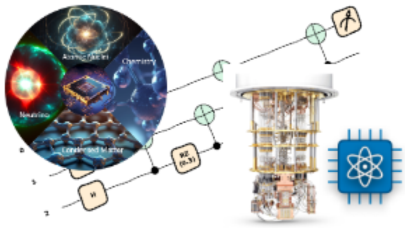

Contribution ID: **42** Type: **Contributed Talk (45min including questions)**

Phase-space approximation for three-flavor neutrino oscillations: challenging quantum algorithms

Wednesday, November 19, 2025 3:45 PM (45 minutes)

The simulation of collective neutrino oscillations represents a paradigmatic many-body quantum problem, where the exponential complexity of the Hilbert space severely limits classical approaches. We present an algorithmic framework for simulating three-flavor neutrino oscillations, based on the recently developed Phase-Space Approximation (PSA). Originally formulated for two-flavor systems, the PSA is here generalized to the full SU(3) case, enabling an efficient representation of the many-body dynamics of interacting neutrinos (M. Mangin-Brinet et al., "Three-flavor neutrino oscillations using the Phase Space Approach" [arXiv:2507.18482 [hep-ph]]). By reformulating the problem in terms of coupled mean-field–like equations, the PSA avoids the exponential growth of Hilbert space, while achieving an excellent reproduction of the exact dynamics for small ensembles – up to eight neutrinos – and scaling to systems of hundreds of particles on standard classical hardware. Such scalability, unattainable with brute-force diagonalization, highlights the potential of PSA as both an efficient approximation scheme and a serious competitor for quantum simulations. In addition, the parallelizable nature of the equations makes the method particularly relevant both for the development of quantum algorithms strategies, and for the benchmarking of quantum simulators. We will present the theoretical derivation, algorithmic principles, numerical validation, and discuss its embedding into the broader context of quantum algorithms for many-body physics, with an emphasis on applications to astrophysical neutrino flavor conversions.

Authors: MANGIN BRINET, Mariane (LPSC/CNRS); BAUGE, Angel; LACROIX, Denis

Presenter: MANGIN BRINET, Mariane (LPSC/CNRS)