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Title: Statistical mechanics insights into the complexity of tensor networks contractions

Abstract: Projected entangled pair states (PEPS) offer memory-efficient representations of some quantum many-body states that obey an entanglement area law, and are the basis for classical simulations of ground states in two-dimensional (2d) condensed matter systems. However, rigorous results show that exactly computing observables from a 2d PEPS state is generically a computationally hard problem. Yet approximation schemes for computing properties of 2d PEPS are regularly used, and empirically seen to succeed, for a large subclass of (‘not too entangled’) condensed matter ground states. Adopting the philosophy of random matrix theory, in this talk I will discuss the complexity of approximately contracting a 2d random PEPS by exploiting an analytic mapping to an effective replicated statistical mechanics model that permits a controlled analysis at large bond dimension. Through this statistical-mechanics lens, I will argue that: i) although approximately sampling wave-function amplitudes of random PEPS faces a computational-complexity phase transition above a critical bond dimension, ii) one can generically efficiently estimate the norm and correlation functions for any finite bond dimension.