CLAIMS

1. A method comprising:

controlling a quantum processor having controllable quantum states characterized by a quantum Hamiltonian H_{total}, the quantum processor being controlled such that the Hamiltonian H_{total} evolves from an initial quantum Hamiltonian H_i over time to a problem quantum Hamiltonian H_p, where an energy spectrum of H_p encodes a solution to a machine learning optimization problem, and where a quantum state of the quantum processor evolves from a ground state of H_i towards a ground state of H_p as H_{total} evolves from H_i to H_p,

deriving, by one or more processors, data characterizing a spontaneous energy spectrum of H_{total} of the quantum processor, the deriving being based on a combination of H_i and H_p at a time that H_{total} has the spontaneous energy spectrum;

estimating based on, reorganization energy and frequency of a bath, by the one or more processors, an average phonon energy of the bath in which the piece of quantum hardware is located; and

determining, by the one or more processors, an additional quantum Hamiltonian H_{QG} based on the derived data characterizing the spontaneous energy spectrum of H_{total} and the calculated average phonon energy, such that when combined with H_{total}, H_{QG} limits evolution of the quantum state into the ground state of H_p as H_{total} evolves to H_p without diagonalizing H_p.

2. The method of claim 1, comprising recording a selected probability mass function for a probability of the quantum state being in the ground state of H_p when H_{total} evolves to H_p, and H_{QG} is determined also based on the selected probability mass function and using the selected probability mass function in determining the additional quantum Hamiltonian.

3. The method of claim 1, wherein the spontaneous energy spectrum is obtained at approximately half time of a total time for H_{total} to evolve from H_i to H_p.

4. The method of claim 1, wherein deriving an information about an energy spectrum of H_{total} at the time of a quantum phase transition comprises evaluating ground state energy of H_{total} using quantum Monte-Carlo techniques, mean-field theories, or Markus theory.

5. The method of claim 1, wherein an information about an energy spectrum comprises actual energy levels, spacing among the actual energy levels, distribution of the spacing among the actual energy levels, or an average spacing between adjacent average energy levels.

6. The method of claim 1, wherein calculating the average phonon energy of the bath comprises calculating the average phonon energy using an open quantum systems model.

7. The method of claim 6, wherein the average phonon energy satisfies the following equation:

$$\overline{\omega} = \frac{\sum_0^\infty \omega J(\omega) d\omega / (e^{\omega/kT} - 1)}{\sum_0^\infty J(\omega) d\omega / (e^{\omega/kT} - 1)},$$

where $J(\omega)$ is one of an Omhic spectral density: $J(\omega) = \lambda \omega e^{-\frac{\omega}{\gamma}}$, a super-Omhic spectral density: $J(\omega) = \lambda \omega^3 e^{-\frac{\omega}{\gamma}}$, a Drude-Lorentz spectral density: $J(\omega) = \frac{2\lambda\omega\gamma}{\omega^2+\gamma^2}$, and a flat spectral distribution: $J(\omega) = 1$, λ is a reorganization energy, and γ is a bath frequency cut-off.

8. The method of claim 1, wherein determining an additional quantum Hamiltonian H_{QG} comprises selecting an exponential family of random matrices to represent a distribution of H_{QG} and determining control parameters for the selected exponential family of random matrices.

9. The method of claim 1, wherein determining an additional quantum Hamiltonian H_{QG} comprises determining H_{QG} such that during the evolution of the Hamiltonian H_{total} and the time the Hamiltonian H_{total} has the spontaneous energy spectrum, excitations of the quantum state from a ground state of H_{total} to an excited state of H_{total} is suppressed, and after the time, the quantum state relaxes from an excited state of H_{total} to the ground state of H_{total}.

10. The method of claim 9, wherein H_{QG} is determined such that, before the time, an average spacing $\overline{\Delta g}$ between energy levels of H_{QG} and an average spacing $\overline{\Delta \varepsilon}$ between energy levels of H_{total} in combination are much larger than an average phonon energy $\overline{\Delta \omega}$ of the bath, and after the time, the average spacing $\overline{\Delta g}$ between the energy levels of H_{QG} and the average spacing $\overline{\Delta \varepsilon}$ between energy levels of H_{total} in combination are similar to the average phonon energy $\overline{\Delta \omega}$ of the bath.