**Improve Shor’s algorithm with quantum annealing and pausing combined hybrid p-spin quantum annealing**

**n = 4**

1. **METHODOLOGY**

Shor’s algorithm

As a factoring algorithm using Hamiltonian’s property, Shor’s algorithm use fast multiplication, making the interger-factoriation into bounded-error quantum polynomial time(BQP), i.e. the error probability of at most 1/3 is guaranteed for all instances in polynomial time. As this can be cut into two parts hybridly, the first classical part is to initialize the problem with a random number, a, among 1 and N. With the aim of finding the period r so that a(x+T) mod N is equal to ax mod N, changes to quantum part for the set of the period and the stop of the process is also finally checked by classical part as it is on the base of the measurement result of the quantum computer on classical bit.

Quantum annealing

As integer factorization problem solved by Shor’s algorithm is based on the idea of reducing the factorization problem to the order-finding problems, quantum annealing solve the factorization on the base of quantum adiabatic computing(QAC), combining Ising Hamiltonian and modified multiplication table, making the computation does not rely on ad-hoc calculations and does not need to increase one extra bit.

According to the adiabatic theorem, given slow enough evolution, the system state can evolve from ground state of the complex Hamiltonian avoid turning to any higher-level excitation state. And thus, the measured qubits are in a bounded degree of certainty.

Meanwhile, adiabatic quantum empowers quantum annealing to be a heuristic method solving NP-hard optimization outperforming the classical digital computers and in some cases, it is a better choice instead of thermal annealing which is its classical counter part.

The time-dependent Hamiltonian H(t) evolves according to Schordinger equation (\*) here is the addition of the initial Hamiltonian and the final Hamiltonian:

Where HB is the initial Hamiltonian, ground state conveniently constructed as the summation of gates:

Where considering the environment as a series of independent harmonic oscillators with regarding to the orthonormal basis via the relationships interaction potential[1] that linearly coupled to the system:

with Pauli operator ϭx defines the x-basis. And to simplify the computation, the annealing oscillator a and creation oscillator utilized in this paper is expressed in:

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The Hamiltonian HP is the final Hamiltonian encoding the ground state as the solution to the prime factor finding of a, mapped to the final Ising Hamiltonian:

where gives the total energy of the system, and the function of time, is to induce flips of so that the intensity of the transverse ﬁeld will change in time. Further more, this general Hamiltonian is expressed in Quantum Annealing expressed in (14\*) where is the magnetic field on particle i..and it minimizes quadratic unconstrained binary optimization(QUBO) or Ising functions in n ∈N variables by multiplying a new variable z of{-1,+1},which , a slack variable to each linear term.

**Anneal paths based on reverse annealing**

**~~pausing combined hybrid p-spin quantum annealing~~**

In the final p-spin model, the natural units of ferromagnetic model is fixed as ==1.

We can easily achieve the p-spin dimensionless Hamiltonian:

To describe the ground state with ferromagnetic, all spins are aligned as up and p is odd (p ≤ n)while for two degenerate ground states, the system is is symmetric and p is even , the when n and p goes infinite, the system achieve limit.And to reach a quantum annealing , the transverse filed Hamiltonian is :

Thus, the time-independent Hamiltonian,

Where s = t/τ∈[0,1] is the dimensionless time and τ is the annealing time. A(s) and B(s) encode typical annealing schedules of ground state of symmetry subspace of and the symmetric of maximum spin with N = n+1.

And the final annealer-environment Hamiltonian becomes:

Thus, the g becomes gik, noise in superconducting QA is modeled as the sum of a low-frequency.

Noise in super condition quantum annealers becomes the addition of a low-frequency 1/f contribution and a high-frequency Ohmic spectrum:

where the cutoff β=1/T, is a high-frequency and η is a dimensionless coupling defined via:

The final time-dependent Markovian quantum master equation

(QME) in has the deterministic equation in the Lindblad form as”

Where

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And if we collect all dephasing operators into a single one, as Lab, then ignore the accidental degeneracies and define and *D[ρ(t)]=*

Thus, Hamiltonian becomes: