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Structure of the Lefschetz thimbles decomposition of lattice fermion models

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We discuss a framework for studying the properties of the Lefschetz thimbles decomposition for lattice fermion models. Non-iterative solver for the inversion of fermion determinants forms the core of the method. It allows us to solve the gradient flow (GF) equations taking into account the fermion determinant exactly. Being able to do so, we can find both real and complex saddle points of the lattice action and describe the structure of the Lefschetz thimbles decomposition for large enough lattices to extrapolate our results to the thermodynamic limit.
We show two possible applications of this technique. First of all, the knowledge about the saddle points can help us to simplify the structure of the Lefschetz thimbles decomposition and to alleviate the sign problem. The second application is systematic building of the quasi-classical approximation taking into account Gaussian fluctuations around exact saddle points.

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