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A design of annealer dynamics with quantum and thermal effects

We introduce a novel design of annealer dynamics which consists of quantum and thermal dynamics into optimization problems. The design space is not limited to the physically interpretable subspace. In this study, transverse field is utilized as a source of quantum effect, but any interaction can be applied. We use Sherrington-Kirkpatrick model to assess two annealer dynamics, a linear combination of von Neumann and Master equations, and a parallel dynamics of these equations with frequent intervention of both states to harmonize them. The parallel dynamics shows synergistic enhancement of performance on probability of finding ground state after averaged over randomness, while the linear combination dynamics does not. Performance improvements are observed in both conditions of shorter and longer annealing periods in which thermal dynamics is superior to quantum one and vice versa, respectively. The results suggest robust dynamics in a wide range of annealing period and its usefulness. Then, we investigate the two annealer dynamics with ferromagnetic and quantum signature models. In both models, the parallel dynamics seems to relax into a thermal equilibrium state of the quantum system with given amplitude of the quantum effect. This finding gives us an example of how we can design annealer dynamics.