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# Exact gradient flow and saddle points in lattice fermion models

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We describe new theoretical opportunities arising from the possibility to solve the gradient flow (GF) equations taking into account the fermion determinant exactly employing non-iterative solvers. Using this exact GF we can find real saddle points of the lattice action at zero chemical potential and trace their evolution in complex space at non-zero chemical potential. We show that these saddle points correspond to modified instantons, where the back reaction from the fermion determinant is taken into account already at the level of the Euclidean field equations. We demonstrate how this approach leads to the rigorous numerical procedure for the definition of the inter-instanton interactions and give examples of interaction profiles computed in this way.

We show two possible applications of this technique. First of all, the knowledge of 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 the systematic building of a statistical model of interacting instantons from first principles without need of any phenomenological input.

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