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Effect of State transition of multi level systems to Performance of Quantum Annealing

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Hamiltonian design is an important factor for performance of quantum annealing (QA). It is known that selection of driver Hamiltonian which induces quantum effects into the system greatly influences the required running time of QA for certain problems: A non-stoquastic driver Hamiltonian including XX ferromagnetic interactions enables us to avoid problematic first-order phase transitions for the ferromagnetic p-spin model and the Hopfield model. In the present work, we focus on the degree of freedom of quantum information unit. Although spin-1/2 system is usually used as the unit, we can use other system called qudit which has multi levels more than two. In this case, we have a choice of state transitions between the multi levels. We examine QA on multi level systems. First, we investigate the effect of the transitions, we study the Wajnflasz-Pick model which is considered as a simple extension of two level system. As a result, we found that we can control the degree of quantum phase transitions by changing the stat transitions between the multi levels. Second, we study the effect of state transitions of qudit for another multi level system, the Potts model. The first study is a joint work with Shu Tanaka, and the second study is with Shun Kataoka and Kazuyuki Tanaka.