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Phase Fluctuations and Sign Problems

Friday, 27 July 2018 14:00 (20 minutes)

Correlation functions for baryons, or generically systems with different U(1) charges than the vacuum, have phase fluctuations that lead to sign problems obstructing studies of finite-density matter using correlation functions. I will discuss phase fluctuations in lattice QCD and in a one-dimensional complex scalar field toy model and methods to exploit the structure of phase fluctuations to avoid or reduce sign problems. Phase reweighting correlation functions with destructively interfering phases near correlation function sources and sinks allows additional independent interpolating operators to be constructed from correlation functions in a generalization of the generalized pencil-of-functions technique that reduces the variance of the additional sources by suppressing phase fluctuations during source-creation. I will also introduce a new method in which phase unwrapping techniques from signal processing and engineering are applied to map compact random variables for which parameter inference has an exponentially severe signal-to-noise problem to non-compact random variables whose moments can be calculated without sign problems or severe signal-to-noise degradation. A cumulant expansion can be used to relate unwrapped phase moments to average correlation functions, but large phase jumps associated with heavy-tailed distributions surprisingly observed in free scalar field theory and lattice QCD can lead to significant truncation errors. I will briefly outline one-dimensional phase unwrapping results and outlook towards multi-dimensional applications where truncation errors might be better controlled.

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