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Machine Learning assisted Quantum Sensing: from Noise Characterization to Plaquette Phase Detection

SPEAKER

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ABSTRACT

Quantum sensing exploits the sensitivity of quantum systems to external perturbations to detect physical quantities with very high precision. In recent years, machine learning has emerged as a powerful complementary tool in this context, enabling the extraction of information from data, and helping overcome the complexity of quantum dynamics in realistic environments.

In this work, we present a machine-learning-assisted framework for quantum sensing in which a controlled quantum system acts as a probe to infer properties of external noise and intrinsic system parameters from a small number of measurements. The approach combines coherent control techniques with data-driven analysis, allowing relevant information to be reconstructed without requiring full dynamical characterization.

First, we introduce and numerically validate a protocol to identify spatial and temporal correlations of classical noise acting on two ultrastrongly coupled qubits. We consider different classes of Markovian and non-Markovian noise and exploit the sensitivity of STIRAP dynamics under a small set of driving conditions. Remarkably, the various noise regimes can be distinguished using only final-state population measurements, avoiding the need for time-resolved observables. A shallow neural network trained on these few features achieves high classification accuracy, including near-perfect discrimination between Markovian and non-Markovian noise.

Second, we investigate sensing of the plaquette phase in three-level systems with triangular (Δ-type) coupling configurations, where all energy levels are mutually connected. In these systems, a gauge-invariant plaquette phase emerges as an observable parameter that strongly influences the dynamics by modifying the dark-state condition responsible for coherent population transfer in STIRAP. This leads to a highly nonlinear dependence of the final populations on the phase. To reconstruct this phase efficiently, we employ supervised machine learning techniques that infer its value directly from population measurements.

Together, these results illustrate a unified approach in which quantum systems act as probes and machine learning provides an efficient tool to extract information from their response.

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