx\,dt,$$
$$\frac{\partial}{\partial t}\mathbf{v}(x,t)-\nu\Delta\mathbf{v}(x,t)+\nabla p(x,t)=\mathbf{f}(x,t),\ (x,t)\in Q(\theta),$$
$$\nabla\cdot\mathbf{v}(x,t)=0,\ (x,t)\in Q(\theta),$$
$$\mathbf{v}(x,t)=\mathbf{v}_{\mathrm{in}}(x,t),\ (x,t)\in\Sigma_{\mathrm{in}}(\theta),\ \mathbf{v}(x,t)=0,\ (x,t)\in\Sigma_{\mathrm{lat}}(\theta),$$
$$(\nu\nabla\mathbf{v}(x,t)-p(x,t)I)\mathbf{n}=0,\ (x,t)\in\Sigma_{\mathrm{lat}}(\theta),$$
$$\mathbf{v}(x,0)=0,\ x\in\Omega(\theta).$$

The domain decomposition in space is used in order to reduce the computational complexity. *Igor Bock*

MR2806573 49Q10 49J40 65K15

Hintermüller, M. [Hintermüller, Michael] (D-HUMB; Berlin)**; Laurain, A.** (A-GRAZ-MSP; Graz)

Optimal shape design subject to elliptic variational inequalities. (English summary)

SIAM J. Control Optim. **49** (2011), *no.* 3, 1015–1047.

Summary: "The shape of the free boundary arising from the solution of a variational inequality is controlled by the shape of the domain where the variational inequality is defined. Shape and topological sensitivity analysis is performed for the obstacle problem and for a regularized version of its primal-dual formulation. The shape derivative for the regularized problem can be defined and converges to the solution of a linear problem. These results are applied to an inverse problem and to the electrochemical machining problem."

MR2854276 51N15 14J25 51N20 65D17 65D18 68U05 68U07

Albrecht, Gudrun (F-VALN-LMA; Valenciennes)

Geometric invariants of parametric triangular quadric patches. (English summary)

Int. Electron. J. Geom. **4** (2011), *no.* 2, 63–84.

A rational parametric plot $\mathbf{p}\colon \mathbb{R}^2 \to \mathbb{R}^3$ of the form

$$(u,v) \mapsto \left(\frac{p_1(u,v)}{p_0(u,v)}, \frac{p_2(u,v)}{p_0(u,v)}, \frac{p_3(u,v)}{p_0(u,v)} \right)$$

maps a coordinate patch in the u,v-plane to a surface in space. It is well known that when $p_0, \ldots, p_3$ are quadratic polynomials, the image is generally contained in a real quartic called a Steiner surface, and that degenerate cases, where the image is contained in a cubic or quadric surface, can occur when $p_0, \ldots, p_3$ have common zeros, called base points of the parametrization.

This paper considers the quadric case, with a view toward application in computer-aided geometric design, and solves the following two geometric construction problems. Given a quadratic rational parametrization $\mathbf{p}$ of a patch on a general central quadric in $\mathbb{R}^3$, find the quadric's center and the directions of its principal axes. The solutions take advantage of the geometry of the base point locus, and use methods of classical real projective geometry without algebraic implicitization. The constructions necessarily fall into finitely many cases depending on the affine type of quadric, and analogous properties are considered for rotationally symmetric or non-central quadrics. The step in the algorithm where the quadric's affine type is determined is the topic of an earlier article by the same author [Comput. Aided Geom. Design **15** (1998), no. 7, 675–697; MR1632733 (99e:65190)], to which this article is a natural sequel.

There are clear diagrams that illustrate the lines and (possibly imaginary) conics that appear in the various cases of the construction, and the paper concludes with some examples showing computer algebra steps leading to numerical solutions.

Adam Coffman

MR2882664 52A39 65H20 90C05

Lee, Tsung-Lin (RC-SYS-AM; Kaohsiung)**; Li, Tien-Yien** (1-MIS; East Lansing, MI)

Mixed volume computation in solving polynomial systems. (English summary)

Randomization, relaxation, and complexity in polynomial equation solving, 97–112, *Contemp. Math.*, 556, *Amer. Math. Soc.*, *Providence*, *RI*, 2011.

Summary: "The idea of *dynamic enumeration* of all mixed cells for the mixed volume computation was introduced by T. Mizutani, A. Takeda and M. Kojima [Discrete Comput. Geom. **37** (2007), no. 3, 351–367; MR2301523 (2008b:52012)], and the resulting software package DEMiCs exhibited its superiority over the then fastest mixed volume computation code MixedVol [T. Gao, T.-Y. Li and M. Wu, ACM Trans. Math. Software **31** (2005), no. 4, 555–560; MR2272345 (2007j:65059)]. The fundamental approaches for the mixed volume computation in DEMiCs and MixedVol are very different. In this article, we developed a version of dynamic enumeration for the algorithm in MixedVol. Illustrated by the numerical results, the resulting new code MixedVol-2.0 has reached the speed range of DEMiCs. But, more importantly, results show that MixedVol-2.0 appears to be much reliable for accurate mixed volume computations."

{For the entire collection see MR2885268 (2012i:65003).}

MR2876348 52C22 52B55 52B70 65D17 65N50

Schiffer, T. (A-TGRZ-CGK; Graz); **Aurenhammer, F.** (A-TGRZ-TI; Graz); **Demuth, M.** [**Demuth, Markus**] (A-TGRZ-TI; Graz)

Computing convex quadrangulations. (English summary)

Discrete Appl. Math. **160** (2012), *no.* 4-5, 648–656.

In contrast to triangulation of the plane, quadrangulations are much less studied. Here the authors consider the problem of building a quadrangulation on a given plane point set. The easy counting argument gives that the number of vertices has to be even and in that case one can prove the existence of a quadrangulation.

Hence the authors focus on the problem of constructing convex quadrangulations. Such convex quadrangulations do not necessarily exist and one may have to add some Steiner points in order to obtain one. It is known that $\lceil (n-3)/2 \rceil$ Steiner points may be necessary and $3\lfloor n/2 \rfloor$ are always sufficient.

Here the authors propose an efficient algorithm for building a strictly convex quadrangulation on a finite plane set. The idea is to add one coordinate z to the point of the plane and to construct a Delaunay tessellation for the 3-dimensional point set. The intersection graph (in the projection) is then built on the valid quadrangles. An independent point set is computed on the intersection graph by a heuristic greedy method.

The implementation is compared with the pairing method on various point sets, and the methods of choosing the height function z are discussed. *Mathieu Dutour Sikirić*

MR2875912 53A07 65D17

Abdel-All, Nassar H. [**Abdel-All, Nassar Hassan**] (ET-ASIS; Assiut); **Badr, Sayed Abdel-Naeim** (ET-ASIS; Assiut); **Soliman, M. A.** [**Soliman, Mohamed Abdel-Latif**] (ET-ASIS; Assiut); **Hassan, Soad A.** [**Hassan, Soad Ali**] (ET-ASIS; Assiut)

Intersection curves of hypersurfaces in $\mathbb{R}^4$. (English summary)

Comput. Aided Geom. Design **29** (2012), *no.* 2, 99–108.

The paper deals with the problem of the transversal intersection of hypersurfaces in 4-dimensional real space. This is an issue quite relevant to the modelling of complex shapes, and it has already been studied and solved both in the case of three implicit and of three parametric hypersurfaces. Therefore, in this paper the authors consider the not yet solved cases: the intersection of two implicit and one parametric hypersurface, and of one implicit and two parametric hypersurfaces. The goal is, for each of the considered intersection curves, to provide formulae to evaluate the differential geometric properties of the Frenet apparatus, that is, the unit tangent vector field, the unit principal normal vector field, the first and second binormal vector fields and the three curvature functions. Starting from the representations of the hypersurfaces, in both the considered cases the authors construct a suitable linear system whose solution gives the derivatives of the parameters involved in the description of the parametric surface(s) with respect to the parameter involved in the parameterization of the intersection curve. Such derivatives are the key to obtaining the Frenet apparatus, by applying some classical differential geometric techniques. Finally, several examples are presented in order to clarify the meaning of the formulae obtained. In conclusion, the authors succeed in describing the basic differential geometry properties of the transversal intersection curve of hypersurfaces in the 4-dimensional case, for the two cases not yet studied in the literature. *Tae-wan Kim*

MR2852376 58J32 35J10 35R01 35R30 65N21 78A05

Kenig, Carlos E. (1-CHI; Chicago, IL); **Salo, Mikko** (FIN-HELS-MS; Helsinki); **Uhlmann, Gunther** (1-WA; Seattle, WA)

Reconstructions from boundary measurements on admissible manifolds. (English summary)

Inverse Probl. Imaging **5** (2011), *no.* 4, 859–877.

The paper gives a reconstruction procedure for two inverse boundary value problems on a three-dimensional manifold. Specifically, the first problem is to determine a smooth positive function c, defined on a bordered Riemannian three-manifold (M, g), starting from the Dirichlet-to-Neumann map Λ_{cg} associated to the operator Δ_{cg}, where Δ_g is the Laplace-Beltrami operator and g is a (known) Riemannian metric. The second one is to determine a smooth potential q, defined on (M, g), starting from the Dirichlet-to-Neumann map $\Lambda_{g,q}$ associated to the operator $-\Delta_g + q$.

Uniqueness results for these problems were given in [D. Dos Santos Ferreira et al., Invent. Math. **178** (2009), no. 1, 119–171; MR2534094 (2010h:58033)] for admissible n-dimensional manifolds, for $n \geq 3$. In the present paper a constructive proof is given for the three-dimensional case; this result extends the reconstruction procedure of R. G. Novikov [Funktsional. Anal. i Prilozhen. **22** (1988), no. 4, 11–22, 96; MR0976992 (90h:35243)] and A. I. Nachman [Ann. of Math. (2) **128** (1988), no. 3, 531–576; MR0970610 (90i:35283)] in Euclidean space. The main points are the derivation of a boundary integral equation characterizing the boundary values of Faddeev-type solutions (also called complex geometrical optics solutions), as well as the development of an associated layer potential adapted to a cylindrical geometry. *Matteo Santacesaria*

MR2895417 60F10 60J22 60K35 65C05

Chan, Hock Peng (SGP-SING-SA; Singapore); **Lai, Tze Leung** (1-STF; Stanford, CA)

A sequential Monte Carlo approach to computing tail probabilities in stochastic models. (English summary)

Ann. Appl. Probab. **21** (2011), *no.* 6, 2315–2342.

Summary: "Sequential Monte Carlo methods which involve sequential importance sampling and resampling are shown to provide a versatile approach to computing probabilities of rare events. By making use of martingale representations of the sequential Monte Carlo estimators, we show how resampling weights can be chosen to yield logarithmically efficient Monte Carlo estimates of large deviation probabilities for multidimensional Markov random walks."

MR2833612 60F10 60J80 65C05

Dean, Thomas [Dean, Thomas A.] (4-OX-CMF; Oxford); **Dupuis, Paul [Dupuis, Paul G.]** (1-BRN-DY; Providence, RI)

The design and analysis of a generalized RESTART/DPR algorithm for rare event simulation. (English summary)

Ann. Oper. Res. **189** (2011), 63–102.

The paper deals with the estimation of rare events whose probability obeys a large deviation rule, that is, the probability is one of a sequence $\{p_n\}$ such that for some $\gamma > 0$,

$$\lim_{n\to\infty} -\frac{1}{n}\log p_n = \gamma.$$

Often these probabilities are numerically estimated by using accurate and efficient Monte Carlo algorithms. The efficiency is related to a measure of performance taking into account the variance of a random variable whose mean is p_n. The two most common Monte Carlo methods employed in this context are importance sampling and multi-level

splitting. In this paper, two multi-level splitting methods are considered: RESTART (repetitive simulation trials after reaching thresholds) and DPR (direct probability redistribution). The multi-level splitting method is often used to simulate probabilities of the form $P(X \in \mathcal{A})$. The method consists in simulating particles that evolve according to the law of a discrete time stochastic process $X = \{X_i\}$ and at certain times splits those particles considered more likely to lead to a trajectory that belongs to the set $\mathcal{A}$. For example, $\mathcal{A}$ might be the set of trajectories that reach some unlikely set B before hitting a likely set A after starting in neither A nor B. The killing strategy involves abandoning a particle prior to entry into either A or B, presumably because a continuation of the trajectory may not be worth the computational effort. For the RESTART algorithm, particles are split every time they enter a splitting threshold and are killed when they exit the splitting threshold where they were born. Differently from the DPR algorithm, the process does not upcross more than one the splitting threshold at each time step.

The purpose of this paper is to extend the framework of the RESTART and the DPR algorithms by using subsolutions to a Hamilton-Jacobi-Bellman partial differential equation via a large deviations analysis. Actually the asymptotic performance of the methods can be characterized in terms of subsolutions and, for a class of problems, this approach generates asymptotically optimal splitting algorithms. As a result, a generalized RESTART/DPR algorithm is defined for estimators with expected values of the form

$$E\left[\sum_{i=0}^{\tau} f(X_i)\right]$$

with $f(x)$ a non-negative measurable function and τ the almost surely finite time of first entry into some closed set M. Numerical results, comparisons with ordinary splitting and some open problems are addressed at the end of the paper. *Elvira Di Nardo*

MR2883790 60G60 60G55 65C35

Mikhaĭlov, G. A. [**Mikhaĭlov, Gennadiĭ Alekseevich**] (RS-AOSSI-CMG; Novosibirsk)

Numerically realizable models of exponentially correlated random fields and stochastic problems of particle transport. (Russian)

Dokl. Akad. Nauk **439** (2011), *no.* 5, 593–596; *translation in Dokl. Math.* **84** (2011), *no.* 1, 535–538.

The paper is a continuation of the papers of Mikhaĭlov and co-authors from 2010 and 2011. Here multidimensional models of exponentially correlated random fields of the following type are studied. In the models the partitioning of the space is given by a grid of coordinate planes passing through points of a Poisson field. Unfortunately, the considered model is not isotropic. Nevertheless the author is able to show that the model's correlation function is exponential. Moreover, the correlation function has weakly varying coefficients. Additionally, the paper gives asymptotic estimates for the mean probability of passing of particles through a stochastic medium.

The paper is interesting and provides new results for models based on Poisson random point fields. Such fields are the most useful from the application point of view because in order to solve some stochastic problems with using the Monte Carlo method, models of random fields admitting computer realization should be constructed, particularly, the models based on Poisson random fields. *Anna Karczewska*

MR2875351 60H15 46N20 65C30

Cioica, Petru A. (D-MRBG-MI; Marburg)**;**
Dahlke, Stephan (D-MRBG-MI; Marburg)**; Kinzel, Stefan** (D-MRBG-MI; Marburg)**;**
Lindner, Felix (D-TUD-MS; Dresden)**; Raasch, Thorsten** (D-MNZ-IM; Mainz)**;**
Ritter, Klaus (D-TUKS; Kaiserslautern)**; Schilling, René L.** (D-TUD-MS; Dresden)

Spatial Besov regularity for stochastic partial differential equations on Lipschitz domains. (English summary)

Studia Math. **207** (2011), *no.* 3, 197–234.

Summary: " We use the scale of Besov spaces $B^{\alpha}_{\tau,\tau}(\mathcal{O})$, $1/\tau = \alpha/d + 1/p$, $\alpha > 0$, p fixed, to study the spatial regularity of solutions of linear parabolic stochastic partial differential equations on bounded Lipschitz domains $\mathcal{O} \subset \mathbb{R}$. The Besov smoothness determines the order of convergence that can be achieved by nonlinear approximation schemes. The proofs are based on a combination of weighted Sobolev estimates and characterizations of Besov spaces by wavelet expansions."

MR2863508 60H15 60H35 65C30 65M60 65M75

Lang, Annika (D-MNHMM; Mannheim)

Almost sure convergence of a Galerkin approximation for SPDEs of Zakai type driven by square integrable martingales. (English summary)

J. Comput. Appl. Math. **236** (2012), *no.* 7, 1724–1732.

In this paper the author studies a Galerkin method for the space approximation of the solution of an SPDE of the form

$$dX(t) = (A+B)X(t)dt + G(X(t))dM(t), \quad X(t_0) = X_0,$$

where M is a cadlag square integrable martingale with values in a separable Hilbert space U. As the author claims, the main result of this paper is that if the above equation is approximated by the projected SPDE on a finite-dimensional subspace of H with convergence parameter h and if the corresponding homogeneous deterministic problem converges with order $O(h^a)$ to the solution of the homogeneous problem, then the approximated SPDE converges with order $O(h^a)$ in L^p and almost surely with order $O(h^{a-\varepsilon})$ for any $\varepsilon > 0$ to the mild solution of the equation. These results are confirmed by simulations of the heat equation driven by Lévy noise. *Nikolaos Halidias*

MR2860933 60H35 60H15 65C30

Hairer, Martin (4-WARW-NDM; Coventry)**;**
Voss, Jochen [Voß, Jochen] (4-LEED-NDM; Leeds)

Approximations to the stochastic Burgers equation. (English summary)

J. Nonlinear Sci. **21** (2011), *no.* 6, 897–920.

A stochastic Burgers equation

$$du = \nu\partial_x^2 u\,dt + u\partial_x u\,dt + \sigma\,dw, \quad x \in [0, 2\pi],$$

with periodic boundary conditions and its finite-difference approximation given by

$$du^\varepsilon = \nu\partial_x^2 u^\varepsilon\,dt - u^\varepsilon D_\varepsilon u^\varepsilon\,dt + \sigma\,dw$$

are studied. It is assumed that w is a standard cylindrical Wiener process in $L^2(0,T)$ and D_ε is defined by

$$D_\varepsilon\psi(t,x) = \frac{\psi(t,x+a\varepsilon) - \psi(t,x-b\varepsilon)}{(a+b)\varepsilon}.$$

The authors state several conjectures concerning (non)convergence of u^ε to u as $\varepsilon \downarrow 0$; these conjectures are supported by heuristic arguments and numerical simulations. The

results are extended to more general nonlinearities, and the case of a less rough noise is also discussed. *Jan I. Seidler*

MR2817614 60J22 60J35 65C05
Andrieu, Christophe (4-BRST; Bristol)**; Jasra, Ajay** (4-LNDIC; London)**;**
Doucet, Arnaud (3-BC-S; Vancouver, BC)**; Del Moral, Pierre** (F-BORD-IM; Talence)
On nonlinear Markov chain Monte Carlo. (English summary)
Bernoulli **17** (2011), *no.* 3, 987–1014.

In this paper a class of nonlinear Markov chain Monte Carlo (MCMC) methods for simulation is studied. However, their nonlinear kernels cannot be simulated directly, so a suitable approximation is introduced. The performance of algorithms is accessed numerically. A strong law of large numbers is established for the sequence of associated approximations. The proof technique is based on the Poisson equation and Foster-Lyapunov conditions. The authors provide a brief introduction into nonlinear Markov chains and the MCMC method. They justify the use of the nonlinear Markov chains in Monte Carlo simulations via auxiliary or self-interacting approximations.

The material is clearly presented; however, the presence of a large number of short subsections may have the effect of interrupting the flow of the paper. Theoretical results of the paper may serve as a basis for new interesting simulations improving the mixing property of Markov chains for the standard Monte Carlo algorithms.

Anatoly Yambartsev

MR2849670 60J22 60J05 65C05 68T05 68W40
Bai, Yan [Bai, Yan$^{[4]}$] (3-TRNT-S; Toronto, ON)**;**
Roberts, Gareth O. (4-WARW-S; Coventry)**;**
Rosenthal, Jeffrey S. (3-TRNT-S; Toronto, ON)
On the containment condition for adaptive Markov chain Monte Carlo algorithms. (English summary)
Adv. Appl. Stat. **21** (2011), *no.* 1, 1–54.

This paper explores the ergodicity of adaptive Markov chain Monte Carlo (MCMC) algorithms for multidimensional target distributions, $\pi(\cdot)$, on unbounded state spaces. First, let $\mathbb{Z} = \{(X_n, \Gamma_n)\colon\ n \geq 0\}$ denote the adaptive algorithm where, at the $n+1$ iteration, X_{n+1} is sampled from kernel $P_{\Gamma_n}(X_n, \cdot)$. Further, the Γ_n are constructed using an adaptive scheme which seeks to improve convergence by "learning" from the sampling history.

The authors establish several conditions under which the adaptive MCMC is ergodic, i.e. converges to π. To begin, they present a simple-to-check *summable adaptive* condition for ergodicity. However, they focus on establishing ergodicity via two conditions: (1) Diminishing Adaptation, i.e. levels of adaptation diminish as the chain evolves; and (2) Containment, i.e. times to convergence from (X_n, Γ_n) to π are bounded in probability for $n \geq 0$. Whereas Diminishing Adaptation is easily guaranteed by selecting an appropriate adaptive scheme, it is not as straightforward to establish Containment. To this end, the authors present two sets of sufficient conditions for *Containment*. The first of these is the simultaneously geometrically ergodic condition, a weaker version of the simultaneously strongly aperiodic geometrically ergodic condition already known to be sufficient for Containment. The second is the even weaker simultaneously polynomially ergodic condition along with some additional assumptions.

Finally, the authors apply their results to study ergodicity among families of adaptive Metropolis-Hastings algorithms for lighter-than-exponentially, exponentially, and hyperbolically tailed distributions π. *Alicia Anne Johnson*

MR2869496 60J22 15A23 60J10 65C40

Barreto, André M. S. [**da Motta Salles Barreto, André**] (BR-LCC; Rio de Janeiro); **Fragoso, Marcelo D.** [**Fragoso, Marcelo Dutra**] (BR-LCC; Rio de Janeiro)

Computing the stationary distribution of a finite Markov chain through stochastic factorization. (English summary)

SIAM J. Matrix Anal. Appl. **32** (2011), *no.* 4, 1513–1523.

Summary: "This work presents an approach for reducing the number of arithmetic operations involved in the computation of a stationary distribution for a finite Markov chain. The proposed method relies on a particular decomposition of a transition-probability matrix called stochastic factorization. The idea is simple: when a transition matrix is represented as the product of two stochastic matrices, one can swap the factors of the multiplication to obtain another transition matrix, potentially much smaller than the original. We show in the paper that the stationary distributions of both Markov chains are related through a linear transformation, which opens up the possibility of using the smaller chain to compute the stationary distribution of the original model. In order to support the application of stochastic factorization, we prove that the model derived from it retains all the properties of the original chain which are relevant to the stationary distribution computation. Specifically, we show that (i) for each recurrent class in the original Markov chain there is a corresponding class in the derived model with the same period and, given some simple assumptions about the factorization, (ii) the original chain is irreducible if and only if the derived chain is irreducible and (iii) the original chain is regular if and only if the derived chain is regular. The paper also addresses some issues associated with the application of the proposed approach in practice and briefly discusses how stochastic factorization can be used to reduce the number of operations needed to compute the fundamental matrix of an absorbing Markov chain." *James Ledoux*

MR2846498 60J60 60E07 60G51 65C10 68U20

Kawai, Reiichiro (4-LSTR; Leicester); **Masuda, Hiroki** (J-KYUS-INM; Fukuoka)

Exact discrete sampling of finite variation tempered stable Ornstein-Uhlenbeck processes. (English summary)

Monte Carlo Methods Appl. **17** (2011), *no.* 3, 279–300.

Applications of Ornstein-Uhlenbeck (OU) processes as practical models in physics and financial mathematics have had a huge impact on the development of statistical procedures for these processes, mainly concentrated in parameter estimation and simulation domains. In this paper simple simulation algorithms are developed for a class of OU processes with tempered stable stationary distributions of finite variation. This class of processes is attractive from both a mathematical and a practical point of view, since its homogeneous Markovian autoregressive structure enables calculation of the transition density between consecutive time points in the closed form and therefore opens the way to the exact simulation techniques.

In this paper the exact recursion-based simulation of the arbitrary discrete time skeleton of finite variation tempered stable OU processes is performed under the decomposition of explicitly known transition density (Theorem 3.1 and Corollary 3.2) on two independent parts—tempered stable and compound Poisson components—which could be simulated exactly. The paper provides several algorithms for simulation and discusses various alternative simulation methods on the basis of acceptance rate in the acceptance-rejection sampling method (Section 4, Algorithms 1–5). It is shown that Algorithms 1, 3 and 5 approach perfect acceptance-rejection sampling as simulation stepsize tends to zero. This supports the application of proposed algorithms in validation and estimation problems under high-frequency sampling, but seems to be inadequate for low

sampling frequencies. In comparison to the existing simulation methods based on the series representation of sample paths, the proposed algorithms are more efficient and have implications for future research (e.g. infinite variation setting and future improvement of the proposed algorithms). *Nenad Šuvak*

MR2872891 60K15 60J60 65C05 70L05
Grigoriu, Mircea [Grigoriu, Mircea D.] (1-CRNL-NDM; Ithaca, NY)
Conditional Monte Carlo method for dynamic systems with random properties. (English summary)
Appl. Math. Model. **36** (2012), *no.* 3, 1209–1218.
Summary: "A method is developed for calculating moments and other properties of states $X(t)$ of dynamic systems with random coefficients depending on semi-Markov processes $\xi(t)$ and subjected to Gaussian white noise. Random vibration theory is used to find probability laws of conditional processes $X(t) \mid \xi(\cdot)$. Unconditional properties of $X(t)$ are estimated by averaging conditional statistics of this process corresponding to samples of $\xi(t)$. The method is particularly efficient for linear systems since $X(t) \mid \xi(\cdot)$ is Gaussian during periods of constant values of $\xi(t)$, so that and its probability law is completely defined by the process mean and covariance functions that can be obtained simply from equations of linear random vibration. The method is applied to find statistics of an Ornstein-Uhlenbeck process $X(t)$ whose decay parameter is a semi-Markov process $\xi(t)$. Numerical results show that $X(t)$ is not Gaussian and that the law of this process depends essentially on features of $\xi(t)$. A version of the method is used to calculate the failure probability for an oscillator with degrading stiffness subjected to Gaussian white noise."

MR2851242 60K35 60F05 60J25 62G20 65C35
Del Moral, P. [Del Moral, Pierre] (F-INRIA9; Talence)**;**
Patras, F. (F-NICE-LD; Nice)**; Rubenthaler, S.** (F-NICE-LD; Nice)
Convergence of U-statistics for interacting particle systems. (English summary)
J. Theoret. Probab. **24** (2011), *no.* 4, 1002–1027.
Consider N points $x_1, \ldots, x_N$ belonging to a measurable space E. The associated U-statistics are the probability measures on E^q, for $q \in \mathbf{N}$, defined by $m^{\odot q}(x) = \sum_{s \in \langle q,N \rangle} \delta_{x_{s(1)},\ldots,x_{s(q)}}/(N)_q$, where $\langle q, N \rangle$ is the set of injective mappings from $\{1, \ldots, q\}$ to $\{1, \ldots, N\}$. The goal of the authors is to study the behavior of the U-statistics for large N when the points correspond to the random positions at time $t \geq 0$ of the genetic algorithm associated to a (time-inhomogeneous) potential on E, in the spirit of the book of P. Del Moral [*Feynman-Kac formulae*, Probab. Appl. (N. Y.), Springer, New York, 2004; MR2044973 (2005f:60003)]. In contrast with the classical framework, these positions are no longer independent.

The main part of the paper is devoted to the exact expansion $\sum_{r \geq 0} C(t, q, r)/N^r$ of the expectations of the U-statistics. The coefficients $C(t, q, r)$ are given in terms of a stochastic interacting system using only q particles (conditioning by the number of jumps enables the authors to remove the dependence in N of their jump rates). The proof is based on the study of the time evolution of the corresponding unnormalized U-statistics, the authors taking advantage of the symmetries to come back to Feynman-Kac integrals relative to q particles. The continuous time setting leads to some simplifications of the combinatorics already developed by the authors [Ann. Appl. Probab. **19** (2009), no. 2, 778–825; MR2521888 (2010c:47110)] for discrete time.

Next the obtained expansion enables the authors to recover the usual convergence results about the underlying particle systems. Finally, in conjunction with Hoeffding's decomposition, an asymptotic normality for their empirical U-statistic is obtained,

as well as Wiener integral expansions, when functions of the type $f_1 \otimes \cdots \otimes f_q$ are integrated.

Despite the involved computations, the paper is pedagogically written.

Laurent Miclo

MR2816335 62F15 60J22 65C05

Chen, S. [Chen, Su^2] (1-STF; Stanford, CA)**; Dick, J. [Dick, Josef]** (5-NSW; Sydney)**; Owen, A. B. [Owen, Art B.]** (1-STF; Stanford, CA)

Consistency of Markov chain quasi-Monte Carlo on continuous state spaces. (English summary)

Ann. Statist. **39** (2011), *no.* 2, 673–701.

The authors consider the validity of MCMC simulation when one takes into account that the $U(0,1)$ random bits used by the computer for generating the Markov chain dynamics are a deterministic sequence rather than a truly random i.i.d. sequence.

The paper focuses on Markov chains on continuous state spaces with transition functions driven by CUD (completely uniformly distributed) sequences arising in quasi-Monte Carlo algorithms. This is motivated by recent numerical investigations [S. D. Tribble, *Markov chain Monte Carlo algorithms using completely uniformly distributed driving sequences*, Ph.D. thesis, Stanford Univ., 2007; MR2710331] and extends previous consistency results obtained for discrete state spaces [A. B. Owen and S. D. Tribble, Proc. Natl. Acad. Sci. USA **102** (2005), no. 25, 8844–8849; MR2168266 (2006h:65006); Electron. J. Stat. **2** (2008), 634–660; MR2426105 (2009h:62033)].

The consistency results rest on a precise structure of the Markov update functions assumed throughout the paper, and when specialised to Metropolis-Hastings kernels, a condition equivalent to uniform ergodicity is assumed. Deterministic scan Gibbs samplers are also considered under convenient technical conditions.

The development deals with many technical difficulties absent in the usual probabilistic approach when one assumes that the driving sequence is i.i.d. $U(0,1)$ and involves techniques necessary for the deterministic setting. Thus it should be of interest to anyone concerned with rigorous justification of computer MCMC and QMCMC simulations.

Krzysztof Łatuszyński

MR2815781 62F15 60J22 62G32 62G99 65C05

Guillotte, Simon; Perron, François (3-MTRL; Montreal, QC)**; Segers, Johan** (B-UCL; Louvain-la-Neuve)

Non-parametric Bayesian inference on bivariate extremes. (English summary)

J. R. Stat. Soc. Ser. B Stat. Methodol. **73** (2011), *no.* 3, 377–406.

Summary: "The tail of a bivariate distribution function in the domain of attraction of a bivariate extreme value distribution may be approximated by that of its extreme value attractor. The extreme value attractor has margins that belong to a three-parameter family and a dependence structure which is characterized by a probability measure on the unit interval with mean equal to $\frac{1}{2}$, which is called the spectral measure. Inference is done in a Bayesian framework using a censored likelihood approach. A prior distribution is constructed on an infinite dimensional model for this measure, the model being at the same time dense and computationally manageable. A trans-dimensional Markov chain Monte Carlo algorithm is developed and convergence to the posterior distribution is established. In simulations, the Bayes estimator for the spectral measure is shown to compare favourably with frequentist non-parametric estimators. An application to a data set of Danish fire insurance claims is provided."

MR2862646 62F25 65C05
Du, Jiong (PRC-BJ-MAM; Beijing)**; Fang, Xiangzhong** (PRC-BJ-MAM; Beijing)
Tolerance interval for exponential distribution. (English summary)
Front. Math. China **6** (2011), *no.* 6, 1059–1066.
Summary: "Tolerance interval is a kind of interval that assures the probability of at least a given proportion of population falls into the interval attains to a fixed level. It is widely needed in various industrial practices and business activities, such as product design, reliability analysis, and quality inspection. However, comparing to its widely needs, the research on it is still quite limited. In this paper, we propose a numerical method to compute the tolerance interval for exponential distribution. As the simulation study illustrates, our method performs consistently well as the sample size varies. In particular, its good performance for small sample endows itself broadly potential usefulness in practice."

MR2814492 62F99 62F15 62H11 65C05
Girolami, Mark (4-LNDUC-S; London)**; Calderhead, Ben** (4-LNDUC; London)
Riemann manifold Langevin and Hamiltonian Monte Carlo methods. (English summary)
With discussion and a reply by the authors.
J. R. Stat. Soc. Ser. B Stat. Methodol. **73** (2011), *no.* 2, 123–214.
Summary: "The paper proposes Metropolis adjusted Langevin and Hamiltonian Monte Carlo sampling methods defined on the Riemann manifold to resolve the shortcomings of existing Monte Carlo algorithms when sampling from target densities that may be high dimensional and exhibit strong correlations. The methods provide fully automated adaptation mechanisms that circumvent the costly pilot runs that are required to tune proposal densities for Metropolis-Hastings or indeed Hamiltonian Monte Carlo and Metropolis adjusted Langevin algorithms. This allows for highly efficient sampling even in very high dimensions where different scalings may be required for the transient and stationary phases of the Markov chain. The methodology proposed exploits the Riemann geometry of the parameter space of statistical models and thus automatically adapts to the local structure when simulating paths across this manifold, providing highly efficient convergence and exploration of the target density. The performance of these Riemann manifold Monte Carlo methods is rigorously assessed by performing inference on logistic regression models, log-Gaussian Cox point processes, stochastic volatility models and Bayesian estimation of dynamic systems described by non-linear differential equations. Substantial improvements in the time-normalized effective sample size are reported when compared with alternative sampling approaches. MATLAB code that is available from www.ucl.ac.uk/statistics/research/rmhmc allows replication of all the results reported."

MR2876812 62G07 62N01 65T60 92B15
Niu, Si-Li (PRC-TONG; Shanghai)
Nonlinear wavelet density estimation with censored dependent data. (English summary)
Math. Methods Appl. Sci. **35** (2012), *no.* 3, 293–306.
Summary: "In this paper, we provide an asymptotic expansion for the mean integrated squared error (MISE) of nonlinear wavelet estimator of survival density for a censorship model when the data exhibit some kind of dependence. It is assumed that the observations form a stationary and α-mixing sequence. This asymptotic MISE expansion, when the density is only piecewise smooth, is same. However, for the kernel estimators, the MISE expansion fails if the additional smoothness assumption is absent. Also, we

establish the asymptotic normality of the nonlinear wavelet estimator."

MR2862993 62H15 60G35 65C99 93A30
Huynh, D. B. P. (1-MIT-ME; Cambridge, MA);
Knezevic, D. J. [Knezevic, David J.] (1-MIT-ME; Cambridge, MA);
Patera, A. T. (1-MIT-ME; Cambridge, MA)
Certified reduced basis model validation: a frequentistic uncertainty framework. (English summary)
Comput. Methods Appl. Mech. Engrg. **201/204** (2012), 13–24.
Summary: "We introduce a frequentistic validation framework for assessment—acceptance or rejection—of the consistency of a proposed parametrized partial differential equation model with respect to (noisy) experimental data from a physical system. Our method builds upon the Hotelling T^2 statistical hypothesis test for bias first introduced by O. Balci and R. G. Sargent in 1984 [Amer. J. Math. Management Sci. **4** (1984), no. 3-4, 375–406; see MR0806000 (86f:90047)] and subsequently extended by J. McFarland and S. Mahadevan [Comput. Methods Appl. Mech. Engrg. **197** (2008), no. 29-32, 2467–2479, doi:10.1016/j.cma.2007.05.030]. Our approach introduces two new elements: a spectral representation of the misfit which reduces the dimensionality and variance of the underlying multivariate Gaussian but without introduction of the usual regression assumptions; a certified (verified) reduced basis approximation—reduced order model—which greatly accelerates computational performance but without any loss of rigor relative to the full (finite element) discretization. We illustrate our approach with examples from heat transfer and acoustics, both based on synthetic data. We demonstrate that we can efficiently identify possibility regions that characterize parameter uncertainty; furthermore, in the case that the possibility region is empty, we can deduce the presence of 'unmodeled physics' such as cracks or heterogeneities."

MR2895991 62H17 62L05 65C60 90C90
Dinwoodie, Ian H. [Dinwoodie, Ian Hepburn] (1-PRLS-MS; Portland, OR);
Chen, Yuguo (1-IL-ST2; Champaign, IL)
Sampling large tables with constraints. (English summary)
Statist. Sinica **21** (2011), *no.* 4, 1591–1609.
This paper presents a new sequential importance sampling method for multi-way contingency tables. Such a class of algorithms has major applications in algebraic statistics.

The algorithm is based on the normal approximation of the distribution of the cell counts. The proposed algorithm is particularly useful for large sparse contingency tables with some high cell counts.

Several examples with real-world multi-way contingency tables show the practical applicability of the algorithm. *Fabio Rapallo*

MR2863877 62H17 60J22 62G10 62P10 65C05
Kieffer, David; Bianchetti, Laurent; Poch, Olivier; Wicker, Nicolas
Perfect sampling on $2 \times \cdots \times 2 \times K$ contingency tables with an application to SAGE data. (English summary)
J. Statist. Plann. Inference **142** (2012), *no.* 4, 896–901.
Summary: "The perfect sampling method of S. Kijima and T. Matsui [Random Structures Algorithms **29** (2006), no. 2, 243–256; MR2245503 (2007f:68238)] for $2 \times K$ contingency tables is extended to $2 \times \cdots \times 2 \times K$ tables. Based on this, a Metropolis sampling method is then proposed to implement Zelen's homogeneity test. Finally, an application is shown on gene expression data where cancer samples are compared to non-cancer

samples across various tissues."

MR2863593 62H35 62F15 65R32 94A20
Dupé, F.-X. [**Dupé, François-Xavier**] (F-CAEN-GR; Caen)**;**
Fadili, M. J. [**Fadili, Jalal M.**] (F-CAEN-GR; Caen)**;**
Starck, J.-L. (F-CENS-AP; Gif-sur-Yvette)
Deconvolution under Poisson noise using exact data fidelity and synthesis or analysis sparsity priors. (English summary)
Stat. Methodol. **9** (2012), *no.* 1-2, 4–18.
Summary: "In this paper, we propose a Bayesian MAP estimator for solving the deconvolution problems when the observations are corrupted by Poisson noise. Toward this goal, a proper data fidelity term (log-likelihood) is introduced to reflect the Poisson statistics of the noise. On the other hand, as a prior, the images to restore are assumed to be positive and sparsely represented in a dictionary of waveforms such as wavelets or curvelets. Both analysis- and synthesis-type sparsity priors are considered. Piecing together the data fidelity and the prior terms, the deconvolution problem boils down to the minimization of non-smooth convex functionals (for each prior). We establish the well-posedness of each optimization problem, characterize the corresponding minimizers, and solve them by means of proximal splitting algorithms originating from the realm of non-smooth convex optimization theory. Experimental results are conducted to demonstrate the potential applicability of the proposed algorithms to astronomical imaging datasets."

MR2861698 62J07 62F10 62G05 62J05 65J20
Golubev, Yuri [**Golubev, Yuri K.**] (F-PROV-CM; Marseille)
Adaptive spectral regularizations of high dimensional linear models. (English summary)
Electron. J. Stat. **5** (2011), 1588–1617.
Summary: "This paper focuses on recovering an unknown vector β from the noisy data $Y = X\beta + \sigma\xi$, where X is a known $n \times p$-matrix, ξ is a standard white Gaussian noise, and σ is an unknown noise level. In order to estimate β, a spectral regularization method is used, and our goal is to choose its regularization parameter with the help of the data Y. In this paper, we deal solely with regularization methods based on the so-called ordered smoothers [see A. Kneip, Ann. Statist. **22** (1994), no. 2, 835–866; MR1292543 (95k:62110)] and extend the oracle inequality from [Y. K. Golubev, Ann. Statist. **38** (2010), no. 5, 2751–2780; MR2722455 (2011j:62172)] to the case where the noise level is unknown."

MR2876000 62J07 65K05 90C90 94A20
Osborne, M. R. (5-ANU-MI; Canberra)**; Prvan, Tania** (5-MCQR-S; North Ryde)
Applications of ℓ_1 regularisation. (English summary)
ANZIAM J. Electron. Suppl. **52** (2010), (*C*), *C*866–*C*881.
From the introduction: "This article has two objectives. The first is to provide a review of applications of l_1 regularisation along with some insights not found in the literature. The second is to describe exploratory computations that provide interesting information about the performance of the l_1 descent algorithm in the context of variable selection compared with the homotopy algorithms."

MR2894770 62K15 62K05 62K20 65C60 90C15

Ba, Shan (1-GAIT-I; Atlanta, GA)**; Joseph, V. Roshan** (1-GAIT-I; Atlanta, GA)

Multi-layer designs for computer experiments. (English summary)

J. Amer. Statist. Assoc. **106** (2011), *no.* 495, 1139–1149.

Design and analysis of computer experiments plays an important role in exploring the true relationship between responses and factors in modern science and technology. Computer experiments differ from traditional physical experiments in that repeated observations at the same set of inputs yield identical responses. Space-filling designs like Latin hypercube designs (LHDs) are popular in computer experiments due to their good space-filling properties.

Finding an optimal LHD is computationally challenging and time consuming. The paper successfully proposes multi-layer designs (MLDs) for computer experiments by taking advantage of the geometrical properties of factorial designs in physical experiments. An essential step in constructing an MLD is to split the base design points optimally into several subgroups in order to allocate each of them to different layers. The basic idea is to split a given design into two parts in such a way that each of them forms the foldover plan of the other, and their combined design is the original design. The actual procedure involves obtaining a 2^{p-k} design, defining a new generator for a chosen basic factor, and keeping all previous generators unchanged (the details can be found in Section 4.1). An MLD can be constructed by iterating this procedure, each time splitting the design points into two optimal half-designs and moving half points inward as a new layer.

Minimum aberration is used as the optimal criterion for selecting half-designs from full or fractional factorial designs. Extensions to designs with flexible run sizes are also discussed in the paper. Numerical studies given show that MLDs achieve a good compromise between maxmin and minmax designs. Also, MLDs are much easier to construct than the optimal LHD. For designs with a large number of factors and/or a large number of runs, the savings on computational time is substantial. *Xianggui Qu*

MR2851257 62M20 62F15 62G07 62M05 65C05

Neddermeyer, Jan C. (D-HDBG-A; Heidelberg)

Nonparametric particle filtering and smoothing with quasi-Monte Carlo sampling. (English summary)

J. Stat. Comput. Simul. **81** (2011), *no.* 11, 1361–1379.

Sequential Monte Carlo methods (also known as particle filters and smoothers) are used for filtering and smoothing in general state-space models (GSSM). The paper considers the following special case of this study: a GSSM fully specified by the transition and observation densities

$$\mathbf{X}_t|\mathbf{X}_{t-1} \sim p(\mathbf{x}_t|\mathbf{x}_{t-1}),$$
$$\mathbf{Y}_t|\mathbf{X}_t \sim p(\mathbf{y}_t|\mathbf{x}_t),$$

where the state variables $\mathbf{X}_t$, $t = 0, 1, \ldots$, constitute an observed Markov process, and the observations $\mathbf{Y}_t$, $t = 1, 2, \ldots$, are conditionally independent given the states. The initial state $\mathbf{X}_0$ is distributed according to some prior density $p(\mathbf{x}_0)$. Two methods of estimation are used. The first one is the linear blend frequency polygon (LBFP) estimation, and the second one is the on-line ML parameter estimation. A nonparametric particle filter and an algorithm are given for each method of estimation. The author also considers the quasi-Monte Carlo method, bin width selection and a simulation study. *Truc Nguyen*

MR2894233 62M20 60F05 62F15 62M05 65C05
Whiteley, Nick (4-BRST; Bristol); **Johansen, Adam M.** (4-BRST; Bristol)
Auxiliary particle filtering: recent developments.
Bayesian time series models, 52–81, *Cambridge Univ. Press*, *Cambridge*, 2011.
The authors consider the classical statistical filtering problem under a general state space model where a signal process x_t $(t = 1, 2, \dots)$ is an unobserved Markov sequence with transition probability distribution $f(x_t \mid x_{t-1})$ and initial probability distribution $\nu(x_1)$; the observed time series y_t is stochastically dependent on x_t by the conditional probability distribution $g(y_t \mid x_t)$. The filtering problem consists in computing the conditional probability distribution $p(x_t \mid y_1, \dots, y_t)$ and its functionals. It is solved in this paper by approximating the distribution of interest with a special modifications of Monte Carlo algorithms: auxiliary particle filter (APF) and sequential importance resampling (SIR). An elementary technique for variance reduction when applying the APF is given. The performance of the proposed algorithms is demonstrated in the context of a switching stochastic volatility model using real stock index returns data.
{For the entire collection see MR2894230 (2012i:62005).} *Yurij S. Kharin*

MR2863612 62M30 62F15 65D05
Ghosh, Souparno (1-DUKE-S; Durham, NC);
Gelfand, Alan E. (1-DUKE-S; Durham, NC);
Mølhave, Thomas (1-DUKE-C; Durham, NC)
Attaching uncertainty to deterministic spatial interpolations. (English summary)
Stat. Methodol. **9** (2012), *no.* 1-2, 251–264.
Summary: "Deterministic spatial interpolation algorithms such as the natural neighbor interpolation (NNI) or the Cressman interpolation schemes are widely used to interpolate environmental features. In particular, the former have been applied to digital elevation models (DEM's), the latter to weather data and pollutant exposure. However, they are unsatisfying in that they fail to provide any uncertainty assessment. Such schemes are not model-based; rather, they provide a set of rules, usually geometrically motivated, by which point-level data is interpolated to a grid. We distinguish this setting from the case where the deterministic model is essentially a mapping from inputs to outputs in which case a joint model can be formulated to assign uncertainty. In our setting we have no inputs, only an interpolated surface at some spatial resolution.

"We propose a general approach to handle the non model-based setting. In fact, the approach can be used to assign uncertainty to any supplied surface regardless of how it was created. We first formulate a useful notion of uncertainty and then show, with additional external validation data, that we can attach uncertainty using a convenient version of a data fusion model. We also clarify the distinction between this setting and the more usual case where we are trying to build an explanatory model to explain an environmental surface.

"We discuss two settings for such interpolation, one where the surface is presumed to be continuous such as elevation or temperature and the other where the surface would be discontinuous such as with precipitation where, at any location, there would be a point mass in the distribution at 0. We work within a hierarchical Bayesian framework and illustrate with a DEM within the Cape Floristic Region of South Africa."

MR2805775 62P05 60H30 65C50 91B70

Liu, Wei (PRC-SFU-S; Shanghai)**; Zheng, Wei An** (PRC-ECNU-S; Shanghai)

Stochastic volatility model and technical analysis of stock price. (English summary)

Acta Math. Sin. (*Engl. Ser.*) **27** (2011), *no.* 7, 1283–1296.

Summary: "In the stock market, some popular technical analysis indicators (e.g. Bollinger Bands, RSI, ROC,...) are widely used by traders. They use the daily (hourly, weekly,...) stock prices as samples of certain statistics and use the observed relative frequency to show the validity of those well-known indicators. However, those samples are not independent, so the classical sample survey theory does not apply. In earlier research, we discussed the law of large numbers related to those observations when one assumes Black-Scholes' stock price model. In this paper, we extend the above results to the more popular stochastic volatility model."

MR2894688 68-02 65-02 68W30

Naumann, Uwe (D-AACH-NDM; Aachen)

★**The art of differentiating computer programs.**

An introduction to algorithmic differentiation.

Software, Environments, and Tools, 24.

Society for Industrial and Applied Mathematics (*SIAM*), *Philadelphia*, *PA*, 2012.

xviii+340 *pp.* $93.00. *ISBN* 978-1-611972-06-1

Publisher's description: "This is the first entry-level book on algorithmic (also known as automatic) differentiation (AD), providing fundamental rules for the generation of first- and higher-order tangent-linear and adjoint code. The author covers the mathematical underpinnings as well as how to apply these observations to real-world numerical simulation programs.

"Readers will find

- many examples and exercises, including hints to solutions;
- the prototype AD tools `dco` and `dcc` for use with the examples and exercises;
- first- and higher-order tangent-linear and adjoint modes for a limited subset of C/C++, provided by the derivative code compiler `dcc`;
- a supplementary website containing sources of all software discussed in the book, additional exercises and comments on their solutions (growing over the coming years), links to other sites on AD, and errata.

"This book is intended for undergraduate and graduate students in computational science, engineering, and finance as well as applied mathematics and computer science. It will provide researchers and developers at all levels with an intuitive introduction to AD."

MR2844270 68Q15 05C85 65J15 68W25

Goldreich, Oded (IL-WEIZMC-NDM; Rehovot)

Bravely, moderately: a common theme in four recent works. (English summary)

Studies in complexity and cryptography, 373–389, *Lecture Notes in Comput. Sci.*, 6650, *Springer*, *Heidelberg*, 2011.

Summary: "We highlight a common theme in four relatively recent works that establish remarkable results by an iterative approach. Starting from a trivial construct, each of these works applies an ingeniously designed sequence of iterations that yields the desired result, which is highly nontrivial. Furthermore, in each iteration, the construct is modified in a relatively moderate manner. The four works we refer to are

1. the polynomial-time approximation of the permanent of non-negative matrices

(by M. R. Jerrum, A. Sinclair and E. Vigoda [in *STOC'01: Proceedings of the 33rd Annual ACM Symposium on Theory of Computing*, 712–721, ACM, New York, 2001; MR2120374; see also J. ACM **51** (2004), no. 4, 671–697; MR2147852 (2006b:15013)]);

2. the iterative (Zig-Zag) construction of expander graphs (by O. Reingold, S. P. Vadhan and A. Wigderson [in *41st Annual Symposium on Foundations of Computer Science*, 3–13, IEEE Comput. Soc. Press, Los Alamitos, CA, 2000; MR1931799; see also Ann. of Math. (2) **155** (2002), no. 1, 157–187; MR1888797 (2003c:05145)]);
3. the log-space algorithm for undirected connectivity (by O. Reingold [in *STOC'05: Proceedings of the 37th Annual ACM Symposium on Theory of Computing*, 376–385, ACM, New York, 2005; MR2181639 (2006g:68118)]);
4. and, the alternative proof of the PCP Theorem (by I. Dinur [in *STOC'06: Proceedings of the 38th Annual ACM Symposium on Theory of Computing*, 241–250, ACM, New York, 2006; MR2277150 (2008f:68037a); see also J. ACM **54** (2007), no. 3, Art. 12; MR2314254 (2008f:68037b)]).”

{For the entire collection see MR2895150 (2012i:94002).}

MR2844266 68Q87 60C99 65C10 94A20

Goldreich, Oded (IL-WEIZMC-NDM; Rehovot)

Three XOR-lemmas—an exposition. (English summary)

Studies in complexity and cryptography, 248–272, *Lecture Notes in Comput. Sci.*, 6650, *Springer*, *Heidelberg*, 2011.

Summary: “We provide an exposition of three lemmas that relate general properties of distributions over bit strings to the exclusive-or (xor) of values of certain bit locations.

“The first XOR-Lemma, commonly attributed to U. V. Vazirani [“Randomness, adversaries and computation”, Ph.D. dissertation, Univ. California, Berkeley, 1986], relates the statistical distance of a distribution from the uniform distribution over bit strings to the maximum bias of the xor of certain bit positions. The second XOR-Lemma, due to Vazirani [in *Proceedings of the Nineteenth Annual ACM Symposium on Theory of Computing*, 160–168, ACM, New York, 1987, doi:10.1145/28395.28413], is a computational analogue of the first. It relates the pseudorandomness of a distribution to the difficulty of predicting the xor of bits in particular or random positions. The third Lemma, due to O. Goldreich and L. A. Levin [in *Proceedings of the Twenty-first Annual ACM Symposium on Theory of Computing*, 25–32, ACM, New York, 1989; see MR1010042 (90c:68003)], relates the difficulty of retrieving a string and the unpredictability of the xor of random bit positions. The most notable XOR Lemma—that is the so-called Yao XOR Lemma—is not discussed here.

“We focus on the proofs of the aforementioned three lemmas. Our exposition deviates from the original proofs, yielding proofs that are believed to be simpler, of wider applicability, and establishing somewhat stronger quantitative results. Credits for these improved proofs are due to several researchers.”

{For the entire collection see MR2895150 (2012i:94002).}

MR2872187 68U07 51M15 65D17

Kunkli, Roland (H-LAJOIF; Debrecen)

Biarc analysis for skinning of circles. (English summary)

Ann. Math. Inform. **38** (2011), 87–93.

Summary: “By circle skinning we have a discrete set of circles and we would like to find two curves, which touch each of them and satisfy some conditions. There exist methods to give a solution for this problem, but none of them use biarcs for the construction. Meek and Walton published a very deep analysis of biarcs in [D. S. Meek and D. J.

Walton, J. Comput. Appl. Math. **212** (2008), no. 1, 31–45; MR2386860 (2009b:68220)], and they divided them into several families.

"Of course one of the basic problems is to find the mentioned curves for *two* circles. In this paper several necessary conditions are given to avoid intersections in this basic case between the skinning curve and the circles using a concrete family of biarcs from [op. cit.]. A method is published in [R. Kunkli and M. Hoffmann, Comput. Aided Geom. Design **27** (2010), no. 8, 611–621; MR2725722 (2011j:65040)] with which we can find the touching points for the skinning."

MR2863931 68U10 65M06 94A08

Bazan, C. (1-SDS-CSR; San Diego, CA)**; Abouali, M.** (1-SDS-CSR; San Diego, CA)**;**
Castillo, J. [Castillo, José E.] (1-SDS-CSR; San Diego, CA)**;**
Blomgren, P. (1-SDS-MS; San Diego, CA)

Mimetic finite difference methods in image processing. (English summary)

Comput. Appl. Math. **30** (2011), *no.* 3, 701–720.

Summary: "We introduce the use of mimetic methods to the imaging community, for the solution of the initial-value problems ubiquitous in the machine vision and image processing and analysis fields. PDE-based image processing and analysis techniques comprise a host of applications such as noise removal and restoration, deblurring and enhancement, segmentation, edge detection, inpainting, registration, motion analysis, etc. Because of their favorable stability and efficiency properties, semi-implicit finite difference and finite element schemes have been the methods of choice (in that order of preference). We propose a new approach for the numerical solution of these problems based on mimetic methods. The mimetic discretization scheme preserves the continuum properties of the mathematical operators often encountered in the image processing and analysis equations. This is the main contributing factor to the improved performance of the mimetic method approach, as compared to both of the aforementioned popular numerical solution techniques. To assess the performance of the proposed approach, we employ the Catté-Lions-Morel-Coll model to restore noisy images, by solving the PDE with the three numerical solution schemes. For all of the benchmark images employed in our experiments, and for every level of noise applied, we observe that the best image restored by using the mimetic method is closer to the noise-free image than the best images restored by the other two methods tested. These results motivate further studies of the application of the mimetic methods to other imaging problems."

MR2850408 68W30 65Y20

Chèze, Guillaume (F-TOUL3-IM; Toulouse)**; Galligo, André** (F-NICE-LD; Nice)**;**
Mourrain, Bernard (F-INRIA2-GAL; Sophia Antipolis)**;**
Yakoubsohn, Jean-Claude (F-TOUL3-IM; Toulouse)

A subdivision method for computing nearest gcd with certification. (English summary)

Theoret. Comput. Sci. **412** (2011), *no.* 35, 4493–4503.

Summary: "A new subdivision method for computing the nearest univariate gcd is described and analyzed. It is based on an exclusion test and an inclusion test. The exclusion test in a cell exploits Taylor expansion of the polynomial at the center of the cell. The inclusion test uses Smale's α-theorems to certify the existence and unicity of a solution in a cell.

"Under the condition of simple roots for the distance minimization problem, we analyze the complexity of the algorithm in terms of a condition number, which is the inverse of the distance to the set of degenerate systems.

"We report on some experimentation on representative examples to illustrate the behavior of the algorithm." *Alkiviadis G. Akritas*

MR2869319 68W30 65D18 68U05
Kerber, Michael [Kerber, Michael^2] (A-IST; Klosterneuburg)**;**
Sagraloff, Michael (D-MPI-I; Saarbrücken)
A worst-case bound for topology computation of algebraic curves. (English summary)
J. Symbolic Comput. **47** (2012), *no.* 3, 239–258.
Summary: "Computing the topology of an algebraic plane curve $\mathcal{C}$ means computing a combinatorial graph that is isotopic to $\mathcal{C}$ and thus represents its topology in $\mathbb{R}^2$. We prove that, for a polynomial of degree n with integer coefficients bounded by 2^ρ, the topology of the induced curve can be computed with $\tilde{O}(n^8\rho(n+\rho))$ bit operations ($\tilde{O}$ indicates that we omit logarithmic factors). Our analysis improves the previous best known complexity bounds by a factor of n^2. The improvement is based on new techniques to compute and refine isolating intervals for the real roots of polynomials, and on the consequent amortized analysis of the critical fibers of the algebraic curve."

MR2861000 68W30 65D99
Nagasaka, Kosaku (J-KOBEGH; Kobe)
Approximate polynomial GCD over integers. (English summary)
J. Symbolic Comput. **46** (2011), *no.* 12, 1306–1317.
Summary: "Symbolic numeric algorithms for polynomials are very important, especially for practical computations since we have to operate with empirical polynomials having numerical errors on their coefficients. Recently, for those polynomials, a number of algorithms have been introduced, such as approximate univariate GCD and approximate multivariate factorization for example. However, for polynomials over integers having coefficients rounded from empirical data, changing their coefficients over reals does not remain them in the polynomial ring over integers; hence we need several approximate operations over integers. In this paper, we discuss computing a polynomial GCD of univariate or multivariate polynomials over integers approximately. Here, 'approximately' means that we compute a polynomial GCD over integers by changing their coefficients slightly over integers so that the input polynomials still remain over integers."

MR2861001 68W30 65D99
Sekigawa, Hiroshi
Computing the nearest polynomial with a zero in a given domain by using piecewise rational functions. (English summary)
J. Symbolic Comput. **46** (2011), *no.* 12, 1318–1335.
Summary: "For a real univariate polynomial f and a closed complex domain D whose boundary C is a simple curve parameterized by a univariate piecewise rational function, a rigorous method is given for finding a real univariate polynomial $\tilde{f}$ such that $\tilde{f}$ has a zero in D and $\|f-\tilde{f}\|_\infty$ is minimal. First, it is proved that the minimum distance between f and polynomials having a zero at $\alpha \in \mathbb{C}$ is a piecewise rational function of the real and imaginary parts of α. Thus, on C, the minimum distance is a piecewise rational function of a parameter obtained through the parameterization of C. Therefore, $\tilde{f}$ can be constructed by using the property that $\tilde{f}$ has a zero on C and computing the minimum distance on C. We analyze the asymptotic bit complexity of the method and show that it is of polynomial order in the size of the input."

MR2869318 68W30 13P15 65H10

Wu, Xiaoli (PRC-HZDZ-NDM; Hangzhou)**; Zhi, Lihong** (PRC-ASBJ-MML; Beijing)

Determining singular solutions of polynomial systems via symbolic-numeric reduction to geometric involutive forms. (English summary)

J. Symbolic Comput. **47** (2012), *no.* 3, 227–238.

Summary: "We present a method based on symbolic-numeric reduction to geometric involutive form to compute the primary component of and a basis of Max Noether space for a polynomial system at an isolated singular solution. The singular solution can be known exactly or approximately. For the case where the singular solution is known with limited accuracy, we then propose a generalized quadratic Newton iteration for refining it to high accuracy."

MR2876577 70H05 65L05 65P10

Dharmaraja, Sohan (1-STF-N; Stanford, CA)**;**
Kesari, Haneesh (1-STF-N; Stanford, CA)**; Darve, Eric** (1-STF-N; Stanford, CA)**;**
Lew, Adrian J. [Lew, Adrián J.] (1-STF-N; Stanford, CA)

Time integrators based on approximate discontinuous Hamiltonians. (English summary)

Internat. J. Numer. Methods Engrg. **89** (2012), *no.* 1, 71–104.

Summary: "We introduce a class of time integration algorithms for finite dimensional mechanical systems whose Hamiltonians are separable. By partitioning the system's configuration space to construct an approximate potential energy, we define an approximate discontinuous Hamiltonian (ADH) whose resulting equations of motion can be solved exactly. The resulting integrators are symplectic and precisely conserve the approximate energy, which by design is always close to the exact one. We then propose two ADH algorithms for finite element discretizations of nonlinear elastic bodies. These result in two classes of *explicit* asynchronous time integrators that are scalable and, because they conserve the approximate Hamiltonian, could be considered to be unconditionally stable in some circumstances. In addition, these integrators can naturally incorporate frictionless contact conditions. We discuss the momentum conservation properties of the resulting methods and demonstrate their performance with several problems, such as rotating bodies and multiple collisions of bodies with rigid boundaries."

MR2875430 70J50 15A18 65F15 65N25

Yuan, Yongxin (PRC-UJS-SMP; Zhenjiang)**; Liu, Hao** (PRC-NAA; Nanjing)

An iterative updating method for undamped structural systems. (English summary)

Meccanica **47** (2012), *no.* 3, 699–706.

Summary: "Finite element model updating is a procedure to minimize the differences between analytical and experimental results and can be mathematically reduced to solving the following problem. **Problem P**: Let $M_a \in \mathbf{SR}^{n\times n}$ and $K_a \in \mathbf{SR}^{n\times n}$ be the analytical mass and stiffness matrices and $\Lambda = \mathrm{diag}\{\lambda_1, \ldots, \lambda_p\} \in \mathbf{R}^{p\times p}$ and $X = [x_1, \ldots, x_p] \in \mathbf{R}^{n\times p}$ be the measured eigenvalue and eigenvector matrices, respectively. Find $(\widehat{M}, \widehat{K}) \in S_{MK}$ such that $\|\widehat{M} - M_a\|^2 + \|\widehat{K} - K_a\|^2 = \min_{(M,K)\in S_{MK}}(\|M - M_a\|^2 + \|K - K_a\|^2)$, where $S_{MK} = \{(M, K)|X^T MX = I_p,\ MX\Lambda = KX\}$ and $\|\cdot\|$ is the Frobenius norm. This paper presents an iterative method to solve Problem P. By the method, the optimal approximation solution $(\widehat{M}, \widehat{K})$ of Problem P can be obtained within finite iteration steps in the absence of round-off errors by choosing a special kind of initial matrix pair. A numerical example shows that the introduced iterative algorithm is quite efficient."

MR2861715 74A25 65Z05 74E15

Van Koten, Brian (1-MN-SM; Minneapolis, MN);
Luskin, Mitchell (1-MN-SM; Minneapolis, MN)

Analysis of energy-based blended quasi-continuum approximations. (English summary)

SIAM J. Numer. Anal. **49** (2011), *no.* 5, 2182–2209.

In this paper, the authors present a rigorous analysis of the quasi-continuum method for a periodic one-dimensional chain of atoms with next nearest neighbor interaction. They propose a blended quasi-continuum energy (BQCE). Numerical studies are performed for both the original quasi-continuum energy (QCE) and the proposed BQCE. Defining k as the number of atoms in the blending region, they show that the l^2 strain error for QCE may be reduced by a factor of $k^{3/2}$ for an optimal blending function, and that for BQCE it may be reduced by a factor of k^2. BQCE has a potential of providing an accurate approximation of the deformation near lattice instabilities. *Shaoqiang Tang*

MR2844774 74B05 65N30 74S05

Bochev, Pavel [**Bochev, Pavel B.**] (1-SAND-NAA; Albuquerque, NM);
Lehoucq, Richard (1-SAND-MPS; Albuquerque, NM)

Energy principles and finite element methods for pure traction linear elasticity. (English summary)

Comput. Methods Appl. Math. **11** (2011), *no.* 2, 173–191.

This paper discusses finite element methods for the pure traction linear elasticity boundary value problem using the principle of minimum potential energy rather than the weak form of the differential equations. Three formulas are developed for this problem. The first two formulas purge the rigid modes from the admissible space H^1 while retaining the original definition of the strain energy. The third one retains the original admissible space, but regularizes the strain energy in a manner that flushes out rigid displacements. It is proved that each of the three alternative energy principles is a well-posed minimization problem with a unique minimizer, by Korn's inequalities. Using standard C^0 Lagrangian finite elements, this paper presents numerical methods for solving the resulting discrete minimization problem. *Shaochun Chen*

MR2872023 74B05 35J86 35Q74 65N30

Bonfils, N. (F-NANTC-ICM; Nantes); **Chevaugeon, N.** (F-NANTC-ICM; Nantes);
Moës, N. [**Moës, Nicolas**] (F-NANTC-ICM; Nantes)

Treating volumetric inequality constraint in a continuum media with a coupled X-FEM/level-set strategy. (English summary)

Comput. Methods Appl. Mech. Engrg. **205/208** (2012), 16–28.

Summary: "Some mechanical problems involve inequality kinematic constraints. This study deals with an original approach to handle those difficult problems. The inequality constraint implies variational inequality since the area where the constraint is active is a priori unknown. The method, introduced here, is to find the exact constrained area iteratively starting from an initial trial one. Thanks to numerical tools such as level-set and X-FEM we turn the constrained minimization problem into a shape equilibrium problem."

MR2875255 74B05 65N30 74S05

Gopalakrishnan, J. [Gopalakrishnan, Jayadeep] (1-FL; Gainesville, FL)**;**
Guzmán, J. [Guzmán, Johnny] (1-BRN-A; Providence, RI)

A second elasticity element using the matrix bubble. (English summary)

IMA J. Numer. Anal. **32** (2012), *no.* 1, 352–372.

Summary: "We presented a family of finite elements that use a polynomial space augmented by certain matrix bubbles in [B. Cockburn, J. Gopalakrishnan and J. Guzmán, Math. Comp. **79** (2010), no. 271, 1331–1349; MR2629995 (2011m:65276)]. In this sequel we exhibit a second family of elements that use the same matrix bubble. This second element uses a stress space smaller than the first while maintaining the same space for rotations (which are the Lagrange multipliers corresponding to a weak symmetry constraint). The space of displacements is of one degree less than the first method. The analysis, while similar to the first, requires a few adjustments as the new Fortin projector may not preserve weak symmetry, but we are able to prove optimal convergence for all the variables. Finally, we present a sufficient condition wherein a mixed method with weakly imposed stress symmetry in fact yields an exactly symmetric stress tensor approximation."

MR2895492 74B05 65N38 74C05 74E30

Grzhibovskis, R. [Grzhibovskis, Richards] (D-SAAR; Saarbrücken)**;**
Rjasanow, S. (D-SAAR; Saarbrücken)

New applications of the adaptive cross approximation in mechanical engineering. (English summary)

Riv. Math. Univ. Parma (*N.S.*) **2** (2011), *no.* 1, 77–98.

Summary: "Three new applications of the Adaptive Cross Approximation will be reviewed. The first one is devoted to the reconstruction of the three-dimensional metal sheet surfaces obtained via incremental forming techniques by the use of the radial basis functions. In the second application, a calculation of effective elastic moduli in three-dimensional linear elasticity for highly anisotropic composite material is considered. The third application is a coupling of the Finite and Boundary Element Methods for elastic-plastic deformations arising in deep rolling processes."

MR2868752 74C05 65M60 74S05

Biotteau, E. (F-INSAL-NDM; Villeurbanne)**;**
Gravouil, A. [Gravouil, Anthony] (F-INSAL-NDM; Villeurbanne)**;**
Lubrecht, A. A. (F-INSAL-NDM; Villeurbanne)**;**
Combescure, A. (F-INSAL-NDM; Villeurbanne)

Three dimensional automatic refinement method for transient small strain elastoplastic finite element computations. (English summary)

Comput. Mech. **49** (2012), *no.* 1, 123–136.

Summary: "In this paper, the refinement strategy based on the 'Non-Linear Localized Full MultiGrid' solver originally published in [E. Biotteau et al., Internat. J. Numer. Methods Engrg. **84** (2010), no. 8, 947–971; MR2762644 (2011h:65166)] for 2-D structural problems is extended to 3-D simulations. In this context, some extra information concerning the refinement strategy and the behavior of the error indicators are given. The adaptive strategy is dedicated to the accurate modeling of elastoplastic materials with isotropic hardening in transient dynamics. A multigrid solver with local mesh refinement is used to reduce the amount of computational work needed to achieve an accurate calculation at each time step. The locally refined grids are automatically constructed, depending on the user prescribed accuracy. The discretization error is estimated by a dedicated error indicator within the multigrid method. In contrast to

other adaptive procedures, where grids are erased when new ones are generated, the previous solutions are used recursively to reduce the computing time on the new mesh. Moreover, the adaptive strategy needs no costly coarsening method as the mesh is reassessed at each time step. The multigrid strategy improves the convergence rate of the non-linear solver while ensuring the information transfer between the different meshes. It accounts for the influence of localized non-linearities on the whole structure. All the steps needed to achieve the adaptive strategy are automatically performed within the solver such that the calculation does not depend on user experience. This paper presents three-dimensional results using the adaptive multigrid strategy on elastoplastic structures in transient dynamics and in a linear geometrical framework. Isoparametric cubic elements with energy and plastic work error indicators are used during the calculation."

MR2851586 74C05 65N30
Sauter, Martin (D-KITM; Karlsruhe)**; Wieners, Christian** (D-KITM; Karlsruhe)
On the superlinear convergence in computational elasto-plasticity. (English summary)
Comput. Methods Appl. Mech. Engrg. **200** (2011), *no.* 49-52, 3646–3658.
Summary: "We consider the convergence properties of return algorithms for a large class of rate-independent plasticity models. Based on recent results for semismooth functions, we can analyze these algorithms in the context of semismooth Newton methods guaranteeing local superlinear convergence. This recovers results for classical models but also extends to general hardening laws, multi-yield plasticity, and to several non-associated models. The superlinear convergence is also numerically shown for a large-scale parallel simulation of Drucker-Prager elasto-plasticity and an example for the modified Cam-clay model." *Rolf Stenberg*

MR2851098 74F10 65M06 76M20 76N99
Liu, Tiegang (PRC-BUAA-LMS; Beijing)**;**
Chowdhury, A. W. (SGP-SING-ME; Singapore)**;**
Khoo, Boo Cheong (SGP-SING-ME; Singapore)
The modified ghost fluid method applied to fluid-elastic structure interaction. (English summary)
Adv. Appl. Math. Mech. **3** (2011), *no.* 5, 611–632.
Summary: "In this work, the modified ghost fluid method is developed to deal with 2D compressible fluid interacting with elastic solid in an Euler-Lagrange coupled system. In applying the modified Ghost Fluid Method to treat the fluid-elastic solid coupling, the Navier equations for elastic solid are cast into a system similar to the Euler equations but in Lagrangian coordinates. Furthermore, to take into account the influence of material deformation and nonlinear wave interaction at the interface, an Euler-Lagrange Riemann problem is constructed and solved approximately along the normal direction of the interface to predict the interfacial status and then define the ghost fluid and ghost solid states. Numerical tests are presented to verify the resultant method."

MR2873050 74G05 65N38 65N80 74B05

Mantič, V. [**Mantič, Vladislav**] (E-SEVLE-EMT; Seville);
Távara, L. (E-SEVLE-EMT; Seville);
Ortiz, J. E. [**Ortiz, Jhonny E.**] (E-SEVLE-EMT; Seville);
París, F. [**París, Federico**] (E-SEVLE-EMT; Seville)

Recent developments in the evaluation of the 3D fundamental solution and its derivatives for transversely isotropic elastic materials. (English summary)

Electron. J. Bound. Elem. **10** (2012), *no.* 1, 1–41.

Summary: "Explicit closed-form real-variable expressions of a fundamental solution and its derivatives for three-dimensional problems in transversely linear elastic isotropic solids are presented. The expressions of the fundamental solution in displacements U_{ik} and its derivatives, originated by a unit point force, are valid for any combination of material properties and for any orientation of the radius vector between the source and field points. An expression of U_{ik} in terms of the Stroh eigenvalues on the oblique plane normal to the radius vector is used as starting point. Working from this expression of U_{ik}, a new approach (based on the application of the rotational symmetry of the material) for deducing the first and second order derivative kernels, $U_{ik,j}$ and $U_{ik,j\ell}$ respectively, has been developed. The expressions of the fundamental solution and its derivatives do not suffer from the difficulties of some previous expressions, obtained by other authors in different ways, with complex valued functions appearing for some combinations of material parameters and/or with division by zero for the radius vector at the rotational symmetry axis. The expressions of U_{ik}, $U_{ik,j}$ and $U_{ik,j\ell}$ are presented in a form suitable for an efficient computational implementation in BEM codes."

MR2882869 74G15 30E25 35Q74 65N99 74K10 74S30

Santoro, Roberta (I-MESS-CE; Messina)

Solution of de Saint Venant flexure-torsion problem for orthotropic beam via LEM (Line Element-less Method). (English summary)

Eur. J. Mech. A Solids **30** (2011), *no.* 6, 924–939.

The numerical analysis of the Saint-Venant problem for orthotropic beams with arbitrary cross section is presented. The line element-less method is employed for single and multiply-connected cross-section orthotropic beams via a novel kind of complex potential function for problem domains. The potential function is constructed as a Laurent series having harmonic polynomials. After the implementation of the developed method, the problem is reduced to a system of linear algebraic equations with symmetric and positive definite matrix. Shear stress fields and stress variation through the cross-section are investigated for interior points in the section of beams. The paper is a theoretical study but it is not clear which specific novel problem benefits from this study. *Ömer Civalek*

MR2875443 74G60 65N99 74K20

Malekzadeh, P. [**Malekzadeh, Parviz**[1]] (IR-PGU-ME; Bushehr);
Golbahar Haghighi, M. R. (IR-PGU-ME; Bushehr);
Alibeygi Beni, A. (IR-PGU-CE; Bushehr)

Buckling analysis of functionally graded arbitrary straight-sided quadrilateral plates on elastic foundations. (English summary)

Meccanica **47** (2012), *no.* 2, 321–333.

Summary: "As a first endeavor, the buckling analysis of functionally graded (FG) arbitrary straight-sided quadrilateral plates rested on two-parameter elastic foundation under in-plane loads is presented. The formulation is based on the first order shear deformation theory (FSDT). The material properties are assumed to be graded in the

thickness direction. The solution procedure is composed of transforming the governing equations from physical domain to computational domain and then discretization of the spatial derivatives by employing the differential quadrature method (DQM) as an efficient and accurate numerical tool. After studying the convergence of the method, its accuracy is demonstrated by comparing the obtained solutions with the existing results in literature for isotropic skew and FG rectangular plates. Then, the effects of thickness-to-length ratio, elastic foundation parameters, volume fraction index, geometrical shape and the boundary conditions on the critical buckling load parameter of the FG plates are studied."

MR2876677 74J20 65N21

Gintides, Drossos (GR-ATHN2-NDM; Zografou); **Sini, Mourad** (A-OAW-RIC; Linz); **Thành, Nguyen Trung** (A-OAW-RIC; Linz)

Detection of point-like scatterers using one type of scattered elastic waves. (English summary)

J. Comput. Appl. Math. **236** (2012), *no.* 8, 2137–2145.

Summary: "In this paper, we are concerned with the detection of point-like obstacles using elastic waves. We show that one type of waves, either the P or the S scattered waves, is enough for localizing the points. We also show how the use of S incident waves gives better resolution than the P waves. These affirmations are demonstrated by several numerical examples using a MUSIC type algorithm."

MR2862994 74M15 65K15 65M55 65M60

Hager, Corinna (D-STGT-ANS; Stuttgart); **Hauret, Patrice** (F-MICH-MFP; Clermont-Ferrand); **Le Tallec, Patrick** (F-POLY-MC; Palaiseau); **Wohlmuth, Barbara I.** (D-MUTU-ZMG; Garching)

Solving dynamic contact problems with local refinement in space and time. (English summary)

Comput. Methods Appl. Mech. Engrg. **201/204** (2012), 25–41.

This interesting paper discusses the numerical simulation of a challenging problem that combines several difficulties, such as contact with friction in large deformation elastodynamics and complex multi-scale contact geometry due to the presence of fine details of the structure being studied: a tire.

Several well-established methods are combined to build an efficient numerical scheme: a two-scale iterative scheme based on an overlapping mortar method, an active-set strategy to solve the contact problem and the mass redistribution method for the elastodynamical contact condition.

A linearized model is introduced first in order to present the two-scale iterative method and exhibit its main properties.

The main interest of the paper is the construction of a two-scale overlapping domain decomposition approach both in space and time which is implemented with contact constraint and dynamical terms. Theoretical justifications and a numerical investigation on a realistic application are given. *Yves Renard*

MR2872024 74M15 49M29 65N30 74M10

Hüeber, S. (D-MUTUM2; Garching); **Wohlmuth, B.** (D-MUTUM2; Garching)

Equilibration techniques for solving contact problems with Coulomb friction. (English summary)

Comput. Methods Appl. Mech. Engrg. **205/208** (2012), 29–45.

A problem of frictional contact between two linearly elastic bodies with the linearized

non-penetration condition and the static Coulomb friction law is considered. The contact problem is reformulated in the form of discrete nonsmooth equalities and is handled within the abstract framework of saddle point problems. The discretization of the problem is based on a low-order pair of primal-dual variables for the displacement and the surface traction on the possible contact zone. Residual and equilibrated error indicators which provide upper and local lower bounds for the discretization error are considered for the Lagrange multiplier which acts as a Neumann condition on the possible contact zone as well as for additional contact/friction terms which measure the non-conformity of the discrete Lagrange multiplier. Numerical results in two and three dimensions illustrate the influence of the material parameters on the adaptive refinement process. It is shown that a weakly consistent discretization based on a biorthogonal set of displacement traces and surface tractions is well suited for the numerical simulation of frictional contact problems. *Ivan I. Argatov*

MR2872022 74M15 65N30 65N55 74G15 74S05

Laursen, Tod A. (UAE-KUSTAR2; Abu Dhabi)**;**
Puso, Michael A. [**Puso, Michael Anthony**] (1-LLL-MD; Livermore, CA)**;**
Sanders, Jessica [**Sanders, Jessica D.**] (1-DUKE-CPM; Durham, NC)

Mortar contact formulations for deformable-deformable contact: past contributions and new extensions for enriched and embedded interface formulations. (English summary)

Comput. Methods Appl. Mech. Engrg. **205/208** (2012), 3–15.

The paper summarizes the major ideas in the formulation and error analysis of the mortar finite element method for linear elasticity problems. Further, an extension, with recent contributions and applications, for large deformations, elastic contact problems and enriched and embedded interface problems, is presented. The described computational algorithms and techniques make the paper useful for those working in the field of computer simulation of complex multi-body contact processes. *T. A. Angelov*

MR2880253 74M15 49J40 65N15 65N30 74B20 74M10 74S05

Touzaline, Arezki (DZ-BOUMM-SDY; Algiers)

Study of a contact problem with normal compliance and nonlocal friction. (English summary)

Appl. Math. (*Warsaw*) **39** (2012), *no.* 1, 43–55.

In this paper, the author considers a contact problem in nonlinear elasticity involving normal compliance and nonlocal friction. The variational formulation is written as a nonlinear variational inequality of the second kind. The existence of a unique weak solution is proved for small friction coefficients by using fixed-point arguments. Moreover, the behaviour of this solution with respect to perturbations of the normal compliance function is considered, obtaining a continuous dependence on such perturbation parameters. Finally, a priori error estimates are provided, assuming additional regularity on the solution for small friction coefficients. *José R. Fernández*

MR2872027 74M15 65N30 65N55 74G15

Weyler, R. (E-UPBIAE; Terrassa)**; Oliver, J.** (E-UPBCE-NDM; Barcelona)**;**
Sain, T. (E-UPBCE-NDM; Barcelona)**;**
Cante, J. C. [**Cante, Juan Carlos**] (E-UPBIAE; Terrassa)

On the contact domain method: a comparison of penalty and Lagrange multiplier implementations. (English summary)

Comput. Methods Appl. Mech. Engrg. **205/208** (2012), 68–82.

Summary: "This work focuses on the assessment of the relative performance of the

so-called contact domain method, using either the Lagrange multiplier or the penalty strategies. The mathematical formulation of the contact domain method and the imposition of the contact constraints using a stabilized Lagrange multiplier method are taken from the seminal work (as cited later), whereas the penalty based implementation is firstly described here. Although both methods result into equivalent formulations, except for the difference in the constraint imposition strategy, in the Lagrange multiplier method the constraints are enforced using a stabilized formulation based on an interior penalty method, which results into a different estimation of the contact forces compared to the penalty method. Several numerical examples are solved to assess certain numerical intricacies of the two implementations. The results show that both methods perform similarly as one increases the value of the penalty parameter or decreases the value of the stabilization factor (in case of the Lagrange multiplier method). However there seems to exist a clear advantage in using the Lagrange multiplier based strategy in a few critical situations, where the penalty method fails to produce convincing results due to excessive penetration."

MR2895491 74R10 65N38 74S15

Phan, A.-V. [Phan, Anh-Vũ] (1-SAL-NDM; Mobile, AL)**;**
Guduru, V. (1-SAL-NDM; Mobile, AL)

Boundary element transient analysis of the dynamic T-stress and biaxiality ratio. (English summary)

Riv. Math. Univ. Parma (*N.S.*) **2** (2011), *no.* 1, 57–76.

Summary: "In this paper, we introduce a 2-D boundary integral equation (BIE) for determining the T-stress for cracks under dynamic loading conditions (dynamic T-stress or DTS). This BIE is only weakly singular and it can be used in the post-processing stage of a boundary element dynamic analysis of cracks. The formula can also be employed, in conjunction with any technique for the mode-I dynamic stress intensity (DSIF), for calculating the dynamic biaxiality ratio (DBR). In this work, the proposed BIE is formulated in the frequency domain so it can be used within the framework of the symmetric-Galerkin boundary element method for elastodynamics in the Fourier-space frequency domain. By applying the inverse fast Fourier transform to the frequency responses of the DTS and mode-I DSIF, the time histories (transient responses) of the DTS and DBR can be obtained. Numerical examples involving 2-D crack plates subjected to the Heaviside step loading are presented. The DTS results obtained from the aforementioned BIE are compared with some references available in the literature to validate the proposed technique."

MR2844034 74S05 65N15 65N30 74B05

Hansbo, Peter (S-CHAL; Göteborg)**; Larson, Mats G.** (S-UMEA-MMS; Umeå)

Energy norm a posteriori error estimates for discontinuous Galerkin approximations of the linear elasticity problem. (English summary)

Comput. Methods Appl. Mech. Engrg. **200** (2011), *no.* 45-46, 3026–3030.

Summary: "We present a residual-based a posteriori error estimate in an energy norm of the error in a family of discontinuous Galerkin approximations of linear elasticity problems. The theory is developed in two and three spatial dimensions and general nonconvex polygonal domains are allowed. We also present some illustrating numerical examples."

MR2870038 76A20 65M06 76M20
Peterson, Ellen R. (1-CMU; Pittsburgh, PA)**; Shearer, Michael** (1-NCS; Raleigh, NC)
Simulation of spreading surfactant on a thin liquid film. (English summary)
Appl. Math. Comput. **218** (2012), *no.* 9, 5157–5167.
Summary: "The spreading of insoluble surfactant on a thin liquid film is modeled by a pair of nonlinear partial differential equations for the height of the free surface and the surfactant concentration. A numerical method is developed in which the leading edge of the surfactant is tracked. In the absence of higher order regularization the system becomes hyperbolic/degenerate-parabolic, introducing jumps in the height of the free surface and the surfactant concentration gradient. We compare numerical simulations to those of a hybrid Godunov method in which the height equation is treated as a scalar conservation law and a parabolic solver is used for the surfactant equation. We show how the tracking method applies to the full equations with realistic gravity and capillarity terms included, even though the disturbance in the height of the free surface extends beyond the support of the surfactant concentration."

MR2850963 76B15 65M06 65M08 76M12 76M20
Caleffi, Valerio (I-FERR-E; Ferrara)
A new well-balanced Hermite weighted essentially non-oscillatory scheme for shallow water equations. (English summary)
Internat. J. Numer. Methods Fluids **67** (2011), *no.* 9, 1135–1159.
Summary: "Hermite weighted essentially non-oscillatory (HWENO) methods were introduced in the literature, in the context of Euler equations for gas dynamics, to obtain high-order accuracy schemes characterized by high compactness [e.g. J. X. Qiu and C.-W. Shu, J. Comput. Phys. **193** (2004), no. 1, 115–135; MR2022691 (2004j:65123)]. For example, classical fifth-order weighted essentially non-oscillatory (WENO) reconstructions are based on a five-cell stencil whereas the corresponding HWENO reconstructions are based on a narrower three-cell stencil. The compactness of the schemes allows easier treatment of the boundary conditions and of the internal interfaces. To obtain this compactness in HWENO schemes both the conservative variables and their first derivatives are evolved in time, whereas in the original WENO schemes only the conservative variables are evolved.

"In this work, an HWENO method is applied for the first time to the shallow water equations (SWEs), including the source term due to the bottom slope, to obtain a fourth-order accurate well-balanced compact scheme. Time integration is performed by a strong stability preserving the Runge-Kutta method, which is a five-step and fourth-order accurate method. Besides the classical SWE, the non-homogeneous equations describing the time and space evolution of the conservative variable derivatives are considered here. An original, well-balanced treatment of the source term involved in such equations is developed and tested. Several standard one-dimensional test cases are used to verify the high-order accuracy, the *C-property* and the good resolution properties of the model."

MR2863108 76B15 65M06
Lu, Changna (PRC-NUIST-MP; Nanjing)**; Li, Gang** (PRC-QGD-SM; Qingdao)
Simulations of shallow water equations by finite difference WENO schemes with multilevel time discretization. (English summary)
Numer. Math. Theory Methods Appl. **4** (2011), *no.* 4, 505–524.
Summary: "In this paper we study a class of multilevel high order time discretization procedures for the finite difference weighted essential non-oscillatory (WENO) schemes to solve the one-dimensional and two-dimensional shallow water equations with source

terms. Multilevel time discretization methods can make full use of computed information by WENO spatial discretization and save CPU cost by holding the former computational values. Extensive simulations are performed, which indicate that the finite difference WENO schemes with multilevel time discretization can achieve higher accuracy, and are more cost effective than WENO scheme with Runge-Kutta time discretization, while still maintaining nonoscillatory properties."

MR2847119 76D05 41A30 65N35

Bourantas, G. C.; Petsi, A. J.; Skouras, E. D.; Burganos, V. N.

Meshless point collocation for the numerical solution of Navier-Stokes flow equations inside an evaporating sessile droplet. (English summary)

Eng. Anal. Bound. Elem. **36** (2012), *no.* 2, 240–247.

Summary: "The Navier-Stokes flow inside an evaporating sessile droplet is studied in the present paper, using sophisticated meshfree numerical methods for the computation of the flow field. This problem relates to numerous modern technological applications, and has attracted several analytical and numerical investigations that expanded our knowledge on the internal microflow during droplet evaporation. Two meshless point collocation methods are applied here to this problem and used for flow computations and for comparison with analytical and more traditional numerical solutions. Particular emphasis is placed on the implementation of the velocity-correction method within the meshless procedure, ensuring the continuity equation with increased precision. The Moving Least Squares (MLS) and the Radial Basis Function (RBF) approximations are employed for the construction of the shape functions, in conjunction with the general framework of the Point Collocation Method (MPC). An augmented linear system for imposing the coupled boundary conditions that apply at the liquid-gas interface, especially the zero shear-stress boundary condition at the interface, is presented. Computations are obtained for regular, Type-I embedded nodal distributions, stressing the positivity conditions that make the matrix of the system stable and convergent. Low Reynolds number (Stokes regime), and elevated Reynolds number (Navier-Stokes regime) conditions have been studied and the solutions are compared to those of analytical and traditional CFD methods. The meshless implementation has shown a relative ease of application, compared to traditional mesh-based methods, and high convergence rate and accuracy."

MR2869619 76D05 65M12 65M60 76M10

De Sampaio, P. A. B. [de Sampaio, P. A. B.]; Gonçalves, M. A., Jr. (BR-FRJ-CPL; Rio de Janeiro)

A second-order time accurate finite element method for quasi-incompressible viscous flows. (English summary)

Internat. J. Numer. Methods Fluids **67** (2011), *no.* 12, 1848–1864.

Summary: "A finite element method for quasi-incompressible viscous flows is presented. An equation for pressure is derived from a second-order time accurate Taylor-Galerkin procedure that combines the mass and the momentum conservation laws. At each time step, once the pressure has been determined, the velocity field is computed solving discretized equations obtained from another second-order time accurate scheme and a least-squares minimization of spatial momentum residuals. The terms that stabilize the finite element method (controlling wiggles and circumventing the Babuska-Brezzi condition) arise naturally from the process, rather than being introduced *a priori* in the variational formulation. A comparison between the present second-order accurate method and our previous first-order accurate formulation is shown. The method is also demonstrated in the computation of the leaky-lid driven cavity flow and in the

simulation of a crossflow past a circular cylinder. In both cases, good agreement with previously published experimental and computational results has been obtained."

MR2846529 76D05 65M06 76M20 76M27
Tan, Jie (PRC-JTU-LIC; Shanghai)**; Yang, XuBo** (PRC-JTU-LIC; Shanghai)**;**
Zhao, Xin (PRC-JTU-DGA; Shanghai)**; Yang, ZhanXin** (PRC-JTU-DGA; Shanghai)
A multi-layer grid approach for fluid animation. (English summary)
Sci. China Inf. Sci. **54** (2011), *no.* 11, 2269–2278.

The authors present a new method for solving the Navier-Stokes equation by means of finite-difference schemes on multiple layers of grids.

The following equation is considered:

$$\nabla \mathbf{u} = 0, \tag{1}$$

$$\frac{\partial \mathbf{u}}{\partial t} = -\mathbf{u} \cdot \nabla \mathbf{u} - \frac{1}{\rho} \nabla p + \mathbf{f}, \tag{2}$$

where $\mathbf{u} = (u, v, w)$ is the velocity, p is the pressure, ρ is the density, $\mathbf{f}$ is the external body force.

For (1), (2) the following finite-difference scheme is suggested:

$$\mathbf{u}^{n+1} = \mathbf{u}^* - \frac{\Delta t}{\rho} \nabla p,$$

where $\mathbf{u}^*$ is an intermediate velocity

$$\mathbf{u}^* = \mathbf{u}^n + \Delta t(-\mathbf{u}^n \cdot \nabla \mathbf{u}^n + \mathbf{f}),$$

and the pressure field is computed from the Poisson equation

$$\nabla^2 p = \frac{\rho}{\Delta t} \nabla \mathbf{u}^*$$

with Neumann boundary conditions at the solid-fluid interface and Dirichlet boundary conditions at the free surface.

The equations are solved on different layers in successive passes. The accuracy of these schemes is established intuitively.

The method suggested by the authors reflects the multi-scale behavior of fluids, shortens the simulation time and is applicable to different kinds of grids.

The regular tetrahedral and the coarse-fine bi-layer grids are considered as examples.

Nina G. Khatiashvili

MR2868257 76D07 65M08 76M12
An, Jing [An, Jing[1]] (PRC-GUZN-SMC; Guiyang)**;**
Sun, Ping (PRC-GUZN-SMC; Guiyang)**;**
Luo, Zhen Dong [Luo, Zhen Dong[1]] (PRC-GUZN-SMC; Guiyang)**;**
Huang, Xiao Ming (PRC-BJTU-SS; Beijing)
A stabilized fully discrete finite volume element formulation for a nonstationary Stokes equation. (Chinese. English and Chinese summaries)
Math. Numer. Sin. **33** (2011), *no.* 2, 213–224.

In this paper, the authors extend the stabilized finite volume method for the stationary Stokes equations by Li and Chen. A finite volume element method for nonstationary Stokes equations is studied and a stabilized fully discrete finite volume element formulation based on two local Gauss integrals for nonstationary Stokes equations is deduced. The errors of solution for this formulation are analyzed. *Yinnian He*

MR2876753 76D07 65R20 76S05

Kohr, Mirela (R-CLUJMI-NDM; Cluj-Napoca)**;**
Raja Sekhar, G. P. (6-IITKH; Kharagpur)**;**
Ului, Elena M. [Ului, Elena-Maria] (R-CLUJMI-NDM; Cluj-Napoca)**;**
Wendland, Wolfgang L. (D-STGT-ANS; Stuttgart)

Two-dimensional Stokes-Brinkman cell model—a boundary integral formulation. (English summary)

Appl. Anal. **91** (2012), *no.* 2, 251–275.

Summary: "The purpose of this article is to prove the existence and uniqueness of the solution to a two-dimensional cell model problem, which describes the Stokes flow of a viscous incompressible fluid in a bounded Lipschitz region past a porous medium and in the presence of a solid core. The flow within the porous medium is described by the Brinkman equation. One uses the continuity of the velocity and traction fields at the fluid-porous interface, while on the exterior boundary of the fluid envelope, as well as on the boundary of the solid core the velocity field satisfies the prescribed Dirichlet conditions. In order to show the desired existence and uniqueness in certain Sobolev spaces, we develop a layer potential approach based on the potential theory for the Stokes and Brinkman equations. In addition, some particular cases are also analysed."

Vladimir Mityushev

MR2868250 76D07 65N08 76M12

Xie, Chun Mei (PRC-EST-SM; Chengdu)**;**
Luo, Yan [Luo, Yan^2] (PRC-EST-SM; Chengdu)**;**
Feng, Min Fu (PRC-SUN-SM; Chengdu)

Analysis of a unified stabilized finite volume method for the Darcy-Stokes problem. (Chinese. English and Chinese summaries)

Math. Numer. Sin. **33** (2011), *no.* 2, 133–144.

In this paper, the authors extend the unified stabilized finite volume method to solve the Darcy-Stokes problem. Two grids are used for the discrete formulation; one is a triangulation and the other is a quadrilateral mesh. The velocity and pressure are approximated by the P_1-P_0 element pair. The proposed unified stabilized finite volume method is shown to be stable and optimally convergent for both velocity and pressure. Moreover, numerical tests are made to demonstrate the theoretical results.

Yinnian He

MR2869627 76D08 65N30 76M10

Nilsson, B. [Nilsson, Bertil]; Hansbo, P. (S-CHAL; Göteborg)

A Stokes model with cavitation for the numerical simulation of hydrodynamic lubrication. (English summary)

Internat. J. Numer. Methods Fluids **67** (2011), *no.* 12, 2015–2025.

Summary: "We present a cavitation model based on the Stokes equation and formulate adaptive finite element methods for its numerical solution. *A posteriori* error estimates and adaptive algorithms are derived, and numerical examples illustrating the theory are supplied, in particular with comparison to the simplified Reynolds model of lubrication."

MR2877969 76D27 65N30

Rüberg, T. (4-CAMB-E; Cambridge)**; Cirak, F.** (4-CAMB-E; Cambridge)

Subdivision-stabilised immersed b-spline finite elements for moving boundary flows. (English summary)

Comput. Methods Appl. Mech. Engrg. **209/212** (2012), 266–283.

Summary: "An immersed finite element method is presented to compute flows with

complex moving boundaries on a fixed Cartesian grid. The viscous, incompressible fluid flow equations are discretized with b-spline basis functions. The two-scale relation for b-splines is used to implement an elegant and efficient technique to satisfy the LBB condition. On non-grid-aligned fluid domains and at moving boundaries, the boundary conditions are enforced with a consistent penalty method as originally proposed by Nitsche. In addition, a special extrapolation technique is employed to prevent the loss of numerical stability in presence of arbitrarily small cut-cells. The versatility and accuracy of the proposed approach is demonstrated by means of convergence studies and comparisons with previous experimental and computational investigations."

MR2855661 76F65 65M08 76M12

Chaouat, Bruno (F-ONERA-CFD; Châtillon)

An efficient numerical method for RANS/LES turbulent simulations using subfilter scale stress transport equations. (English summary)

Internat. J. Numer. Methods Fluids **67** (2011), *no.* 10, 1207–1233.

Summary: "We propose a numerical method for performing hybrid non-zonal RANS/LES simulations by using a subfilter scale stress transport model in the framework of finite volume technique. The turbulent equations are derived from the new partial integrated transport modeling (PITM) method. The PITM method has been initially developed for devising subfilter energy models based on the viscosity concept [R. Schiestel and A. Dejoan, Theor. Comput. Fluid Dyn. **18** (2005), no. 6, 443–468, doi:10.1007/s00162-004-0155-z], and has been then extended to subfilter stress models relying on second-moment closures [B. Chaouat and R. Schiestel, Phys. Fluids **17** (2005), no. 6, 065106; MR2152439 (2006a:76059); Int. J. Heat Fluid Flow **30** (2009), no. 4, 602–616, doi:10.1016/j.ijheatfluidflow.2009.02.021; Theor. Comput. Fluid Dyn. **21** (2007), no. 3, 201–229, doi:10.1007/s00162-007-0044-3]. The numerical method put in place is developed in a general framework of large eddy simulations and can be applied to almost all subfilter scale models based on transport equations of subfilter scale turbulent quantities. In this work, we have developed specific numerical schemes for solving the turbulent transport equations of compressible flows including the density, velocity, energy, subfilter scale turbulent stresses and subfilter scale dissipation rate that are strongly coupled together. When performing LES or VLES simulations, this coupling between the motion and turbulent equations poses some numerical problems because the subfilter scale turbulent stresses and dissipation rate are more fluctuating in time and space than in the case of RANS computations, so that a specific numerical treatment has been proposed. In this framework, new implicit iterative algorithms in time are especially developed for solving the unsteady equations of the turbulent energy, stresses and dissipation rate by ensuring the positivity of the normal stresses at each step of the computation. We show that the convective fluxes resulting from the volume technique including the main and turbulent variables can be computed by an approximate Riemann solver using new tensorial operators. The numerical solver is calibrated on the decay of isotropic spectrum and on the well-known fully turbulent channel flow for assessing the performances of the numerical method. Then, we perform numerical simulations of the turbulent channel flow over periodic hills on coarse and medium grids. This flow encountered in aeronautical applications is of complex physics as it is governed by interacting turbulence mechanisms associated with separation, recirculation and reattachment. As a result, it is found that the proposed numerical method used in conjunction with the subfilter stress model performs fairly well with these turbulent flows on different grids. From a practical point of view, this numerical method can be easily implemented in CFD codes for tackling engineering applications."

MR2863630 76M28 65M75
Vanderhoydonc, Y. (B-UA-CS; Wilrijk)**; Vanroose, W.** (B-UA-CS; Wilrijk)
Lifting in hybrid lattice Boltzmann and PDE models. (English summary)
Comput. Vis. Sci. **14** (2011), *no.* 2, 67–78.
Summary: "Mathematical models based on kinetic equations are ubiquitous in the modeling of granular media, population dynamics of biological colonies, chemical reactions and many other scientific problems. These individual-based models are computationally very expensive because the evolution takes place in the phase space. Hybrid simulations can bring down this computational cost by replacing locally in the domain—in the regions where it is justified—the kinetic model with a more macroscopic description. This splits the computational domain into subdomains. The question is how to couple these models in a mathematically correct way with a lifting operator that maps the variables of the macroscopic partial differential equation to those of the kinetic model. Indeed, a kinetic model has typically more variables than a model based on a macroscopic partial differential equation and at each interface we need the missing data. In this contribution we report on different lifting operators for a hybrid simulation that combines a lattice Boltzmann model—a special discretization of the Boltzmann equation—with a diffusion partial differential equation. We focus on the numerical comparison of various lifting strategies."

MR2869426 76N10 65M75 76M28
Chen, Yibing (PRC-BIAP; Beijing)**; Jiang, Song [Jiang, Song[1]]** (PRC-BIAP; Beijing)
A non-oscillatory kinetic scheme for multi-component flows with the equation of state for a stiffened gas. (English summary)
J. Comput. Math. **29** (2011), *no.* 6, 661–683.
Summary: "We extend the traditional kinetic scheme for ideal gases to the Euler equations with the equation of state for a multi-component stiffened gas. Based on a careful analysis of the oscillation mechanism of the traditional kinetic scheme across contact discontinuities, we propose a new non-oscillatory kinetic (NOK) scheme for multi-component stiffened gases. The basic idea in the construction is to use a flux splitting technique to construct numerical fluxes which do not depend on the concrete form of the equilibrium state. The new scheme can not only can avoid spurious oscillations of the pressure and velocity near a material interface which are observed in the traditional kinetic schemes such as the kinetic flux vector splitting (KFVS) and BGK schemes, but also can deal with the stiffened gas equation of state. Moreover, we also carry out a careful analysis on the consistency condition, truncation error and positivity of the NOK scheme. A number of 1D and 2D numerical tests are presented which demonstrate the accuracy and robustness of the new scheme in the simulation of problems with smooth, weak and strong shock wave regions."

MR2859139 76P05 65M75 76M20 76M28
Larina, I. N. (RS-AOS-C; Moscow)**; Rykov, V. A.** (RS-AOS-C; Moscow)
A kinetic model of the Boltzmann equation with limiting regimes of gas flow at low Knudsen numbers. (Russian. Russian summary)
Zh. Vychisl. Mat. Mat. Fiz. **48** (2008), *no.* 7, 1294–1308; *translation in Comput. Math. Math. Phys.* **48** (2008), *no.* 7, 1221–1233.
The paper concerns a kinetic model for the Boltzmann equation which is appropriate for slow non-isothermal flows of gases in the limit of a continuous medium. To derive the model, the distribution function is linearized near the local Maxwellian. The collision integral is decomposed into its linear and quadratic parts. The latter is presented as a quadratic form with respect to the distribution function moment. Moreover, the

perturbation function is decomposed into even and odd parts with respect to the molecular velocity. Finally, the model equation approximating the full Boltzmann equation takes a cumbersome form containing two unknown constants which are obtained under the assumption that the temperature stress of the model is equal to that obtained previously. To demonstrate the efficiency of the model, the authors solve two benchmark problems, viz., shock wave structure and slow non-isothermal flow of gas past a cylinder. A comparison of the present results with those obtained from other models shows that the new terms in the collision integral affect the shock wave weakly, but they change the slow non-isothermal flow significantly. *Felix Sharipov*

MR2869425 76P05 65M75 76M28

Xu, Kun (PRC-HKST; Kowloon)**;**
Guo, Zhaoli [Guo, Zhao Li] (PRC-HUST-LCC; Wuhan)

Multiple temperature gas dynamic equations for non-equilibrium flows. (English summary)

J. Comput. Math. **29** (2011), *no.* 6, 639–660.

Summary: "In an early approach, a kinetic model with multiple translational temperature [K. Xu, H. Liu and J. Jiang, Phys. Fluids **19** (2007), no. 1, 016101, doi:10.1063/1.2429037] to simulate non-equilibrium flows was proposed. In this paper, instead of using three temperatures in the x, y and z-directions, we define the translational temperature as a second-order symmetric tensor. Under the new framework, the differences between the temperature tensor and the pressure tensor will be explicitly pointed out. Based on a multiple stage BGK-type collision model and the Chapman-Enskog expansion, the corresponding macroscopic gas dynamics equations in three-dimensional space will be derived. The zeroth-order expansion gives 10 moment closure equations similar to that of C. D. Levermore [J. Statist. Phys. **83** (1996), no. 5-6, 1021–1065; MR1392419 (97e:82041)]. The derived gas dynamic equations can be considered as a regularization of the 10 moments equations in the first-order expansion. The new gas dynamic equations have the same structure as the Navier-Stokes equations, but the stress-strain relationship in the Navier-Stokes equations is replaced by an algebraic equation with temperature differences. At the same time, the heat flux, which is absent in Levermore's 10 moment closure, is recovered. As a result, both the viscous and the heat conduction terms are unified under a single anisotropic temperature concept. In the continuum flow regime, the new gas dynamic equations automatically recover the standard Navier-Stokes equations. Our gas dynamic equations are natural extensions of the Navier-Stokes equations to the near continuum flow regime and can be used for microflow computations. Two examples, the force-driven Poiseuille flow and the Couette flow in the transition flow regime, are used to validate the model. Both analytical and numerical results are presented. Theoretically, the Boltzmann equation can be also applied to the current multiple stage gas evolution model to derive generalized macroscopic governing equations in the near continuum flow regime. Instead of using Maxwellian as an expansion point in the Chapman-Enskog method, the multiple temperature Gaussian can be used as an expansion point as well."

MR2872882 76S05 65M12 65M60 76M10

Yang, Jiming [Yang, Ji Ming[1]] (PRC-XIE-CSC; Xiangtan)**;**
Chen, Yanping [Chen, Yan Ping[1]] (PRC-SCN-SM; Guangzhou)

Superconvergence of a combined mixed finite element and discontinuous Galerkin approximation for an incompressible miscible displacement problem. (English summary)

Appl. Math. Model. **36** (2012), *no.* 3, 1106–1113.

Summary: "A combined mixed finite element and discontinuous Galerkin approximation for an incompressible miscible displacement problem which includes molecular diffusion and dispersion in porous media is studied. That is to say, the mixed finite element method is applied to the flow equation, and the transport equation is solved by an interior penalty discontinuous Galerkin method. Convolution of the Darcy velocity approximation with the Bramble-Schatz kernel function and averaging are applied in the evaluation of the coefficients in the Galerkin procedure for the concentration. A superconvergence estimate is obtained. Numerical experimental results are presented to verify the theoretical analysis." *John M. Stockie*

MR2896090 76W05 65M06 76M20

Loganathan, P. (6-ANUN; Chennai)**; Kannan, M.; Ganesan, P.** (6-ANUN; Chennai)

MHD effects on free convective flow over moving semi-infinite vertical cylinder with temperature oscillation. (English summary)

Appl. Math. Mech. (*English Ed.*) **32** (2011), *no.* 11, 1367–1376.

The authors present numerical solutions for the problem defined in the detailed title. Because of the numerous included effects no less than five characteristic numbers (Grashof, Nusselt, Prandtl, Schmidt, Sherwood) are introduced. The dimensionless unsteady nonlinear and coupled governing equations are solved by means of an implicit finite-difference scheme of the Crank-Nicholson type. A set of selected numerical graphs provides the velocity, temperature and concentration profiles, as well as the local and average skin-friction, depending on the values of characteristic numbers. This obviously includes the effect of the magnetic field. *Gérard A. Maugin*

MR2874189 76W05 65N35 76D10

Parand, K. [Parand, Kourosh] (IR-SHBH-C; Tehran)**;**
Dehghan, Mehdi [Dehghan, Mehdi[2]] (IR-AUTMC-AM; Tehran)**; Pirkhedri, A.**

The use of sinc-collocation method for solving Falkner-Skan boundary-layer equation. (English summary)

Internat. J. Numer. Methods Fluids **68** (2012), *no.* 1, 36–47.

Summary: "The MHD Falkner-Skan equation arises in the study of laminar boundary layers exhibiting similarity on the semi-infinite domain. The proposed approach is equipped by the orthogonal Sinc functions that have perfect properties. This method solves the problem on the semi-infinite domain without truncating it to a finite domain and transforming domain of the problem to a finite domain. In addition, the governing partial differential equations are transformed into a system of ordinary differential equations using similarity variables, and then they are solved numerically by the Sinc-collocation method. It is shown that the Sinc-collocation method converges to the solution at an exponential rate."

MR2862448 76W05 65M06 76M20

Wolff, Marc; Jaouen, Stéphane; Imbert-Gérard, Lise-Marie (F-PARIS6-N; Paris)

Conservative numerical methods for a two-temperature resistive MHD model with self-generated magnetic field term. (English and French summaries)

CEMRACS'10 research achievements: *numerical modeling of fusion*, 195–210, *ESAIM Proc.*, 32, *EDP Sci.*, *Les Ulis*, 2011.

Summary: "We propose numerical methods on Cartesian meshes for solving the 2-D axisymmetric two-temperature resistive magnetohydrodynamics equations with self-generated magnetic field and S. I. Braginskiĭ's ["Transport processes in a plasma", in *Reviews of plasma physics. Vol. 1*, Edited by M. A. Leontovič. Authorized translation from the Russian by Herbert Lashinsky, Consultants Bureau, New York, 1965; per bibl.] closures. These rely on a splitting of the complete system in several subsystems according to the nature of the underlying mathematical operator. The hyperbolic part is solved using conservative high-order dimensionally split Lagrange-remap schemes whereas semi-implicit diffusion operators have been developed for the thermal and resistive conduction equations. Source terms are treated explicitly. Numerical results on the deceleration phase of an ICF implosion test problem are proposed, a benchmark which was initially proposed in [M. Temporal et al., Phys. Plasmas **13** (2006), no. 12, 122701, doi:10.1063/1.2397041]."

{For the entire collection see MR2906045 (2012i:65002).}

MR2862442 76X05 65M75 76M28 82D10

Abiteboul, J. (F-CENC-IFM; Saint-Paul-lez-Durance);
Latu, G. (F-CENC-IFM; Saint-Paul-lez-Durance);
Grandgirard, V. [Grandgirard, Virginie] (F-CENC-IFM; Saint-Paul-lez-Durance);
Ratnani, A. [Ratnani, Ahmed] (F-STRAS-I; Strasbourg);
Sonnendrücker, E. (F-STRAS-I; Strasbourg);
Strugarek, A. (F-CENC-IFM; Saint-Paul-lez-Durance)

Solving the Vlasov equation in complex geometries. (English and French summaries)

CEMRACS'10 research achievements: *numerical modeling of fusion*, 103–117, *ESAIM Proc.*, 32, *EDP Sci.*, *Les Ulis*, 2011.

Summary: "This paper introduces an isoparametric analysis to solve the Vlasov equation with a semi-Lagrangian scheme. A Vlasov-Poisson problem modeling a heavy ion beam in an axisymmetric configuration is considered. Numerical experiments are conducted on computational meshes targeting different geometries. The impact of the computational grid on the accuracy and the computational cost are shown. The use of analytical mapping or Bézier patches does not induce a too large computational overhead and is quite accurate. This approach successfully couples an isoparametric analysis with a semi-Lagrangian scheme, and we expect to apply it to a gyrokinetic Vlasov solver."

{For the entire collection see MR2906045 (2012i:65002).}

MR2863078 76X05 65M06 76M20

Grasso, D. [Grasso, Daniela] (I-TRNP-EG; Turin);
Borgogno, D. (I-TRNP-EG; Turin);
Tassi, E. [Tassi, Emanuele] (F-CNRS-T; Marseille)

Numerical investigation of a three-dimensional four field model for collisionless magnetic reconnection. (English summary)

Commun. Nonlinear Sci. Numer. Simul. **17** (2012), *no.* 5, 2085–2094.

Summary: "In this paper we present the numerical investigation of a three-dimensional four field model for magnetic reconnection in collisionless regimes. The model describes

the evolution of the magnetic flux and vorticity together with the perturbations of the parallel magnetic and velocity fields. We explored the different behavior of vorticity and current density structures in low and high β regimes, β being the ratio between the plasma and magnetic pressure. A detailed analysis of the velocity field advecting the relevant physical quantities is presented. We show that, as the reconnection process evolves, velocity layers develop and become more and more localized. The shear of these layers increases with time ending up with the occurrence of secondary instabilities of the Kelvin-Helmholtz type. We also show how the β parameter influences the different evolution of the current density structures, that preserve for longer time a laminar behavior at smaller β values. A qualitative explanation of the structures formation on the different z-sections is also presented."

MR2862444 76X05 65M60 65M75 65T60 76M28 82D10

Nguyen van yen, Romain (F-ENS-NDM; Paris)**;**
Sonnendrücker, Éric (F-STRAS-I; Strasbourg)**;**
Schneider, Kai (F-PROV-MMP; Marseille)**; Farge, Marie**

Particle-in-wavelets scheme for the 1D Vlasov-Poisson equations. (English and French summaries)

*CEMRACS'*10 *research achievements*: *numerical modeling of fusion*, 134–148, *ESAIM Proc.*, 32, *EDP Sci.*, *Les Ulis*, 2011.

Summary: "A new numerical scheme called particle-in-wavelets is proposed for the Vlasov-Poisson equations, and tested in the simplest case of one spatial dimension. The plasma distribution function is discretized using tracer particles, and the charge distribution is reconstructed using wavelet-based density estimation. The latter consists in projecting the Delta distributions corresponding to the particles onto a finite dimensional linear space spanned by a family of wavelets, which is chosen adaptively. The stability and accuracy of the scheme is supported by numerical computations of Landau damping and of the two-stream instability. By direct comparison with a reference solution obtained by a very precise semi-Lagrangian method, we show that the precision is improved roughly by a factor 3 compared to a classical PIC scheme, for a given number of particles."

{For the entire collection see MR2906045 (2012i:65002).}

MR2869391 76Y05 65M06 76M20 76W05 82D10

Jardin, S. C. (1-PRIN-PP; Princeton, NJ)

Review of implicit methods for the magnetohydrodynamic description of magnetically confined plasmas. (English summary)

J. Comput. Phys. **231** (2012), *no.* 3, 822–838.

Summary: "Implicit algorithms are essential for predicting the slow growth and saturation of global instabilities in today's magnetically confined fusion plasma experiments. Present day algorithms for obtaining implicit solutions to the magnetohydrodynamic (MHD) equations for highly magnetized plasma have their roots in algorithms used in the 1960s and 1970s. However, today's computers and modern linear and non-linear solver techniques make practical much more comprehensive implicit algorithms than were previously possible. Combining these advanced implicit algorithms with highly accurate spatial representations of the vector fields describing the plasma flow and magnetic fields and with improved methods of calculating anisotropic thermal conduction now makes possible simulations of fusion experiments using realistic values of plasma parameters and actual configuration geometry. This article is a review of these developments."

MR2845749 78A25 35Q61 65M15 65M60 78M10

Vrábel', Vladimír (B-GHNT-AN; Ghent); **Slodička, Marián** (B-GHNT-AN; Ghent)

An eddy current problem with a nonlinear evolution boundary condition. (English summary)

J. Math. Anal. Appl. **387** (2012), *no.* 1, 267–283.

Summary: "Our paper is devoted to a study of an eddy current problem with a nonlinear evolution degenerate boundary condition of the type $\boldsymbol{\nu} \times \mathbf{E} = \boldsymbol{\nu} \times \partial_t \mathbf{a}(\mathbf{H} \times \boldsymbol{\nu})$ with a power-law nonlinearity. We have designed a nonlinear numerical scheme for approximation in suitable function spaces. The well-posedness of the problem is addressed and the error estimates are derived. Monotonicity methods and the Minty-Browder argument are used in the proofs." *Xin-She Yang*

MR2907034 78A45 45A05 65R20

Cools, Kristof (B-GHNT-NDM; Ghent);
Andriulli, Francesco P. (I-TRNP-NDM; Turin);
Michielssen, Eric (1-MI-NDM; Ann Arbor, MI)

A Calderón multiplicative preconditioner for the PMCHWT integral equation. (English summary)

IEEE Trans. Antennas and Propagation **59** (2011), *no.* 12, 4579–4587.

Summary: "Electromagnetic scattering by penetrable bodies often is modelled by the Poggio-Miller-Chan-Harrington-Wu-Tsai (PMCHWT) integral equation. Unfortunately the spectrum of the operator involved in this equation is bounded neither from above or below. This implies that the equation suffers from dense discretization breakdown; that is, the condition numbers of the matrix resulting upon discretizing the equation rise with the mesh density. The electric field integral equation, often used to model scattering by perfect electrically conducting bodies, is susceptible to a similar breakdown phenomenon. Recently, this breakdown was cured by leveraging the Calderón identities. In this paper, a Calderón preconditioned PMCHWT integral equation is introduced. By constructing a Calderón identity for the PMCHWT operator, it is shown that the new equation does not suffer from dense discretization breakdown. A consistent discretization scheme involving both Rao-Wilton-Glisson and Buffa-Christiansen functions is introduced. This scheme amounts to the application of a multiplicative matrix preconditioner to the classical PMCHWT system, and therefore is compatible with existing boundary element codes and acceleration schemes. The efficiency and accuracy of the algorithm are corroborated by numerical examples."

MR2844042 78A57 65M60 78M10 92C20

Wong, Jonathan (1-STF-N; Stanford, CA); **Göktepe, Serdar** (TR-MET-CE; Ankara);
Kuhl, Ellen (1-STF-N; Stanford, CA)

Computational modeling of electrochemical coupling: a novel finite element approach towards ionic models for cardiac electrophysiology. (English summary)

Comput. Methods Appl. Mech. Engrg. **200** (2011), *no.* 45-46, 3139–3158.

I would like to emphasize that all the opinions given in this review are personal, and only reflect my own impressions.

First of all, I would like to give some generalities on the article. The article has a very clear motivation which, from its very beginning, is well defined and understandable for me as a reader: to provide a first step in numerical simulations of ionic channels that model/predict heart attacks. In this context, at the beginning of the article, more precisely in its introduction, a massive amount of information about the modeling of ionic channels is given, mainly from the historical point of view, with the classical references

to the works of Hodgkin and Huxley, FitzHugh, and Nagumo. A long list of references is given in the bibliography, which to my knowledge seems very complete. Section 2 goes more into the description of the differential equations to model the phenomena and makes, in my opinion, a major hypothesis on the modeling: the electrical part of the problem is assumed to be governed by partial differential equations, but the chemistry is only modeled by ordinary differential equations. Then, the authors explain the coupling between the phenomena. In section 3, they describe the numerical method to be implemented for solving the problem, which is summarized in the first table. Section 4 gives a description of the main parameters involved in the model, which were chosen from the literature available. Sections 4 and 5 give numerical trials of the model and a discussion on the results reported. Final discussions in section 7 conclude the paper. I liked the structure of the article; it shows coherence and the article itself is in general well presented.

Going now into detail, I missed an explanation in section 2.2 about why the chemical problem was only modeled by ordinary differential equations. I think that probably the length scale of the ionic channels but also the time scale at which they are open/closed is quite small in comparison with the length and time scales of the electrical problem, but this is only my conjecture, and certainly a brief explanation would have been suitable. Even if my conjecture is right, then why is the chemical part modelled by ODEs and not by a set of discrete states? To end my comments on this section, I also have to mention that equation (1) should have been written with a left partial derivative in time, and in equation (2), the tensor $\mathbf{D}$ appears, which is defined in the paper through d_{iso} (isotropic diffusion) and d_{ani} (anisotropic diffusion) and I was not able to find any value for them.

Concerning the numerical solution of the problem, which is detailed in the third section, I also have some comments. First, after equation (7) it is mentioned that the problem would be complemented with boundary conditions, which are detailed as both Dirichlet and Neumann ones, but it is not mentioned which part of the domain is associated to each one and why. The initial condition is clearly specified, and the discretization of the domain B is mentioned. Then the classical arguments on weak formulation are given and the shape function and the time discretization are mentioned, too. I note that the authors explicitly mention the Euler method for integrating in time, where the derivative in time is approximated by a finite difference method, but there is no reference to what types of shape functions are used in the space approximation. I assume that since only second-order derivatives in space are involved, the linear continuous shape functions would work, although I would be careful of eventually having places with big gradients. Then, the authors give some detail on Newton's scheme for a nonlinear part, which is actually the solution of a steady problem within the whole problem. This brings me again to a previous concern: What is the justification for assuming some variables to be steady? Because if the whole evolution problem was solved, no Newton iteration should be needed; just an integration in time would have been enough, whether there is convergence or not. This is a dark part of the work for me, which as of the writing of this review I haven't understood yet.

Sections 4 and 5 give a detailed description of the main parameters of the differential equations, whose values are justified in a long revision of the extensive literature given in the references. I don't want to go into further detail on section 4; as I said before I consider myself far from an authority on this part of the covered topic, but certainly it would be interesting to contrast the proposed choice of parameters with the opinions of experts.

Finally, section 6 presents the results of the simulations under the proposed mathematical model. The set of plots in Figures 3, 4 and 5 certainly presents a qualitative behaviour, which is reasonable with respect to the literature. Despite that, and in par-

ticular with respect to the plots concerning the chemical phenomena, I think that the sharp gradients that are shown will not be stable against a change in the time discretization, or said in a different way, I feel that more information about the time discretization should be given as well as a comparison between different discretizations. It is mentioned in the article that the time step size was 0.125 ms. But why did the authors decide to use this value? Did they try a bigger/smaller time step? If so, how different were the results they got? Clearly, a stability analysis would strengthen the reported results, as well as a discussion on the methods to measure stability. The same point can be raised about the plots that review solutions concerning the human heart: How were the geometry and the mesh built? How many points were taken? What type of shape functions were used? In particular, what approximation method was used for the integration of the nonlinear terms in the finite element approximation and why?

To end this review, I want to say that I like the article, first because it tackles an important problem, but also because despite all the issues that I raised before, I certainly consider working with a nonlinear coupled system of differential equations that involves over three equations to be a hard job, whether this work is theoretical or numerical, and in this case the reported results look fine from a qualitative perspective but surely they also have physiological sense, even if they could be improved. In this issue, the proposed method certainly has some lacunae which I am sure can be improved by the authors or someone else who takes this work as a frame of reference and improves it. Probably my main comment at the end is that this work would have been stronger if the authors had compared their method with the available literature and commented in more detail on their choice of the global parameters and on the discretization procedure. Finally, I wonder if a clinical opinion was asked, which of course would enrich future works but also the view of the authors on the topic. *Alejandro Omón Arancibia*

MR2907044 78A70 65M06 78A25 78M10 92C55

Fahs, Hassan (F-LIMO-IXL; Limoges)**; Hadjem, Abdelhamid; Lanteri, Stéphane** (F-INRIA2-NP; Sophia Antipolis)**; Wiart, Joe; Wong, Man-Fai [Wong, Man-Faï]**

Calculation of the SAR induced in head tissues using a high-order DGTD method and triangulated geometrical models. (English summary)

IEEE Trans. Antennas and Propagation **59** (2011), *no.* 12, 4669–4678.

Summary: "The great majority of numerical calculations of the specific absorption rate (SAR) induced in human tissues exposed to microwaves are performed using the finite difference time-domain (FDTD) method and voxel-based geometrical models. The straightforward implementation of the method and its computational efficiency are among the main reasons for FDTD being currently the leading method for numerical assessment of human exposure to electromagnetic waves. However, the rather difficult departure from the commonly used Cartesian grid and cell size limitations regarding the discretization of very detailed structures of human tissues are often recognized as the main weaknesses of the method in this application context. In particular, interfaces between tissues where sharp gradients of the electromagnetic field may occur are hardly modeled rigorously in these studies. We present here an alternative numerical dosimetry methodology which is based on a high order discontinuous Galerkin time-domain (DGTD) method and adapted geometrical models constructed from unstructured triangulations of tissue interfaces, and discuss its application to the calculation of the SAR induced in head tissues."

MR2872881 78A70 49N45 65J20 94A12

Nasehi Tehrani, J. (5-SYD-SEI; Sydney);
McEwan, A. [**McEwan, Alistair L.**] (5-SYD-SEI; Sydney);
Jin, C. [**Jin, Craig**] (5-SYD-SEI; Sydney); **van Schaik, A.** [**van Schaik, André**]

L1 regularization method in electrical impedance tomography by using the L1-curve (Pareto frontier curve). (English summary)

Appl. Math. Model. **36** (2012), *no.* 3, 1095–1105.

Summary: "Electrical impedance tomography (EIT), as an inverse problem, aims to calculate the internal conductivity distribution at the interior of an object from current-voltage measurements on its boundary. Many inverse problems are ill-posed, since the measurement data are limited and imperfect. To overcome ill-posedness in EIT, two main types of regularization techniques are widely used. One is categorized as the projection methods, such as truncated singular value decomposition (SVD or TSVD). The other categorized as penalty methods, such as Tikhonov regularization, and total variation methods. For both of these methods, a good regularization parameter should yield a fair balance between the perturbation error and regularized solution. In this paper a new method combining the least absolute shrinkage and selection operator (LASSO) and the basis pursuit denoising (BPDN) is introduced for EIT. For choosing the optimum regularization we use the L1-curve (Pareto frontier curve) which is similar to the L-curve used in optimising L2-norm problems. In the L1-curve we use the L1-norm of the solution instead of the L2 norm. The results are compared with the TSVD regularization method where the best regularization parameters are selected by observing the Picard condition and minimizing generalized cross validation (GCV) function. We show that this method yields a good regularization parameter corresponding to a regularized solution. Also, in situations where little is known about the noise level σ, it is also useful to visualize the L1-curve in order to understand the trade-offs between the norms of the residual and the solution. This method gives us a means to control the sparsity and filtering of the ill-posed EIT problem. Tracing this curve for the optimum solution can decrease the number of iterations by three times in comparison with using LASSO or BPDN separately." *JiChun Li*

MR2862443 78M10 65N30 65N75 78A25 82D10

Back, A. [**Back, Aurore**] (F-STRAS-I; Strasbourg);
Crestetto, A. [**Crestetto, Anaïs**] (F-STRAS-I; Strasbourg);
Ratnani, A. [**Ratnani, Ahmed**] (F-STRAS-I; Strasbourg);
Sonnendrücker, E. (F-STRAS-I; Strasbourg)

An axisymmetric PIC code based on isogeometric analysis. (English summary)

CEMRACS'10 research achievements: *numerical modeling of fusion*, 118–133, *ESAIM Proc.*, 32, *EDP Sci.*, *Les Ulis*, 2011.

Summary: "Isogeometric analysis has been developed recently to use basis functions resulting from the CAO description of the computational domain for the finite element spaces. The goal of this study is to develop an axisymmetric Finite Element PIC code in which specific spline Finite Elements are used to solve the Maxwell equations and the same spline functions serve as shape function for the particles. The computational domain itself is defined using splines or NURBS."

{For the entire collection see MR2906045 (2012i:65002).}

MR2896180 78M20 65M60 78A30
Kochubeĭ, T. V. [**Kochubey, Tatiana**]**;**
Astakhov, V. I. [**Astakhov, Vladimir Ivanovich**]
Eddy currents in a conducting plate with nonhomogeneous and anisotropic properties. (Russian. English and Russian summaries)
Mat. Model. **23** (2011), *no.* 8, 19–32.
Summary: "In this paper eddy currents distribution in anisotropic and inhomogeneous conductive plate has been modelled using a scalar integro-differential equation and Bubnov-Galerkin method. Numerical algorithm has been realized in original software package. Examples of its usage have been represented. Influence of anisotropic and homogeneous conductive properties of plate's material on eddy currents distribution has been analyzed."

MR2861588 81Q05 35B25 35Q40 65M99 81-08
Jin, Shi [**Jin, Shi[1]**] (1-WI; Madison, WI)**; Qi, Peng** (1-WI; Madison, WI)
A hybrid Schrödinger/Gaussian beam solver for quantum barriers and surface hopping. (English summary)
Kinet. Relat. Models **4** (2011), *no.* 4, 1097–1120.
This article discusses a numerical discretization of the time-dependent Schrödinger equation for a two-level system. When the two energy levels are well separated, it is possible to transform the unknown function in order to have almost independent evolutions of each of the components. In this case, the wavefunction is discretized using the Gaussian beam method where the solution is represented as a superposition of Gaussian wavepackets. On the other hand, near energy crossings, a diagonal representation is no longer possible, and the full Schrödinger equation has to be solved (here, with a splitting strategy between the kinetic and potential parts of the Schrödinger operator). The authors describe a numerical method allowing one to switch from the computationally less expensive Gaussian beam method to the Schrödinger solver using buffer regions near the energy crossings. This approach is validated by various numerical experiments. *Gabriel Stoltz*

MR2846989 83-08 65Y05 68U20 83F05
Blanco-Pillado, Jose J. (1-TUFT-PA; Medford, MA)**;**
Olum, Ken D. (1-TUFT-PA; Medford, MA)**;**
Shlaer, Benjamin (1-TUFT-PA; Medford, MA)
A new parallel simulation technique. (English summary)
J. Comput. Phys. **231** (2012), *no.* 1, 98–108.
Summary: "We develop a 'semi-parallel' simulation technique suggested by Pretorius and Lehner, in which the simulation spacetime volume is divided into a large number of small 4-volumes that have only initial and final surfaces. Thus there is no two-way communication between processors, and the 4-volumes can be simulated independently and potentially at different times. This technique allows us to simulate much larger volumes than we otherwise could, because we are not limited by total memory size. No processor time is lost waiting for other processors.

"We compare a cosmic string simulation we developed using the semi-parallel technique with our previous MPI-based code for several test cases and find a factor of 2.6 improvement in the total amount of processor time required to accomplish the same job for strings evolving in the matter-dominated era."

MR2851908 86A22 65J22

Chung, Eric (PRC-CHHK; Shatin)**; Qian, Jianliang** (1-MIS; East Lansing, MI)**; Uhlmann, Gunther** (1-CA3; Irvine, CA)**; Zhao, Hongkai** (1-CA3; Irvine, CA)

An adaptive phase space method with application to reflection traveltime tomography. (English summary)

Inverse Problems **27** (2011), *no.* 11, 115002, 22 *pp.*

Traveltime tomography deals with the inverse problem of determining the internal properties of a medium from traveltimes of waves going through the medium. It arises, for example, in global seismology and in ultrasound medical imaging. In a Riemannian geometry setting, the problem of determining the Riemannian metric from first arrivals is known as the boundary rigidity problem.

Using the Stefanov-Uhlmann identity, and noting that ray directions can be derived from the eikonal equation and traveltime data, the authors have previously developed a phase-space method for traveltime tomography. Each traveltime datum provides an integral equation involving the corresponding ray, and equation systems are obtained for iterative improvements of an initial guess of the metric.

In the present paper, the stability and efficiency of the phase-space method are improved by incorporating an adaptive strategy. In each iteration step, only those geodesics/rays that match the data well under the current estimate of the metric are used. The adaptive phase-space method is applied to reflection tomography by incorporating broken geodesics/rays for which a jump condition has to be imposed at the broken point. It is shown that non-broken and broken geodesics can be distinguished, and that the convex hull of an obstacle can be recovered along with the metric outside this convex hull. *Sven Ivansson*

MR2811300 90C20 15A23 49M27 65F05

Domes, Ferenc (A-WIENM; Vienna)**; Neumaier, Arnold** (A-WIENM; Vienna)

Rigorous enclosures of ellipsoids and directed Cholesky factorizations. (English summary)

SIAM J. Matrix Anal. Appl. **32** (2011), *no.* 1, 262–285.

In this paper the authors provide a convenient preprocessing step for constrained optimization problems by introducing a rigorous enclosure of an ellipsoid by a rectangular box and its interval hull. It is well known that a symmetric matrix A has a Cholesky factorization (CF) if and only if A is positive (semi-)definite (this agrees with the result of using the Matlab command chol(A)).

The authors also introduce the concept of a directed CF (DCF) and present some algorithms to obtain a DCF. Examples show that the technique is valid when it is used to numerically calculate the rounding errors involved in the computation of the interval hull and to handle quadratic inequality constraints having uncertain coefficients.

The algorithms introduced in the paper are useful, but some results (such as Theorem 7.1) are trivial and have already been introduced elsewhere. *Chang-Qing Xu*

MR2896616 90C20 65K05 90C11

Li, Guoquan (PRC-SGH; Shanghai)**;**
Wu, Zhiyou [Wu, Zhi You] (5-BAL-ITM; Ballarat)

Global optimality conditions for mixed integer quadratic programming problems. (English and Chinese summaries)

Math. Appl. (*Wuhan*) **24** (2011), *no.* 4, 845–850.

The authors consider the problem of minimizing a quadratic function subject to box constraints and mixed integer constraints. They develop necessary conditions as well as sufficient conditions for a point to be a global minimizer. These conditions are based on

generalized subdifferentials and generalized normal cones. A small example illustrates the conditions. *Mirjam Dür*

MR2854609 90C22 15A12 15B48 65F35 65K05 90C25
Lu, Zhaosong (3-SFR; Burnaby, BC)**; Pong, Ting Kei** (1-WA; Seattle, WA)
Minimizing condition number via convex programming. (English summary)
SIAM J. Matrix Anal. Appl. **32** (2011), *no.* 4, 1193–1211.

The paper deals with the problem of minimizing the condition number over a convex subset of the cone of positive semi-definite matrices of fixed size.

The quasiconvex objective function is replaced by a linear one with additional linear matrix inequality constraints, leading to a new problem that shares with the original one the infimum of the objective functions. If the original constraints on the matrix set are semi-definite representable, then the new problem can be cast as a semi-definite program. For several examples of sets this semi-definite program is explicitly constructed.

In detail, the construction is achieved by replacing the feasible set of the original problem by its conic hull and introducing an additional positive scalar variable that memorizes the scaling of the solution. For receding directions of the feasible set this scalar variable can take the value zero, and thus the new feasible set is both closed and invariant against multiplication by a positive scalar. It follows that the infimum of the objective function is always achieved for the constructed problem. It is shown that epsilon-accurate solutions of the new problem yield epsilon-accurate solutions of the original one.

Besides the semi-definite formulation, a solution by the alternating directions method is proposed and convergence is shown. Numerical experiments are performed to compare the two approaches, and the alternating directions method is found to be slightly better.

Finally, the problem of finding optimal preconditioners for positive definite matrices in a convex set of given positive semi-definite preconditioners is considered, i.e., the problem of finding a matrix X in a given set of positive semi-definite matrices such that the product X^TC^TCX for a given matrix C has the least possible condition number. A semi-definite relaxation for this nonconvex problem is proposed and a bound on the gap between the optimal values of the original and the relaxed problem is given. If the preconditioners are constrained to be diagonal matrices, the relaxation is shown to be exact. For the optimization of preconditioners, a numerical experiment is performed comparing the optimal preconditioner with the Jacobi diagonal preconditioner.

It should be noted that the information in the abstract and in the introduction on achievability of the infimum of the condition number over arbitrary closed convex sets of positive semi-definite matrices is inaccurate. What is actually true is that in the constructed optimization problem, which shares the infimum value of the objective with the original one, this infimum can always be achieved. *Roland Hildebrand*

MR2864831 90C25 26E70 65K05 80M50 90C20
Adivar, Murat (TR-IEU-M; Izmir)**; Fang, Shu-Cherng** (1-NCS-ISY; Raleigh, NC)
Convex optimization on mixed domains. (English summary)
J. Ind. Manag. Optim. **8** (2012), *no.* 1, 189–227.

In this paper, the authors lay the foundation to a theory of convex optimization on time scales. The presented results contain corresponding continuous and discrete versions and allow for application to any other domain which is a product of time scales, i.e., a product of closed subsets of the real numbers. Since the time scales in that product may be different, the authors refer to mixed domains.

Section 1 recalls the history of time scales and gives numerous literature references to time scales studies. The reader is reminded of basic time scales notions such as jump

operators on time scales, the graininess function, classification of points, and nabla and delta derivatives of functions defined on a time scale. Section 2 discusses convexity on mixed domains. Right and left convex combinations on such mixed domains are defined and some basic properties are given. The authors proceed to generalize the concepts of right-convex sets, left-convex sets, convex hull, convex closure, convex interior, convex boundary, and supporting hyperplane to the time scales case and prove generalizations of standard results in the area to the time scales case, including a result on the minimum distance from a point to a convex set. Section 3 defines and studies convex functions on mixed domains. The epigraph of a function is defined and a generalization of a well-known characterization of convex functions in terms of convexity of their epigraphs is proved for time scales. Subgradients are defined and some results involving them are proved. Minima and maxima of convex functions are studied. Section 4 contains a discussion of differentiable convex functions. An example shows that, contrary to the classical case, the subgradient may not be unique for convex functions defined on an arbitrary time scale. Convex functions are characterized in terms of subgradients on the product of time scales. A necessary and sufficient condition for the existence of an optimal solution to a convex optimization problem over time scales is given. Section 5 proposes the linear programming problem and the quadratic programming problem on time scales. Some basic results are given and some nice examples are supplied for illustration purposes. Section 6 offers some concluding remarks.

This paper gives the basic definitions needed to study convex optimization on time scales. It opens the door to an extensive study in this area, e.g., the concepts of Lagrange multipliers and Kuhn-Tucker conditions are awaiting their discovery. This nice paper will be useful to any researcher interested in extending the theory of convex optimization on time scales. It will be also of interest to any applied mathematician working in the general area of optimization. *Martin J. Bohner*

MR2864637 90C25 65K99 90C48

Cancès, Eric; Ehrlacher, Virginie; Lelièvre, Tony

Convergence of a greedy algorithm for high-dimensional convex nonlinear problems. (English summary)

Math. Models Methods Appl. Sci. **21** (2011), *no.* 12, 2433–2467.

Summary: "In this paper, we present a greedy algorithm based on a tensor product decomposition, whose aim is to compute the global minimum of a strongly convex energy functional. We prove the convergence of our method provided that the gradient of the energy is Lipschitz on bounded sets. The main interest of this method is that it can be used for high-dimensional nonlinear convex problems. We illustrate this method on a prototypical example for uncertainty propagation on the obstacle problem."

MR2856578 90C29 65K10 90C32 90C46

Mititelu, Ştefan (R-BCE-MIF; Bucharest); **Preda, Vasile** (R-BUCHMC; Bucharest); **Postolache, Mihai** (R-PUBAS-NDM; Bucharest)

Duality of multitime vector integral programming with quasiinvexity. (English summary)

J. Adv. Math. Stud. **4** (2011), *no.* 2, 59–72.

The paper deals with a multiobjective fractional programming problem (VFP), whose objectives are the ratio of multiple integrals on a measurable set Ω of $\mathbb{R}^m$, and with a multitime vector non-fractional variational problem (VVP) having the same domain.

For the two problems, necessary efficiency conditions are established by adapting, to the real space $\mathbb{R}^n$, results stated by Ş. Mititelu and M. Postolache [Balkan J. Geom. Appl. **16** (2011), no. 2, 90–101; MR2785735 (2012a:49035)] in the geometric framework

of a Riemannian manifold.

Furthermore, by using a suitable class of quasi-invex functions, new duality conditions of Mond-Weir-Zamalai type are stated for the VFP, and, as particular cases, some duality results for the VVP are obtained. *Laura Martein*

MR2853489 90C29 65K05 90C25

Shang, Yufeng (PRC-DUT-SM; Dalian); **Yu, Bo [Yu, Bo[1]]** (PRC-DUT-SM; Dalian)

A constraint shifting homotopy method for convex multi-objective programming. (English summary)

J. Comput. Appl. Math. **236** (2011), *no.* 5, 640–646.

From the summary: "In this paper, a constraint shifting combined homotopy method for solving multi-objective programming problems with both equality and inequality constraints is presented. Under some assumptions, the existence and convergence of a smooth path to an efficient solution are proven. Simple numerical results are given." *Stefan Mititelu*

MR2869514 90C30 49M37 65K05 68Q25 90C26 90C60

Cartis, Coralia (4-EDIN-SM; Edinburgh);
Gould, Nicholas I. M. [Gould, Nicholas Ian Mark] (4-RAPL-CPE; Didcot);
Toint, Philippe L. (B-NDP; Namur)

On the evaluation complexity of composite function minimization with applications to nonconvex nonlinear programming. (English summary)

SIAM J. Optim. **21** (2011), *no.* 4, 1721–1739.

In this paper, an unconstrained minimization problem is considered where the objective function is the sum $f(x) + h(c(x))$, where f is a continuously differentiable (not necessarily convex) function, h is a convex (possibly nonsmooth) Lipschitz continuous function and c is a continuously differentiable (not necessarily convex) function. The authors estimate the worst-case complexity of minimizing such an objective function by employing two techniques, a first-order trust-region method and a quadratic regularization method, respectively. When the composite term (i.e., $h(c(x))$) is an exact penalty function, the objective- and constraint-evaluation worst-case complexity of a nonconvex equality-constrained subproblem is studied, and the solution is computed by using a first-order exact penalty method. Thus, the approximate critical points of the exact penalty function are connected with the approximate Karush-Kuhn-Tucker (KKT) points of the considered nonconvex equality-constrained subproblem. An outer exact penalty-function algorithm with a steering procedure is also proposed for solving the considered nonconvex equality-constrained subproblem. It is proved that in the case when the penalty parameters are bounded, the worst-case complexity of reaching an approximate KKT point of the nonconvex equality-constrained subproblem is of the same order as the function-evaluation complexity of the steepest descent method for unconstrained nonconvex smooth optimization. *Stefan M. Stefanov*

MR2896592 90C30 65K05 90C55

Zhang, Xinhua [Zhang, Xin Hua] (PRC-NJAU-CEN; Nanjing);
Zhang, Hao (PRC-NJAU-CEN; Nanjing)

A nonmonotone trust region method for nonlinear equality constrained optimization problems. (English and Chinese summaries)

Math. Appl. (Wuhan) **24** (2011), *no.* 4, 684–690.

Summary: "We propose and analyze a class of nonmonotone trust region algorithms for solving nonlinear equality constrained optimization problems. This method does not need penalty function and filter. Each trial step is composed of a quasi-normal

step and a tangential step. Both steps are required to satisfy a decrease condition for their respective trust region subproblems. This new method has more flexibility for the acceptance of the trial step compared to the filter methods, and requires less computational costs compared with the monotone methods. Under reasonable conditions, the global convergence is established." *Ernö Robert Csetnek*

MR2847523 90C52 65K10 90C30
Babaie-Kafaki, Saman (IR-SEMN-M; Semnan)**;**
Fatemi, Masoud (IR-SHARM; Tehran)**;**
Mahdavi-Amiri, Nezam (IR-SHARM; Tehran)

Two effective hybrid conjugate gradient algorithms based on modified BFGS updates. (English summary)

Numer. Algorithms **58** (2011), *no.* 3, 315–331.

This paper presents two new hybrid conjugate gradient algorithms for solving the unconstrained optimization problem

$$\min_{x\in\mathbb{R}^n} f(x),$$

where $f\colon \mathbb{R}^n \to \mathbb{R}$ is a smooth nonlinear function. The conjugate gradient (CG) algorithm is based on the following iterative scheme:

$$x_{k+1} = x_k + \alpha_k d_k,$$

where α_k is the *stepsize* and d_k is the search direction given by

$$\begin{aligned} d_0 &= -\nabla f(x_0), \\ d_k &= -\nabla f(x_k) + \beta_k d_k, \quad k \geq 0, \end{aligned}$$

where β_k is the so-called *conjugacy parameter*. Convergence properties and computational performance of the CG algorithm mainly depend on the strategy for updating β_k. Promising results have recently been obtained by hybrid CG methods, i.e. where β_k relies on a linear combination of two conjugacy parameters, parameterized by some *hybridization parameter* $0 \leq \theta_k \leq 1$:

$$\beta_k = (1-\theta_k)\beta_k^{\mathrm{HS}} + \theta_k \beta_k^{\mathrm{DY}},$$

where β_k^{HS} and β_k^{DY} are given by the conjugacy formulae of Hestenes and Stiefel and Dai and Yuan, respectively. The main contributions of this paper are:

(1) Two new update rules for θ_k are proposed. These updates are based on the modification of the quasi-Newton BFGS method.
(2) A convergence analysis of the two resulting hybrid CG algorithms is presented, in the case when α_k results from a strong Wolfe linesearch. One of the proposed formulae for θ_k is shown to ensure the global convergence of CG methods for uniformly convex f, while the other is shown to ensure global convergence for general functions. The global convergence is understood in the sense $\lim_{k\to\infty} \inf \|\nabla f(x_k)\| = 0$.
(3) A new initialization strategy to speed up the linesearch procedure is proposed.

The good performance of both hybrid CG algorithms proposed is illustrated through numerical tests on a set of 89 unconstrained optimization problems from the CUTEr collection. *Émilie Chouzenoux*

MR2837564 91A10 65K05 90C30 91B50

Dreves, Axel (D-WRZB-IM; Würzburg); **Facchinei, Francisco** (I-ROME-I; Rome); **Kanzow, Christian** (D-WRZB-IM; Würzburg); **Sagratella, Simone** (I-ROME-I; Rome)

On the solution of the KKT conditions of generalized Nash equilibrium problems. (English summary)

SIAM J. Optim. **21** (2011), *no.* 3, 1082–1108.

In this paper, generalized Nash equilibrium problems are studied using the Karush-Kuhn-Tucker (KKT) optimality conditions for each player. The authors propose two methods to numerically solve the concatenated KKT system. The first uses a merit-function approach, while the second approach is based on an interior-point technique. Convergence results for both methods are presented in which the authors mainly assume the regularity of the Hessian of the concatenated Lagrange function on the whole space.

Vladimir Shikhman

MR2896565 91A15 15A24 65F35

Ivanov, Ivan [Ivanov, Ivan Ganchev] (BG-SOFIB; Sofia)

Improved methods to solve the stochastic Nash games for weakly coupled large-scale systems iteratively. (English summary)

Dyn. Contin. Discrete Impuls. Syst. Ser. B Appl. Algorithms **18** (2011), *no.* 6, 783–798.

Summary: "In this paper, the stochastic Nash games for weakly coupled large-scale systems with state-dependent noise are considered. The considered stochastic algebraic Riccati equations are quite different from the existing results in the sense that the equations have the additional linear term. The numerical algorithm based on the Newton method for solving the set of cross-coupled stochastic algebraic Riccati equations is derived by H. Mukaidani [Automatica J. IFAC **45** (2009), no. 5, 1272–1279; MR2531605 (2011b:91050)]. We modify this iteration and propose two new recursive equations with linear rate of convergence solving the considered set of Riccati equations. We carry out numerical experiments to illustrate the effectiveness of the considered iterations."

MR2895537 91B50 49J40 65K15

Beldiman, Miruna (R-AOS-MSA; Bucharest)

Some results on equilibrium problems. (English summary)

Nonlinear Stud. **18** (2011), *no.* 4, 639–645.

Summary: "We consider sufficient regularity and coercivity conditions for two classes of systems of equilibrium problems. Thus, under suitable assumptions, if the independent equilibrium problems are solvable, then the system of equilibrium problems also has a solution."

MR2863828 91G20 65K05 90C34 91G60

Daum, Sebastian (CH-USII; Lugano); **Werner, Ralf** (D-FAMUIM; Munich)

A novel feasible discretization method for linear semi-infinite programming applied to basket option pricing. (English summary)

Optimization **60** (2011), *no.* 10-11, 1379–1398.

Summary: "In this exposition a novel feasible version of traditional discretization methods for linear semi-infinite programming problems is presented. It will be shown that each—usually infeasible—iterate can be easily supplemented with a feasible iterate based on the knowledge of a Slater point. The effectiveness of the method is demonstrated on the problem of finding model free bounds to basket option prices which has gained a significant interest in the last years. For this purpose a fresh look is taken on the upper bound problem and on some of its structure, which needs to be exploited to yield an efficient solution by the feasible discretization method. The presented approach

allows the generalization of the problem setting by including exotic options (like power options, log-contracts, binary options, etc.) within the super-replicating portfolio."

MR2870197 91G60 65C05 91G20
Baldeaux, J. [Baldeaux, Jan] (5-UTSY-EC; Sydney);
Chan, L. [Chan, Leunglung] (5-NSW-SMS; Sydney);
Platen, E. (5-UTSY-MEC; Sydney)
Quasi-Monte Carlo methods for derivatives on realised variance of an index under the benchmark approach. (English summary)
ANZIAM J. Electron. Suppl. **52** (2010), (*C*), *C*727–*C*741.
Summary: "We apply quasi-Monte Carlo methods to the pricing of derivatives on realised variance of an index under the benchmark approach. The resulting integration problem is shown to depend on the joint density of the realised variance of the index and the terminal value of the index. Employing a transformation mapping for this joint density to the unit square reduces the difficulty of the resulting integration problem. The quasi-Monte Carlo methods compare favourably to Monte Carlo methods when applied to the given problem."

MR2824895 91G60 60E10 65T40
Fang, Fang [Fang, Fang[3]] (NL-DELF-IAM; Delft);
Oosterlee, Cornelis W. (NL-MATH; Amsterdam)
A Fourier-based valuation method for Bermudan and barrier options under Heston's model. (English summary)
SIAM J. Financial Math. **2** (2011), 439–463.
The paper gives a numerical method for pricing Bermudan and barrier options under the Heston model. Continuation values for both kinds of options are computed by a recursive scheme, where the joint density of log-price and log-variance is calculated from the characteristic function using a Fourier cosine expansion. It is preferable to work with log-variance, since the left tail of the variance distribution can take very large values in the case when the Feller condition does not hold. The paper gives a detailed and careful description of the resulting algorithms, and includes an error analysis. *Stefan Gerhold*

MR2837527 91G60 60H30 60J28 65M06 91G20 93E20
Huang, Y. [Huang, Yiqing[1]] (3-WTRL-CP; Waterloo, ON);
Forsyth, P. A. [Forsyth, P. A., Jr.] (3-WTRL-SC; Waterloo, ON);
Labahn, G. [Labahn, George] (3-WTRL-SC; Waterloo, ON)
Methods for pricing American options under regime switching. (English summary)
SIAM J. Sci. Comput. **33** (2011), *no.* 5, 2144–2168.
The pricing of American-style options is a long-standing and very important problem in mathematical finance. On the other hand, the use of regime switching, or Markov modulated models to describe the dynamics of the underlying asset value has generated considerable interest in recent years, mainly due to their ability to reproduce some market features. In this paper the authors use in particular the following description for the underlying dynamics under the objective (or historical) measure:

$$\frac{dS}{S} = \mu_j dt + \sigma^j t dW + \sum_{k=1}^{K} (\xi_{jk} - 1) dX_{jk}, \quad j = 1, \ldots, K,$$

where the index $j \in \{1, 2, \dots, K\}$ identifies the regime and

$$dX_{jk} = \begin{cases} 1 & \text{with probability } \lambda_{jk}dt + \delta_{jk}, \\ 0 & \text{with probability } 1 - \lambda_{jk}dt - \delta_{jk}. \end{cases}$$

Here $\{\lambda_{jk}\}_{j,k=1,\dots,K}$ is the infinitesimal generator of the (continuous time) Markov chain. In this model the jumps can occur only when the Markov chain changes its state and their amplitudes ξ_{jk} are deterministic functions of S and t.

The authors, after having formulated the American-style option pricing problem as an abstract optimal control problem, analyze different numerical methods based on explicit and implicit discretization of the pricing equation, a set of coupled partial differential equations (PDEs) and variational inequalities (VIs). For the implicit schemes, four iterative methods are compared to solve the corresponding system of nonlinear algebraic equations. The results of their numerical experiments show that using Crank-Nicolson time stepping combined with a fixed point policy iteration is an effective and robust method in the considered regime switching framework. *Alessandro Ramponi*

MR2819936 91G60 65C20 91G20

Moon, Kyoung-Sook; Kim, Hongjoong (KR-KOR; Seoul)

An efficient binomial tree method for cliquet options. (English summary)

J. Korean Soc. Ind. Appl. Math. **15** (2011), *no.* 2, 83–96.

Cliquet options are a series of forward-starting at-the-money options with a single premium determined up front that locks in any gains on specific dates. Since cliquet options may be globally and locally floored and capped, they provide a guaranteed minimum return in exchange for capping the maximal return earned each period over the life of the contract.

In this paper the authors propose a binomial method for pricing this type of options in a Black-Scholes framework with constant interest rates and volatilities. The method is based on the idea of J. C. Hull and A. D. White [J. Deriv. **1** (1993), no. 1, 21–31, doi:10.3905/jod.1993.407869] introduced in order to price path-dependent options.

The technique proposed in the paper has been tested by the comparison with previous evaluation methods, in particular with the one introduced in [M. Gaudenzi and A. Zanette, Comput. Manag. Sci. **8** (2011), no. 1-2, 125–135; MR2782426 (2012a:91199)].

The numerical data show the efficiency of the technique. *Marcellino Gaudenzi*

MR2823126 91G60 35K15 35R60 65M80

Pascucci, A. [Pascucci, Andrea] (I-BOLO; Bologna)**;**
Suárez-Taboada, M. (E-CRNA; A Coruña)**;**
Vázquez, C. [Vázquez Cendón, Carlos] (E-CRNA; A Coruña)

Mathematical analysis and numerical methods for a partial differential equations model governing a ratchet cap pricing in the LIBOR market model. (English summary)

Math. Models Methods Appl. Sci. **21** (2011), *no.* 7, 1479–1498.

In this paper, the authors consider several approaches for pricing ratchet cap derivatives in the context of the classical lognormal LIBOR (London InterBank Offer Rate) interest rates model. In particular, they develop two methods based on a PDE formulation of the problem which leads to a sequence of nested Cauchy problems. In the first method, the solution is approximated by the analytical solution of a corresponding problem with constant coefficients. Their finite element numerical method is based on a careful choice of boundary conditions and their discretization. The numerical results presented confirm that for the three methods, Monte Carlo simulations, analytical approximation,

and finite element approximation, the computed prices are very close. They discuss the pros and cons of each of their methods. *Jean-Pierre Fouque*

MR2870043 91G60 65M25 65M60 91G30
Suárez-Taboada, M. (E-CRNAI; A Coruña)**;**
Vázquez, C. [**Vázquez Cendón, Carlos**] (E-CRNAI; A Coruña)
Numerical solution of a PDE model for a ratchet-cap pricing with BGM interest rate dynamics. (English summary)
Appl. Math. Comput. **218** (2012), *no.* 9, 5217–5230.
Summary: "In this paper we present a new numerical method to price an interest rate derivative. The financial product consists of a particular ratchet cap contract which contains a set of ratchet caplets. For this purpose, we first pose the PDE pricing model for each ratchet caplet by means of Feynman-Kac theorem. The underlying interest rates are the forward LIBOR rates, the dynamics of which are assumed to follow the recently introduced BGM (LMM) market model. For the set of PDEs associated to the ratchet caplets pricing problems, we propose a second order Crank-Nicolson characteristics time discretization scheme combined with a finite element discretization in the interest rate variables. In order to illustrate the performance of the numerical methods, we present an academic test and a real example of a particular ratchet cap pricing. In the second case, a comparison between the results obtained by Monte Carlo simulation and the proposed method is presented."

MR2854078 91G60 60H10 65M06 65M12 91B70 91G30
Valero, E. [**Valero, Eusebio**] (E-UPMAE-MA; Madrid)**; Torrealba, M.;**
Lacasa, L. [**Lacasa, Lucas**] (E-UPMAE-MA; Madrid)**;**
Fraysse, F. (E-UPMAE-MA; Madrid)
Fast resolution of a single factor Heath-Jarrow-Morton model with stochastic volatility. (English summary)
J. Comput. Appl. Math. **236** (2011), *no.* 6, 1637–1655.
Summary: "This paper considers the single factor Heath-Jarrow-Morton model for the interest rate curve with stochastic volatility. Its natural formulation, described in terms of stochastic differential equations, is solved through Monte Carlo simulations, that usually involve rather large computation time, inefficient from a practical (financial) perspective. This model turns to be Markovian in three dimensions and therefore it can be mapped into a 3D partial differential equations problem. We propose an optimized numerical method to solve the 3D PDE model in both low computation time and reasonable accuracy, a fundamental criterion for practical purposes. The spatial and temporal discretizations are performed using finite-difference and Crank-Nicolson schemes respectively, and the computational efficiency is largely increased performing a scale analysis and using Alternating Direction Implicit schemes. Several numerical considerations such as convergence criteria or computation time are analyzed and discussed."

MR2883315 91G60 60H10 62F10 65C30 93E10

Weber, G.-W. (TR-MET-IAM; Ankara);
Taylan, P. [**Taylan, Pakize**] (TR-DIC; Diyarbakir);
Görgülü, Z.-K. [**Görgülü, Zafer-Korcan**] (D-BND2; Neubiberg);
Rahman, H. Abd. (MAL-UTMS; Skudai);
Bahar, A. [**Bahar, Arifah**] (MAL-UTMS; Skudai)

Parameter estimation in stochastic differential equations. (English summary)

Dynamics, games and science. II, 703–733, *Springer Proc. Math.*, 2, *Springer, Heidelberg*, 2011.

Summary: "Financial processes as processes in nature, are subject to stochastic fluctuations. Stochastic differential equations turn out to be an advantageous representation of such noisy, real-world problems, and together with their identification, they play an important role in the sectors of finance, but also in physics and biotechnology. These equations, however, are often hard to represent and to resolve. Thus we express them in a simplified manner of approximation by discretization and additive models based on splines. This defines a trilevel problem consisting of an optimization and a representation problem (portfolio optimization), and a parameter estimation [G.-W. Weber et al., Dyn. Contin. Discrete Impuls. Syst. Ser. B Appl. Algorithms **17** (2010), no. 1, 149–174; MR2599672]. Two types of parameter dependency, linear and nonlinear, are considered by constructing a penalized residual sum of squares and investigating the related Tikhonov regularization problem for the first one. In the nonlinear case Gauss-Newton's method and Levenberg-Marquardt's method are employed in determining the iteration steps. Both cases are treated using continuous optimization techniques by the elegant framework of conic quadratic programming. These convex problems are well-structured, hence, allowing the use of the efficient interior point methods. Furthermore, we present nonparametric and related methods, and introduce into research done at the moment in our research groups which ends with a conclusion."

{For the entire collection see MR2866918 (2012h:00039).}

MR2863934 92C05 65T50 76S05

Buchanan, James L. (1-USNA; Annapolis, MD);
Gilbert, Robert P. [**Gilbert, Robert Pertsch**] (1-DE; Newark, DE);
Ou, Miao-jung (1-DE; Newark, DE)

Transfer functions for a one-dimensional fluid-poroelastic system subject to an ultrasonic pulse. (English summary)

Nonlinear Anal. Real World Appl. **13** (2012), *no.* 3, 1030–1043.

Summary: "A one-dimensional model of an *in vitro* experiment, in which a specimen of cancellous bone is immersed in water and insonified by an ultrasonic pulse, is considered. The modification of the poroelastic model of Biot due to D. L. Johnson, J. Koplik and R. Dashen [J. Fluid Mech. **176** (1987), 379–402, doi:10.1017/S0022112087000727] is used for the cancellous bone segment. By working with series expansions of the Laplace transform in terms of travel-time exponentials, a series of transfer functions for the reflection and transmission of fast and slow waves at the fluid-poroelastic interfaces are derived. The approach obviates numerical solution beyond the discretization involved in the use of the fast Fourier transform."

MR2861245 92C17 35K40 65M99 92C10 92C40

Vanderlei, Ben [Vanderlei, Ben A.] (3-BC; Vancouver, BC);
Feng, James J. (3-BC; Vancouver, BC);
Edelstein-Keshet, Leah (3-BC; Vancouver, BC)

A computational model of cell polarization and motility coupling mechanics and biochemistry. (English summary)

Multiscale Model. Simul. **9** (2011), *no.* 4, 1420–1443.

This paper is concerned with a mathematical model for the motion of a living cell and its numerical implementation. The cell moves on a surface, and its boundary at a given time is represented by a curve in the plane. The model consists of a mechanical part and a chemical part. The mechanical part includes a description of the boundary of the cell by elasticity theory, and the medium inside and outside the cell is modelled as a viscous incompressible fluid. Because of the high Reynolds number of the system the motion of the fluid is taken to be a Stokes flow. The chemical part of the model is a system of two reaction diffusion equations on a time-dependent domain. This gives a minimal representation of the actual chemistry going on in the cell. In the full model the mechanical and chemical parts are coupled. A number of numerical results are presented for the two partial models and for the full model. Insights are obtained as to how the internal properties of the cell influence the shape it adopts while moving. Another important aspect of the system included in the model is how the cell polarizes in the direction in which it is going to move. *Alan D. Rendall*

MR2861263 92C40 35Q92 65R99 68U20 78A35 78A70

Xu, Zhenli [Xu, Zhen Li] (PRC-JTU; Shanghai);
Cai, Wei [Cai, Wei[1]] (1-NC3-MS; Charlotte, NC)

Fast analytical methods for macroscopic electrostatic models in biomolecular simulations. (English summary)

SIAM Rev. **53** (2011), *no.* 4, 683–720.

This paper surveys analytical and computational methods for computing the electrostatic interactions in simulations involving a biological molecule or solute (e.g., a protein) and an enveloping solvent. The methods involve tradeoffs between accuracy and computational time. A straightforward method assumes a solvent of many individual atoms and requires the solution of the Poisson-Boltzmann equation; this method, while the most accurate, is especially costly from a computational perspective. Another class of methods is the hybrid solvation methods, which assume both individual atoms close to the solute, encased in a surrounding implicit solvent with uniform properties. A final class of methods is the generalized Born methods, which simply surround the solute with an implicit solvent. The last two classes provide a significant computational advantage over the Poisson-Boltzmann methods. The authors provide a thorough review of the mathematics behind contemporary methods for electrostatic computation and emphasize that there is much room for additional research. *Lenwood S. Heath*

MR2862019 92C42 65L05 65Y15 93A30

Lunacek, Monte (1-NREL; Golden, CO); **Nag, Ambarish** (1-NREL; Golden, CO);
Alber, David M. (1-NREL; Golden, CO); **Gruchalla, Kenny** (1-NREL; Golden, CO);
Chang, Christopher H. (1-NREL; Golden, CO); **Graf, Peter A.** (1-NREL; Golden, CO)

Simulation, characterization, and optimization of metabolic models with the high performance systems biology toolkit. (English summary)

SIAM J. Sci. Comput. **33** (2011), *no.* 6, 3402–3424.

The paper deals with the High Performance Systems Biology Toolkit (HiPer SBTK), a set of simulation/optimization components and the relevant tools to assemble them

into large parallel processing hierarchies, designed to solve systems biology problems on parallel computer architectures. The aim is at describing the observations that led to the creation of the toolkit and its components as well as at how to employ it.

The focus is on mathematical metabolic models formulated at a thermodynamic/kinetic level, which means large systems of stiff ordinary differential equations, large parameter spaces and computationally expensive objective functions. This motivates the use of high performance computing.

After a brief introduction, the authors give motivating observations in Section 2, dividing them according to their nature (mathematics, computer and computational science) and describing the challenges—and the chosen solutions—that each category poses.

The more technical Section 3 describes HiPer SBTK version 2.0. In particular, its components are briefly presented in Section 3.1; their hierarchical arrangement is explained in Section 3.2; possible extensions/incorporations are treated in Section 3.4.

The final Section 4 includes three examples of large-scale computations performed with HiPer SBTK on a model of glycolysis, namely the search for steady states, the constrained species optimization and the global sensitivity optimization.

The paper ends with some concluding remarks, a list of software and hardware requirements and an Appendix giving further details on both the model of Section 4 and the toolkit itself.

HiPer SBTK is shown to be efficiently scalable on large networks of processors, thus providing the system biology metabolic modeling community with a tool to exploit large-scale high performance computing for very demanding simulations.

Dimitri Breda

MR2861099 92C55 44A12 49J10 65J22 65K10 94A08

Klann, Esther (A-LINZ-IIM; Linz)

A Mumford-Shah-like method for limited data tomography with an application to electron tomography. (English summary)

SIAM J. Imaging Sci. **4** (2011), *no.* 4, 1029–1048.

Summary: "In this article the Mumford-Shah-like method of [R. Ramlau and W. Ring, J. Comput. Phys. **221** (2007), no. 2, 539–557; MR2293140 (2007j:94010)] for complete tomographic data is generalized and applied to limited angle and region of interest tomography data. With the Mumford-Shah-like method, one reconstructs a piecewise constant function and simultaneously a segmentation from its (complete) Radon transform data. For limited data, the ability of the Mumford-Shah-like method to find a segmentation, and by that the singularity set of a function, is exploited. The method is applied to generated data from a torso phantom. The results demonstrate the performance of the method in reconstructing the singularity set, the density distribution itself for limited angle data, and also some quantitative information about the density distribution for region of interest data. As a second example limited angle region of interest tomography is considered as a simplified model for electron tomography (ET). For this problem we combine Lambda tomography and the Mumford-Shah-like method. The combined method is applied to simulated ET data."

MR2847087 92C60 65M06 65M22 92C50
Gücüyenen, Nurcan (TR-IIT-DM; Urla);
Tanoğlu, Gamze [**Tanoğlu, Gamze B.**] (TR-IIT-DM; Urla)
Iterative operator splitting method for capillary formation model in tumor angiogenesis problem: analysis and application. (English summary)
Int. J. Numer. Methods Biomed. Eng. **27** (2011), *no.* 11, 1740–1750.
This paper is devoted to the approximation of a mathematical model for capillary formation in tumor angiogenesis. The authors propose the application of the iterative operator splitting method. Convergence properties of the method are presented by using matrix analysis. The numerical results reveal that the iterative splitting method is applicable to this model problem and provides better accuracy compared to the other splitting methods and non-splitting methods. The paper shows that the iterative operator splitting method gives high convergence and small error and it is quite easy to apply to the model problem. The consistency and stability analysis are also studied easily. *Sergio Amat*

MR2831550 92D25 34C60 37N25 65L07
Ghosh, Suma (3-YORK-MS; Toronto, ON);
Bhattacharyya, Samit (3-GLPH; Guelph, ON)
A two-patch prey-predator model with food-gathering activity. (English summary)
J. Appl. Math. Comput. **37** (2011), *no.* 1-2, 497–521.
The authors examine the stability of a two-patch prey-predator system under several foraging parameters such as total time of food-gathering activity, searching rate within a patch, and handling time for food. The ratio of probabilities between the mobility of a predator in searching for food and in handling it is used to reflect the effect of the food-gathering activity on the movement of the predator in space. The mobility is defined as a certain probability that a species moves from one patch to another. Insect species react to change of environmental conditions more dynamically and respond to change of condition practically immediately. The stochastic distribution of the ratio is considered for the numerical investigation. An additional mortality for both the prey and the predator is assumed for taking into account the results of application of control measures such as chemical insecticides. The model has nine equilibria which are briefly discussed. A reference is given for a paper where theoretical studies on stability of equilibria and bifurcation are given in more detail. In this paper the emphasis is put on numerical simulation of the model for its stability with respect to several parameters. In the theoretical study of the model the two patches are supposed to be identical, while in the numerical study differences of some parameters in two patches are imposed. From a series of simulations the conclusion is drawn that the prey-predator system with variable searching and handling activity in food-gathering activity displays complex dynamics different from the density-limited counterpart of the prey-predator system. Important implications of results related to metapopulation theory and to control of insect pests in agroecosystems are indicated and discussed. *Nelli Ajabyan*

MR2871189 92D25 60J70 62F10 62F15 65C05 65C30
Gilioli, Gianni (I-BRSC-BMT; Brescia); **Pasquali, Sara** (I-CNR-IMT; Milan);
Ruggeri, Fabrizio (I-CNR-IMT; Milan)
Nonlinear functional response parameter estimation in a stochastic predator-prey model. (English summary)
Math. Biosci. Eng. **9** (2012), *no.* 1, 75–96.
This work considers a Lotka-Volterra-type stochastic predator-prey system with a one-

parameter nonlinearity of a type introduced by Ivlev in 1961. A system of two stochastic differential equations (SDEs) is analyzed, in which environmental, demographic, and behavioural stochasticity are taken into account. Four scalar parameters (including the one in the nonlinearity) are unknown, and the approach is to estimate them with a Bayesian approach using a Markov Chain Monte Carlo (MCMC) algorithm. The presence of unknown parameters in the diffusion coefficients of the SDE yields slow convergence of basic MCMC, so the authors present a so-called "Metropolis-within-Gibbs" algorithm, in which latent data is generated since the raw data is rather sparse. The model is tested on a system which pits a pest mite (*Tetranychus urticae*) against a biological control agent (*Phytoseiulus persimilis*) and parameter estimates are given.

John Kingen McSweeney

MR2872869 92D25 35F30 65M99

Yousefi, S. A. (IR-SHBH; Tehran); **Behroozifar, M.** (IR-BNUTBS; Babol); **Dehghan, Mehdi [Dehghan, Mehdi[2]]** (IR-AUTMC-AM; Tehran)

Numerical solution of the nonlinear age-structured population models by using the operational matrices of Bernstein polynomials. (English summary)

Appl. Math. Model. **36** (2012), *no.* 3, 945–963.

Summary: "In this paper a numerical method for solving the nonlinear age-structured population models is presented which is based on Bernstein polynomials approximation. Operational matrices of integration, differentiation, dual and product are introduced and are utilized to reduce the age-structured population problem to the solution of algebraic equations. The method in general is easy to implement, and yields good results. Illustrative examples are included to demonstrate the validity and applicability of the new technique."

MR2854031 92D30 34K45 34K60 65L12

Sekiguchi, Masaki; Ishiwata, Emiko (J-SUT-MI; Shinjuku)

Dynamics of a discretized SIR epidemic model with pulse vaccination and time delay. (English summary)

J. Comput. Appl. Math. **236** (2011), *no.* 6, 997–1008.

The authors construct and investigate a discrete version of an SIR model with delay due to incubation, which also features periodic impulsive vaccination, by applying a nonstandard implicit-explicit discretization. This particular discretization has the advantage that the positivity of the solutions, essential to establishing the well-posedness of the model in a biological sense, is easily shown. The global stability of the infection-free periodic solution is obtained via a comparison argument which is parallel to the one commonly employed for the corresponding continuous models, the permanence of the system being also shown by using a similar approach. Sufficient conditions for stability and permanence, which are consistent with those established for similar continuous models, are consequently established. It can also be noted that these conditions together yield a threshold condition for the stability of the system in the absence of vaccination.

Paul Georgescu

MR2863510 92D40 34C60 34D20 37N25 65L99

Rebaza, Jorge (1-MOSU; Springfield, MO)

Dynamics of prey threshold harvesting and refuge. (English summary)

J. Comput. Appl. Math. **236** (2012), *no.* 7, 1743–1752.

The author considers a prey-predator model where harvesting of the prey by an external agent is assumed. The peculiarity is that the harvesting function includes a threshold parameter h to model the situation in which harvesting starts after the population

has reached a certain threshold value; it then increases smoothly to a limit value h. A continuous harvesting function on the prey is proposed as an alternative to constant or linear harvesting. A condition called refuge is included to protect some of the prey from predation. The first theorem asserts that solutions of the model are uniformly bounded in the first quadrant. The study of possible bifurcations in the corresponding dynamical system indicates that there are two cases depending on the number of prey. When the number x is less than the threshold value T either predator extinction or survival is possible depending on the prey conversion rate, thus no coexistence is possible for a relatively small prey conversion rate which is compared to the predator death rate. Examining some bifurcations in the model observed for the case $x > T$ makes it possible to obtain values of parameters for which radical changes in the qualitative behavior of the solutions happen.

From the author's final remarks: "In addition to stability analysis, we have also given conditions under which solutions are uniformly bounded, some critical points or limit cycles are globally asymptotically stable, or no limit cycles exist, we have computed bionomic equilibria and studied some bifurcations, showing the rich dynamics of the proposed system. This system includes the particular cases $m = 0$ (no refuge), $h = 0$ (no harvesting) and $T = 0$ (rational harvesting function, with no threshold)."

Nelli Ajabyan

MR2861256 93A14 35F25 65P99 93B11

Fornasier, M. (D-MUTUM2; Garching)**;**
Haškovec, J. [Haškovec, Jan] (A-OAW-RIC; Linz)**;**
Vybíral, J. [Vybíral, Jan] (A-OAW-RIC; Linz)

Particle systems and kinetic equations modeling interacting agents in high dimension. (English summary)

Multiscale Model. Simul. **9** (2011), *no.* 4, 1727–1764.

This work explores connections between data compression and tractable numerical simulation of dynamical systems, particularly systems of the type

$$\dot{x}_i(t) = f_i(\mathcal{D}x(t)) + \sum_{j=1}^{N} f_{ij}(\mathcal{D}x(t))x_j(t)$$

in which N is a number of agents (such as the number of birds in a flock), $x(t) = (x_1(t), \dots, x_N(t)) \in \mathbb{R}^{d\times N}$, $f_i\colon \mathbb{R}^{N\times N} \to \mathbb{R}^d$ and $f_{ij}\colon \mathbb{R}^{N\times N} \to \mathbb{R}$, and $\mathcal{D}\colon \mathbb{R}^{d\times N} \to \mathbb{R}^{N\times N}$, given by $\mathcal{D}x = \{\|x_i - x_j\|\}_{ij}$, is the *adjacency matrix* of the point cloud x. Such dynamics are analyzed numerically via a discrete Euler method. The idea developed here is to project the system and its initial condition randomly by Johnson–Lindenstrauss embeddings onto a lower-dimensional space where independent simulation can be performed, then through multiple such projections and parallelization, produce approximate reconstructions of the high-dimensional dynamics via compressed sensing techniques. Challenges are posed by cases in which the dimension of the parameter space, d, is large, and when the number of agents, N, is large. Here, the large N case is addressed by analogy with kinematic gas theory in which one models a density distribution with stochastic interactions, rather than individual particles.

The low-dimensional version of the Euler system takes the form

$$\begin{aligned} y_i^{n+1} &= y_i^n + h\left[Mf_i(\mathcal{D}'y^n) + \sum_{j=1}^{N} f_{ij}(\mathcal{D}'y^n)y_j^n\right], \quad n = 0, \dots, n_0 - 1; \\ y_i^0 &= Mx_i^0. \end{aligned}$$

Here, $M \in \mathbb{R}^{k\times d}$ in which $k \ll d$. Let $\mathcal{E}^n = \max_i \|y_i^n - Mx_i^n\|$, where the norm is for $\mathbb{R}^k$.

The first main result states that if M satisfies the conditions

$$\|Mf_i(\mathcal{D}'y^n) - Mf_i(\mathcal{D}x^n)\| \le (1+\varepsilon)\|f_i(\mathcal{D}'y^n) - f_i(\mathcal{D}x^n)\|,$$
$$\|Mx_j^n\| \le (1+\varepsilon)\|x_j^n\| \quad \text{and}$$
$$(1-\varepsilon)\|x_i^n - x_j^n\| \le \|Mx_i^n - Mx_j^n\| \le (1+\varepsilon)\|x_i^n - x_j^n\|,$$

for all i and n in the respective k- and d-dimensional norms, and if the $\mathbb{R}^d$-norms of the x_j^n are uniformly bounded by some $\alpha > 0$, then one has

$$\mathcal{E}^n \le \varepsilon hnB\exp(hnA)$$

with

$$A = L' + 2(1+\varepsilon)(L+\alpha L''), \quad B = 2\alpha(1+\varepsilon)(L+\alpha L''),$$

where L is a uniform Lipschitz bound on the f_i's and L'' is a uniform Lipschitz bound on the f_{ij}'s. The conditions on M are satisfied by Johnson–Lindenstrauss embeddings, that is, essentially, linear embeddings $M \in \mathbb{R}^{k\times d}$ such that

$$(1-\varepsilon)\|x\| \le \|Mx\| \le (1+\varepsilon)\|x\|.$$

As a particular example, a uniform estimate for the Cucker-Smale model for emergent behavior in flocks is derived along with an $l_2^N(l_2^k)$-estimate for the error in the model. Then dimensionality reduction for continuous dynamical systems is addressed by means of a corresponding continuous Johnson-Lindenstrauss lemma, that is, an extension of the norm embedding inequalities to points along a curve, with high probability. Recovery of dynamics in high dimensions from multiple simulations in low dimensions is then addressed by means of the so-called *restricted isometry property* and numerical validation considerations are discussed. The last section of this work addresses mean-field limit and kinetic equations in high dimensions. *Joseph D. Lakey*

MR2817805 93C05 34A09 49K15 49N10 65L80

Kunkel, Peter (D-LEIP-IM; Leipzig)**; Mehrmann, Volker** (D-TUB-IM; Berlin)

Formal adjoints of linear DAE operators and their role in optimal control. (English summary)

Electron. J. Linear Algebra **22** (2011), 672–693.

Summary: "For regular strangeness-free linear differential-algebraic equations (DAEs) the definition of an adjoint DAE is straightforward. This definition can be formally extended to general linear DAEs. In this paper, we analyze the properties of the formal adjoints and their implications in solving linear-quadratic optimal control problems with DAE constraints."

MR2877097 93D20 65K05 93C55

Singh, Vimal

Modified criterion for global asymptotic stability of fixed-point state-space digital filters using two's complement arithmetic. (English summary)

Automatica J. IFAC **46** (2010), *no.* 2, 475–478.

Summary: "A criterion for the global asymptotic stability of fixed-point state-space digital filters using two's complement arithmetic is presented. The criterion is a modified form of a well-known criterion due to Mills, Mullis, and Roberts. The criterion is in the form of linear matrix inequality and, hence, computationally tractable. An example shows the effectiveness of the modified criterion."

MR2879459 93E12 39A60 62M20 65Q10 93B30

Medvedev, Alexander [**Medvedev, Aleksandr Vladislavovich**] (S-UPPS-DIT; Uppsala)**;**
Evestedt, Magnus (S-UPPS-DIT; Uppsala)

Elementwise decoupling and convergence of the Riccati equation in the SG algorithm. (English summary)

Automatica J. IFAC **45** (2009), *no.* 6, 1524–1529.

Summary: "It is shown that the difference Riccati equation of the Stenlund-Gustafsson (SG) algorithm for estimation of linear regression models can be solved elementwise. Convergence estimates for the elements of the solution to the Riccati equation are provided, directly relating convergence rate to the signal-to-noise ratio in the regression model. It is demonstrated that the elements of the solution lying in the direction of excitation exponentially converge to a stationary point while the other elements experience bounded excursions around their current values."

MR2896281 94A08 42C15 65T60 68U10 94A11

Easley, Glenn R. (1-SYSPL; Arlington, VA)**; Labate, Demetrio** (1-HST; Houston, TX)

Image processing using shearlets. (English summary)

Shearlets, 283–325, *Appl. Numer. Harmon. Anal.*, *Birkhäuser/Springer*, *New York*, 2012.

Summary: "Since shearlets provide nearly optimally sparse representations for a large class of functions that are useful to model natural images, many image processing methods benefit from their use. In particular, the error rates of data estimation from noise are highly dependent on the sparsity properties of the representation, so that many successful applications of shearlets center around restoration tasks such as denoising and inverse problems. Other imaging problems, where also the application of the shearlet representation turns out to be very beneficial, include image enhancement, image separation, edge detection, and estimation of the geometric features of an object."

{For the entire collection see MR2896273 (2012k:42001).}

MR2920649 94A08 65F15 94A29

Gu, Zhouye (SGP-NANT-SCE; Singapore)**; Lin, Weisi** (SGP-NANT-NWC; Singapore)**;**
Lee, Bu-sung [**Lee, Bu-Sung**] (SGP-NANT-SCE; Singapore)**;**
Lau, ChiewTong [**Lau, Chiew Tong**] (SGP-NANT-SCE; Singapore)

Low-complexity video coding based on two-dimensional singular value decomposition. (English summary)

IEEE Trans. Image Process. **21** (2012), *no.* 2, 674–687.

Summary: "In this paper, we propose a low-complexity video coding scheme based upon 2-D singular value decomposition (2-D SVD), which exploits basic temporal correlation in visual signals without resorting to motion estimation (ME). By exploring the energy compaction property of 2-D SVD coefficient matrices, high coding efficiency is achieved. The proposed scheme is for the better compromise of computational complexity and temporal redundancy reduction, i.e., compared with the existing video coding methods. In addition, the problems caused by frame decoding dependence in hybrid video coding, such as unavailability of random access, are avoided. The comparison of the proposed 2-D SVD coding scheme with the existing relevant non-ME-based low-complexity codecs shows its advantages and potential in applications."

MR2801926 94A08 26A33 34A08 35B65 35R11 45K05 65D18 68U10
Janev, Marko (SE-NOVIE; Novi Sad);
Pilipović, Stevan [Pilipović, Stevan S.] (SE-NOVI-MIF; Novi Sad);
Atanacković, Teodor (SE-NOVIE; Novi Sad);
Obradović, Radovan (SE-NOVIE; Novi Sad);
Ralević, Nebojša [Ralević, Nebojša M.] (SE-NOVIE; Novi Sad)
Fully fractional anisotropic diffusion for image denoising. (English summary)
Math. Comput. Modelling **54** (2011), *no.* 1-2, 729–741.

In this paper, the authors proposes a novel nonlinear PDE, the Fully Fractional Anisotropic Diffusion (FFAD) for noise removal, which combines temporal and spatial fractional derivatives in order to interpolate between the nonlinear heat equation and the hyperbolic nonlinear equation:

$$(1) \qquad {}^{C}D_t^{\beta}u = -(D_x^{\alpha})^{*}(c(|D_{x,y}^{\alpha}u|^2)D_x^{\alpha}u) - (D_y^{\alpha})^{*}(c(|D_{x,y}^{\alpha}u|^2)D_y^{\alpha}u),$$

where $\alpha \in [1,2]$, $\beta \in [1,2)$; ${}^{C}D_a^{\beta}$ is the left Caputo fractional differential operator defined by ${}^{C}D_a^{\beta}f(t) = J_a^{n-\beta}D^n f(t)$, $n \in \mathbb{N}$; $J_a^{\beta}f(t) = \frac{1}{\Gamma(\beta)}\int_a^t (t-\tau)^{(\alpha-1)}f(\tau)\,\mathrm{d}\tau$, $t \in [a,b]$, is the left tractional integral operator; $D_{x,y}^{\alpha}u = (D_x^{\alpha}, D_y^{\alpha})$ is the Bai–Feng fractional spatial derivative; D_x^{α} and D_y^{α} are defined as pseudo-differential operators:

$$D_x^{\alpha}u(x,y) = \frac{1}{2\pi}\int_{\mathbb{R}^2} e^{i(x\xi_1+y\xi_2)}(i\xi_1)^{\alpha}\,\widehat{u}(\xi_1,\xi_2)\,\mathrm{d}\xi_1\mathrm{d}\xi_2\,,$$

$$D_y^{\alpha}u(x,y) = \frac{1}{2\pi}\int_{\mathbb{R}^2} e^{i(x\xi_1+y\xi_2)}(i\xi_2)^{\alpha}\,\widehat{u}(\xi_1,\xi_2)\,\mathrm{d}\xi_1\mathrm{d}\xi_2\,,\ (x,y) \in \mathbb{R}^2\,;$$

$c\colon \mathbb{R} \to [0,1]$ is a decreasing and continuous function (edge stopping function or diffusion coefficient) vanishing on the edges, and close to 1 on regular regions; $\widehat{u}(\xi_1,\xi_2)$ is the Fourier transform.

For the construction of a numerical scheme, Equation (1) is treated as a spatially discretized Fractional Ordinary Differential Equation (FODE) model, and then the Fractional Linear Multistep Method (FLMM) combined with the discrete Fourier transform (DFT) is used. The authors prove that the analytical solution to the proposed FODE has certain regularity properties which are sufficient to apply a convergent and stable fractional numerical procedure. Experimental results confirm that the proposed model manages to preserve edges, especially highly oscillatory regions, more efficiently than baseline parabolic diffusion models. *V. S. Sizikov*

MR2824608 94A08 49M37 49N45 65K10 68U10
Lukić, Tibor (SE-NOVIT-NDM; Novi Sad);
Lindblad, Joakim (SE-NOVIT-NDM; Novi Sad);
Sladoje, Nataša (SE-NOVIT-NDM; Novi Sad)
Regularized image denoising based on spectral gradient optimization. (English summary)
Inverse Problems **27** (2011), *no.* 8, 085010, 17 *pp.*

This paper proposes a hybrid filtering method based on the optimization methods called SGC and CSG which are in turn based on a spectral gradient method. Empirical results that contain some well-known potential functions are provided. Tests are conducted on many different types of images, some of them medical or biological. Computation times are also measured and provided for the described methods. The authors suggest further research in the reconstruction of tomographic images. *Wojciech Rafajłowicz*

MR2876684 94A08 65K10 65R32 68U10

Shi, Yuying (PRC-EPU2-MP; Beijing); **Wang, Li-Lian** (SGP-NANT-MPM; Singapore); **Tai, Xue-Cheng** (SGP-NANT-MPM; Singapore)

Geometry of total variation regularized L^p-model. (English summary)

J. Comput. Appl. Math. **236** (2012), *no.* 8, 2223–2234.

Summary: "In this paper, the geometry and scale selection properties of the total variation (TV) regularized L^p-model are rigorously analyzed. Some intrinsic features different from the TV-L^1 model are derived and demonstrated. Numerical algorithms based on recent developed augmented Lagrangian methods are implemented and numerical results consistent with the theoretical results are provided."

MR2768733 94A08 49Q20 65D18 65M99

Sulman, M. [**Sulman, Mohamed M.**] (3-SFR; Burnaby, BC); **Williams, J. F.** [**Williams, John Frederick**] (3-SFR; Burnaby, BC); **Beg, M. F.** (3-SFR-EG; Burnaby, BC); **Russell, R. D.** (3-SFR; Burnaby, BC)

Volumetric image registration methods based on solving the Monge-Ampère equation. (English summary)

Can. Appl. Math. Q. **17** (2009), *no.* 3, 585–614.

In a volumetric image registration problem one is looking for a geometric transformation between two images, one of which is called the template and the other the target. What kind of feature does one demand from such a map? Desired properties are bijectivity (even in weak forms) and "preservation of the main features". Among all the possible maps then it is possible to choose on the basis of the regularity and the "fidelity". In this paper the authors decide to use maps obtained as solutions of the Monge-Ampère equation. This is a natural and previously used choice. The solution is obtained by two different methods. First as a steady state of a parabolic Monge-Ampère equation and then as a solution of the Monge-Kantorovich optimal transportation problem. Examples and comparisons are reported. *Luigi De Pascale*

MR2885874 94A08 65K10 65R32 68U10

Wang, Wei [**Wang, Wei[9]**] (PRC-TONG; Shanghai); **Ng, Michael K.** (PRC-BAP-IGV; Kowloon)

On algorithms for automatic deblurring from a single image. (English summary)

J. Comput. Math. **30** (2012), *no.* 1, 80–100.

Summary: "In this paper, we study two variational blind deblurring models for a single image. The first model is to use the total variation prior in both image and blur, while the second model is to use the frame based prior in both image and blur. The main contribution of this paper is to show how to employ the generalized cross validation (GCV) method efficiently and automatically to estimate the two regularization parameters associated with the priors in these two blind motion deblurring models. Our experimental results show that the visual quality of restored images by the proposed method is very good, and they are competitive with the tested existing methods. We will also demonstrate the proposed method is also very efficient." *Ana Belén Petro*

MR2919458 94A08 65T50 90C90

Zhang, Jianjun [**Zhang, Jian Jun[1]**] (PRC-SGH; Shanghai)

An alternating minimization algorithm for binary image restoration. (English summary)

IEEE Trans. Image Process. **21** (2012), *no.* 2, 883–888.

Summary: "The problem we will consider in this paper is binary image restoration. It is, in essence, difficult to solve because of the combinatorial nature of the problem. To

overcome this difficulty, we propose a new minimization model by making use of a new variable to enforce the image to be binary. Based on the proposed minimization model, we present a fast alternating minimization algorithm for binary image restoration. We prove the convergence of the proposed alternating minimization algorithm. Experimental results show that the proposed method is feasible and effective for binary image restoration."

MR2895316 94A12 65T60 94A11

Shadmand, A. (4-LNDKC-NDM; London); **Dilmaghani, R.** (4-LNDKC-NDM; London); **Ghavami, M.** [**Ghavami, Mohammad**] (4-SB-NDM; London); **Shikh-Bahaei, M.** [**Shikh-Bahaei, Mohammad**] (4-LNDKC-NDM; London)

Wavelet-based downlink scheduling and resource allocation for long-term evolution cellular systems. (English summary)

IET Commun. **5** (2011), *no.* 14, 2091–2095.

Summary: "This study proposes the use of wavelet transform in long-term evolution (LTE) cellular systems. Mathematical expressions are derived to represent data rate in LTE downlink transmission based on Wavelet and Fourier Transforms. Furthermore, a comparison between these two systems is provided. Simulation results show the proposed orthogonal wavelet division multiplexing (OWDM) approach outperforms the traditional orthogonal frequency division multiplexing-based systems. The data rate can also be increased by the amount of CyclicPrefix/SymbolTime%, as there is no need for a channel prefix in an OWDM-based system."

MR2837591 94A12 15A42 15B48 65K10 90B18 90C26

Tan, Chee Wei (PRC-CHK-C; Kowloon); **Friedland, Shmuel** (1-ILCC-MS; Chicago, IL); **Low, Steven** [**Low, Steven H.**] (1-CAIT-C; Pasadena, CA)

Nonnegative matrix inequalities and their application to nonconvex power control optimization. (English summary)

SIAM J. Matrix Anal. Appl. **32** (2011), *no.* 3, 1030–1055.

Summary: "Maximizing the sum rates in a multiuser Gaussian channel by power control is a nonconvex NP-hard problem that finds engineering application in code division multiple access (CDMA) wireless communication network. In this paper, we extend and apply several fundamental nonnegative matrix inequalities initiated by Friedland and Karlin in a 1975 paper to solve this nonconvex power control optimization problem. Leveraging tools such as the Perron-Frobenius theorem in nonnegative matrix theory, we (1) show that this problem in the power domain can be reformulated as an equivalent convex maximization problem over a closed unbounded convex set in the logarithmic signal-to-interference-noise ratio domain, (2) propose two relaxation techniques that utilize the reformulation problem structure and convexification by Lagrange dual relaxation to compute progressively tight bounds, and (3) propose a global optimization algorithm with ε-suboptimality to compute the optimal power control allocation. A byproduct of our analysis is the application of Friedland-Karlin inequalities to inverse problems in nonnegative matrix theory." *Constantin Udrişte*

MR2920640 94A20 65T60 94A11

Easley, Glenn R. (1-SYSPL; Arlington, VA); **Labate, Demetrio** (1-HST; Houston, TX)

Critically sampled wavelets with composite dilations. (English summary)

IEEE Trans. Image Process. **21** (2012), *no.* 2, 550—561.

Summary: "Wavelets with composite dilations provide a general framework for the

construction of waveforms defined not only at various scales and locations, as traditional wavelets, but also at various orientations and with different scaling factors in each coordinate. As a result, they are useful to analyze the geometric information that often dominate multidimensional data much more efficiently than traditional wavelets. The shearlet system, for example, is a particular well-known realization of this framework, which provides optimally sparse representations of images with edges. In this paper, we further investigate the constructions derived from this approach to develop critically sampled wavelets with composite dilations for the purpose of image coding. Not only do we show that many nonredundant directional constructions recently introduced in the literature can be derived within this setting, but we also introduce new critically sampled discrete transforms that achieve much better nonlinear approximation rates than traditional discrete wavelet transforms and outperform the other critically sampled multiscale transforms recently proposed."

MR2895758 94A20 65D05 65D18
Zhang, Yongbing [Zhang, Yongbing[3]] (PRC-SZTSI; Shenzhen)**;**
Zhao, Debin (PRC-HIT-C; Harbin)**;**
Zhang, Jian [Zhang, Jian[14]] (PRC-HIT-C; Harbin)**;**
Xiong, Ruiqin (PRC-BJ-SEL; Beijing)**; Gao, Wen [Gao, Wen[1]]** (PRC-BJ-SEL; Beijing)
Interpolation-dependent image downsampling. (English summary)
IEEE Trans. Image Process. **20** (2011), *no.* 11, 3291–3296.

Summary: "Traditional methods for image downsampling commit to remove the aliasing artifacts. However, the influences on the quality of the image interpolated from the downsampled one are usually neglected. To tackle this problem, in this paper, we propose an interpolation-dependent image downsampling (IDID), where interpolation is hinged to downsampling. Given an interpolation method, the goal of IDID is to obtain a downsampled image that minimizes the sum of square errors between the input image and the one interpolated from the corresponding downsampled image. Utilizing a least squares algorithm, the solution of IDID is derived as the inverse operator of upsampling. We also devise a content-dependent IDID for the interpolation methods with varying interpolation coefficients. Numerous experimental results demonstrate the viability and efficiency of the proposed IDID."

MR2849376 94A55 65T50 94A60 94C10
Gong, Guang (3-WTRL-CP; Waterloo, ON)**; Rønjom, Sondre** (N-NSM2; Baerum)**;**
Helleseth, Tor (N-BERG-SC; Bergen)**;**
Hu, Honggang [Hu, Hong-Gang] (PRC-HEF-SIT; Hefei)
Fast discrete Fourier spectra attacks on stream ciphers. (English summary)
IEEE Trans. Inform. Theory **57** (2011), *no.* 8, 5555–5565.

The theory of the selective discrete Fourier spectra attacks, which are closely related to the fast algebraic attacks, is developed. It is shown that the selective attack is more efficient than known methods for the case when the number of observed consecutive bits of a filter generator is less than the linear complexity of the sequence. Consequently, the new attack imposes a new criterion for the design of cryptographic strong Boolean functions, which is defined as the spectral immunity of a sequence or a Boolean function.

Zhixiong Chen

MR2907027 94B12 65T60 94A11
Hou, X. [**Hou, Xingsong**] (PRC-XJU-EI; Xi'an)**;**
Jiang, G. [**Jiang, Guifeng**] (PRC-XJU-EI; Xi'an)**; Ji, R.** (PRC-XJU-EI; Xi'an)**; Shi, C.**
Directional lifting wavelet and universal trellis-coded quantisation-based image coding algorithm and objective quality evaluation. (English summary)
IET Image Process. **5** (2011), *no.* 8, 693–702.
Summary: "In this study, an image coding algorithm based on directional lifting wavelet transform (DLWT) and universal trellis-coded quantisation (UTCQ) is presented, and the coding performance is evaluated with three objective image quality metrics. Compared to the discrete wavelet transform, DLWT performing prediction and update along the direction of the local region can provide an efficient representation of edges in images, but shows a similar ability in representing the smooth region. To further improve the visual quality of the smooth background regions, UTCQ is adopted to quantising the wavelet coefficients. The proposed algorithm is measured with not only the dominant peak signal-to-noise ratio (PSNR), but also new metrics multi-scale structural similarity index measure (MSSIM) and visual information fidelity (VIF) which provide a better approximation to the perceived image quality than PSNR by taking the property of human visual system (HVS) into account. Experimental results show that the proposed algorithm has the best MSSIM and VIF performance among the compared algorithms (including JPEG2000) for the typical test images, and its decoded images at low bit-rate are visually more appealing in both edges and smooth background regions. For image Barbara, the proposed algorithm outperforms JPEG2000 up to 24.63% relatively in VIF and 1.93 dB in PSNR at 0.5 bpp, at most 3.62% relatively in MSSIM at 0.125 bpp. The experimental results also show that UTCQ does perform better than scalar quantisation (SQ) in MSSIM and VIF and improves the subjective visual quality, although UTCQ is not necessarily better than SQ in PSNR."

MR2863349 94D05 65T50
Su, Li-yun (PRC-CQUT-SMS; Chongqing)**;**
Li, Feng-lan [**Li, Fenglan**] (PRC-CQUT-LB; Chongqing)**;**
Li, Jiao-jun [**Li, Jiaojun**] (PRC-CQUT-EIA; Chongqing)**;**
Chen, Bo [**Chen, Bo^2**] (PRC-SW-SMS; Chongqing)
A novel digital image covert communication scheme based on generalized FCM in DCT domain. (English summary)
Fuzzy Inf. Eng. **3** (2011), *no.* 2, 127–136.
Summary: "A novel covert communication method of digital image is presented, based on generalized fuzzy c-means clustering (GFCM), human visual system (HVS) and discrete cosine transform (DCT). Therefore, the original image blocks are classified into two classes according to specified characteristic parameters. So one block is suited for embedding security information, but the other block is not. Hence the appropriate blocks can be selected in an image to embed the security information by selectively modifying the middle-frequency part of the original image in conjunction with HVS and DCT. Furthermore the maximal information strength is fixed based to the frequency masking. Also to improve performances of the proposed algorithm, the security information is modulated into the chaotic modulation array. The simulation results show that we can remarkably extract the hiding security information and can achieve good robustness with common signal distortion or geometric distortion and the quality of the embedded image is guaranteed."