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TItle: Quantum first-order transitions: The problems that > quantum annealing cannot solve

Abstract: Many important practical problems involve the minimization of a function of discrete variables. Solving such combinatorial problems by temperature annealing is a classical strategy : the idea is to use thermal fluctuations to avoid trapping the system in local minima, and thereby efficiently visit the whole configuration space. Quantum annealing is an extension of this approach to quantum fluctuations, where one try to solve the problem by tuning down the amplitude of a quantum mechanical kinetic operator such as a transverse magnetic field. But can this outperform the classical approach? And in particular, can problems that normally take exponential time be solved in only polynomial time?

In this talk, I will show how statistical physics can be used to study exactly this problem, using exact methods (replica, cavity, instanton...) and numerical simulation (continuous time Monte-Carlo, exact diagonalization...). The bottom line is that for the really hard problems the answer to this question is no! The algorithm meet a first-order transition when the transverse field is cooled down and at this point adiabatically is hopelessly lost: this puts a strict limit to the performance of quantum annealing-like algorithms.

In the presentation, I will first start with a very simple (and somehow trivial) problem, and then move to more complex situation such as random spin glasses and random satisfiability problems. The connection with the Grover problem will be also discussed.