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Quantum annealing with parametrically drivennonlinear oscillators

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While progress has been made towards building Ising machines to solve hard combinatorial optimization problems, quantum speedups have so far been elusive. Furthermore, protecting annealers against decoherence and achieving long-range connectivity remain important outstanding challenges. With the hope of overcoming these challenges, I introduce a new paradigm for quantum annealing that relies on continuous variable states. Unlike the more conventional approach based on two-level systems, in this approach, quantum information is encoded in two coherent states that are stabilized by parametrically driving a nonlinear resonator. I will show that a fully connected Ising problem can be mapped onto a network of such resonators, and outline an annealing protocol based on adiabatic quantum computing. During the protocol, the resonators in the network evolve from vacuum to coherent states representing the ground state configuration of the encoded problem. In short, the system evolves between two classical states following non-classical dynamics. As will be supported by numerical results, this new annealing paradigm leads to superior noise resilience. Finally, I will discuss a realistic circuit QED realization of an all-to-all connected network of parametrically driven nonlinear resonators. The continuous variable nature of the states in the large Hilbert space of the resonator provides new opportunities for exploring quantum phase transitions and non-stoquastic dynamics during the annealing schedule.