Quantum coherence-assisted sensing with parallel quantum dots

Stephanie Matern[1,2]
Katarzyna Macieszczak[3], Simon Wozny[2], Martin Leijnse[2]

[1]Pitaevskii BEC Center, CNR-INO and Dipartimento di Fisica, Università di Trento, Trento, Italy
[2]NanoLund and Solid State Physics, Lund University, Box 118, 22100 Lund, Sweden
[3]Department of Physics, University of Warwick, Coventry CV4 7AL, United Kingdom

stephanie.matern@ino.cnr.it

The interplay between quantum interference effects and non-equilibrium dynamics in quantum devices offers a promising avenue for applications. In this talk, we investigate the interplay between these phenomena and their potential for quantum sensing applications, focusing on a specific system consisting of two quantum dots (QD) in a parallel configuration coupled to a source and drain.
The parallel QD system is known to exhibit a sensitive response in its stationary particle current to external perturbations much smaller than the system-lead coupling and the temperature [1], which is a direct consequence of an underlying parity-like symmetry. Under equilibrium conditions this symmetry gives rise to two degenerate ground states, leading to the emergence of two stationary states in nonequilibrium. On an intuitive level the two states correspond to a bright and dark state due to the interference of the electron traveling through the two possible paths of the parallel QD system.
The underlying symmetry also impact the system's transient behavior and the parallel QDs exhibit metastability. The system's metastability manifests in long-lived, slowly decaying states and are described by classical dynamics between two metastable phases. The competition of those two metastable phases explains the sensitive behavior of the stationary current towards small perturbations.
Our goal is to harness this sensitive response for charge sensing which is not limited by temperature. Analyzing the sensitivity in terms of the particle current signal-to-noise ratio we find that the parallel QDs outperform an analogous single QD setup for a wide range of parameters [2].

References

[1] Z.-Z. Li and M. Leijnse, Phys. Rev. B 99, 125406 (2019)
[2] S. Matern, K. Macieszczak, S. Wozny, and M. Leijnse, Phy. Rev. B 107, 125424 (2023)