ICFO

SEMINAR: Heisenberg-Limited Quantum Hamiltonian Learning via Randomly Spread Product-States

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July 07, 2026
12:00 to 13:00
Seminar Room

We show how the Heisenberg-limited quadratic Fisher-information regime of short-time quantum evolution can be made practically accessible for quantum Hamiltonian learning, using only local quantum operations. Our protocol uses experiments initialized in locally Haar-random product states, accompanied by random one-shot Pauli-product measurements, leading to the activation of the full Hamiltonian spectrum in the measurement statistics. This extends the naturally given quadratic Fisher scaling of short-time dynamics into a practically accessible temporal window without requiring entanglement, globally coherent measurements, or dynamical control. Furthermore, we show that the act of ensemble averaging over these initial states makes unbiased estimation data, meaning all Hamiltonian parameters can be simultaneously estimated from the same data-set, removing the need for parameter isolation. We supplement the theoretical results by showing empirically that, even away from the asymptotic limit, one can surpass the SQL using randomly spread product-state ensembles. We do so numerically by learning a selection of different disordered multi-qubit Hamiltonians in a black-box learning scenario.

Hosted by: Prof. Dr. Antonio Acin