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Quantum Computing Simulation for Collective Neutrino Oscillations

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Studies of neutrinos from astrophysical environments such as core-collapse supernovae, neutron star mergers and the early universe provide a large amount of information about various phenomena occurring in them. The description of the flavor oscillation is a crucial aspect for such studies, since the physics of matter under extreme conditions is strongly flavor-dependents (nucleosynthesis, proton/neutron ratio, spectral splits…).
It is well known that the neutrino flavor changes under the effect of 3 contributions: the vacuum oscillation, the interaction with the electrons of the surrounding matter, and the collective oscillations due to interactions between different neutrinos.
This last effect adds a non-linear contribution to the equations of motion, making the exact simulation of such a system inaccessible from any current classical computational resource.

Our goal is to describe the real time evolution of a system of many neutrinos by implementing the unitary propagator $U(t) = e^{-iHt}$ using quantum computation and paying attention to the fact that the flavor Hamiltonian H, in the presence of neutrino-neutrino term, presents an all-to-all interaction
that makes the implementation of $U(t)$, into a quantum algorithm, strongly dependent on the qubit topology. In this contribution we present an efficient way to simulate the coherent collective oscillations of a system of N neutrinos motivating the benefits of full-qubit connectivity which allows for more freedom in gate decomposition and a smaller number of quantum gates making simulation on near-term quantum devises more feasible.
We present the results obtained from a real quantum simulation on a trapped-ions based quantum machine for the cases of $N = 4$ and $N = 8$ neutrinos.

In-person or Virtual?

In-person

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