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Mistaken Identity: The Multi-State Labeling Problem

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In lattice gauge theory, understanding contributions from excited states is imperative for achieving high precision calculations. A variety of methods are available to extract excited states, such as fitting to multiple exponentials, Prony's method, and Matrix Prony, correlator matrices, and generalized eigenvalue problems. A generic problem faced by all these methods is that the resulting states tend to have overlapping error ellipses (e.g. jackknife, bootstrap, cross-validation, etc.) making identification of states ambiguous. The problem may be alleviated somewhat by expert guidance in operator selection to minimize overlap for a few low-lying states, but this defeats the overall design goal of an automated black-box method. Instead, we face the overlapping states labeling problem directly. For example, using the bootstrapping method, resolving excited state energies and their error bars requires finding the most probable set of state labels for each bootstrap sample. We investigate several variants of expectation maximization clustering in attempt to find an efficient algorithm for bootstrap labeling and therefore state identification.

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