1176-57-355 **Yu-Chia Chen** (yuchaz@outlook.com), **Marina Meila*** (mmp@stat.washington.edu) and **Ioannis Kevrekidis**. *Finding shortest loop bases and the decomposition of the higher-order homology embeddings.*

The study of the null space embedding of the graph Laplacian $\mathcal{L}_0$ has spurred new research and applications, such as spectral clustering algorithms with theoretical guarantees and estimators of the Stochastic Block Model. The null space of the k-th order Laplacian $\mathcal{L}_k$, known as the *k-th homology vector space*, encodes the non-trivial topology of a manifold or a network. In this work, we investigate the geometry of the k-th homology embedding and focus on cases reminiscent of spectral clustering. Namely, we analyze the *connected sum* of manifolds as a perturbation to the direct sum of their homology embeddings. We propose an algorithm to factorize the homology embedding into subspaces corresponding to a manifold's simplest topological components. The proposed framework is applied to the *shortest homologous loop detection* problem, a problem known to be NP-hard in general. Our spectral loop detection algorithm scales better than existing methods and is effective on diverse data such as point clouds and images. (Received January 25, 2022)