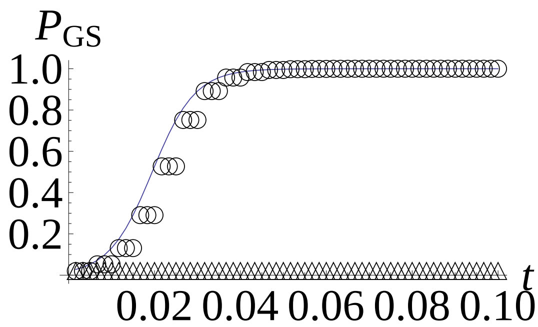

Figure 1: The performance of QA (triangles), and QJA (circles). The reference curve describes the instantaneous Gibbs-Boltzmann factor.

point of JE. Even if quantum nature affects the instantaneous quantum state, the property of JE guarantees that we keep the quantum state expressing the instantaneous equilibrium state. If one considers to simulate this procedure in "classical" computers, we have to need the repetition of the pre-determined process to deal with all fluctuations in the nonequilibrium-process average, since we assume an ensemble in equilibrium in the formulation of JE. However, when we implement QJA in "quantum" computation, we operate QJA to a single quantum system in principal since the classical ensemble is mapped to the quantum wave function. We do not need the repetition of the same procedure differently from the classical case [12].

Let us take a simple instance to search the minimum from a one-dimensional random potential, which is formulated as the Hamiltonian $H_0 = -\sum_{i=1}^{N} V_i|i\rangle\langle i|$. Here V_i denotes the potential energy at site i and chosen randomly. We employ a linear schedule for tuning the parameter β from 0 to 100. Figure 1 shows the plot for QJA (upper circles), which are fixed along the reference curves (solid curve) representing the instantaneous Gibbs-Boltzmann factor. In contrast, QA (lower triangles) can not sufficiently find the ground state since we consider a very short annealing is considered in this case.

5. Summary

We consider an application of JE to quantum computation as QA to solve the optimization problems by using the classical-quantum mapping. As we expected, this protocol keeps the quantum system to express the equilibrium state for the instantaneous inverse temperature. The result by QJA shown here gives the ground state in a short annealing and implies that we may overcome the difficulties in hard optimization problems and solve them in a reasonable time. The present result is nothing but preliminary one. We should address the problem on practical efficiency for several interesting hard problems we wish to solve in the future study [13].

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