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# Improving Schrodinger Equation Implementations with Gray Code for Adiabatic Quantum Computers

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We reformulate the continuous space Schrödinger equation in terms of spin Hamiltonians. For the kinetic energy operator, the critical concept facilitating the reduction in model complexity is the idea of position encoding. Binary encoding of position produces a Heisenberg-like model and yields exponential improvement in space complexity when compared to classical computing. Encoding with a binary reflected Gray code, and a Hamming distance 2 Gray code yields the additional effect of reducing the spin model down to the XZ and transverse Ising model respectively. We also identify the bijective mapping between diagonal unitaries and the Walsh series, producing the mapping of any real potential to a series of k-local Ising models through the fast Walsh transform. Finally, in a finite volume, we provide some numerical evidence to support the claim that the total time

needed for adiabatic evolution is protected by the infrared cutoff of the system. As a result, initial state preparation from a free-field wavefunction to an interacting system is expected to exhibit polynomial time complexity with volume and constant scaling with respect to lattice discretization for all encodings. For the Hamming distance 2 Gray code, the evolution starts with the transverse

Hamiltonian before introducing penalties such that the low lying spectrum reproduces the energy levels of the Laplacian. The adiabatic evolution of the penalty Hamiltonian is therefore sensitive to the ultraviolet scale. It is expected to exhibit polynomial time complexity with lattice discretization, or exponential time complexity with respect to the number of qubits given a fixed volume.

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