Enhanced Sensitivity with Spin-Squeezed States for Probing Ground State Electronic Order

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Recent advancements in quantum measurement techniques have opened new avenues for exploring the intricate properties of materials at the quantum level. For instance, in high-precision quantum metrology, measurement resolution is increased through squeezed states generated by non-linear operations.

Here, we introduce a novel approach that leverages spin-squeezed states to enhance the sensitivity of nuclear magnetic resonance experiments that probe emergent electronic order. Importantly, this technique goes beyond helping us overcome experimental limitations imposed by low signal-to-noise ratios. That is, our nuclear spin-squeezing inspired method can also reveal comprehensive information about the local electronic Hamiltonian. What is more, we demonstrate how to readily determine tensor orbital orders

Because the technique only perturbs the nuclear spin system, it reveals a true picture of the electronic ground state. By delineating the operational regimes of magnetic fields and temperatures, we demonstrate the utility of our method for advanced quantum sensing.

Figures

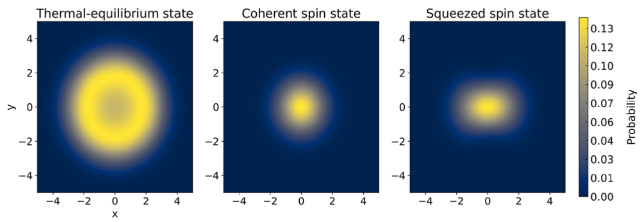

Figure 1: The Husimi-Q function for the initial thermal-equilibrium state, coherent spin state and the spin squeezed state. Best squeezing is achieved for a coherent spin state.

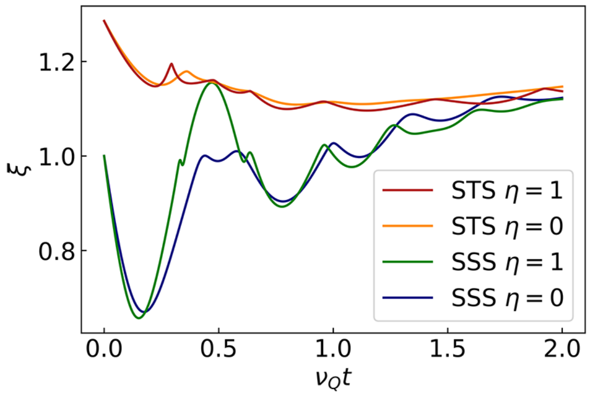

Figure 2: The form of squeezing parameter, ξ, depends on different initial states: spin squeezed state (SSS) from coherent spin state, squeezed thermal state (STS) from thermal equilibrium state, and values of the EFG anisotropy, η. The x-axis is the quadrupolar frequency ν_Q, which defines the time evolution of the nuclear system.

References

[1] **I. K. Nikolov**, S. Carr, A. G. Del Maestro, C. Ramanathan, V. F. Mitrović, Phys. Soc. Jpn. Conf. Proc. 38 (2023) 011149.