Quantum Nonlinear Spectroscopy of Arbitrary Quantum Correlations *via* Spin Sensing

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Correlations of fluctuations in a quantum system are the most important information that can be extracted to study the structures and dynamics of the system. In conventional linear or nonlinear spectroscopy (be it electrical, magnetical, optical, acoustical, or mechanical), a weak, classical "force" is applied to disturb a quantum system, and the response is measured in different orders of the force to determine the correlations in the quantum system. However, spectroscopy using classical probes (such as electromagnetic waves, voltages, acoustic waves, coils, and cantilevers) can only access a limited class of correlations in a quantum system. Using a quantum object as a sensor and extracting information of a target system through entanglement between the sensor and the target, quantum nonlinear spectroscopy can access arbitrary orders and types of correlations in the target system. Here we will present the schemes for extracting arbitrary quantum correlations using weak measurement through a spin sensor and discuss applications to examining the quantum foundation (by, e.g., higher-order Leggett-Garg inequality), to studying quantum many-body physics, and to detecting weakly coupled quantum objects free of the classical noise background.

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References

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