International Conference on Quantum Energy 2025 hosted by Dipartimento di Fisica e Astronomia Galileo Galilei an event by ICQE

Contribution ID: **55** Type: **Poster presentation**

Interferometry to access non-classical work distributions with spins in diamond

Spin defects in diamond have emerged in the last decade as a prominent platform for quantum technological applications, including quantum sensing, communication and computing. More recently, they have been established as a powerful tool for the investigation of fundamental topics such as quantum thermodynamics of nonequilibrium processes at the nanoscale, where quantum coherence and fluctuations play a major role, and the definition of non-state variables –such as work, heat, and entropy –remains a challenge.
The standard approach to quantifying work distributions is the celebrated two-point measurement (TPM) scheme, which measures energy at the beginning and end of a protocol. However, this scheme measures work distributions only for closed quantum systems and also results in the loss of the initial quantum coherence.
We experimentally demonstrated a weak-TPM scheme on the electronic qutrit spin of a nitrogen-vacancy (NV) center in diamond [1] and an interferometric scheme aided by an ancilla which makes use of the electron-nuclear two-qubit spin system based on an NV center [2] to reconstruct the Kirkwood-Dirac quasiprobability distribution of work under unitary processes. We observed anomalous work extraction and verified the Robertson-Schrödinger uncertainty relation.
We now aim at adapting the interferometric scheme to measure work distribution in an open quantum system dynamics, exploiting the interaction of an NV center with an additional nearby nuclear spin of a Carbon-13.

[1] S. Hernández-Gómez et al., Projective measurements can probe non-classical work extraction and time-correlations, Phys. Rev. Research 6, 023280 (2024)

[2] S. Hernández-Gómez et al., Interferometry of quantum correlation functions to access quasiprobability distribution of work, npj Quantum Information 10, 115 (2024)

Theme

Theme 3. Theoretical and experimental methods for quantum effects in energy processes

Primary authors: Dr HERNÁNDEZ-GÓMEZ, Santiago (European Laboratory for Non-linear Spectroscopy (LENS), Università di Firenze, I-50019 Sesto Fiorentino, Italy); Dr ISOGAWA, Takuya (Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, MA 02139, USA); Dr BELENCHIA, Alessio (Institute of Quantum Technologies, German Aerospace Center (DLR), D-89077 Ulm, Germany); Dr LEVY, Amikam (Department of Chemistry, Institute of Nanotechnology and Advanced Materials and the Center for Quantum Entanglement Science and Technology, Bar-Ilan University, Ramat-Gan, 52900, Israel); Dr GHERARDINI, Stefano (European Laboratory for Non-linear Spectroscopy (LENS), Università di Firenze, I-50019 Sesto Fiorentino, Italy); Prof. CAPPELLARO, Paola (Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, MA 02139, USA); Dr LOSTAGLIO, Matteo (Korteweg-de Vries Institute for Mathematics and QuSoft, University of Amsterdam, The Netherlands); Dr CAMPISI, Michele (NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, 56127 Pisa, Italy); Dr FABBRI, Nicole (European Laboratory for Non-linear Spectroscopy (LENS), Università di Firenze, I-50019 Sesto Fiorentino, Italy)

Presenter: RASHID, Zeeshan (Università degli Studi di Napoli Federico II, LENS, CNR)

Track Classification: Theme 3. Theoretical and experimental methods for quantum effects in energy processes