Statistical physics methods in combinatorial optimization, inference and Graphical games

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Statistical physics focuses on microscopic properties of matter using probabilistic and graph theoretic models. It appears, however, that some of the insights of the field, such as the long range independence (correlation decay) property have applications far beyond the intended scope. We illustrate applications of the correlation decay method in three algorithmic domains: combinatorial optimization, graph counting (inference in Markov random fields) and graphical games. In all three contexts we identify models for which one can establish long-range independence of random observables, connected by some graphical structure, and turn this property for designing efficient (polynomial time) algorithms. As an example, we design a polynomial time approximation algorithm for computing maximum weight independent set in arbitrary low degree graphs with stochastic weights, even though the counterpart model with deterministic weights does not admit polynomial time approximation scheme (PTAS).