Andreev drag effect in Coulomb coupled quantum dots

David Sanchez

University of the Balearic Islands, IFISC (UIB-CSIC), Crta. Valldemossa, km 7.5, E07122-Palma de Mallorca, Spain

Coulomb drag is an effect of fundamental interest in nanoscale physics arising from the combined interplay of fluctuations and interactions. It appears as a spectacular consequence of broken symmetries and correlations as a measurable current in an equilibrium conductor under the influence of a nearby voltage-biased conductor. With very few exceptions, research activity has thus far focused on conductors coupled to metallic (normal) reservoirs. In our work [1], we consider the case of a hybrid conductor coupled to both a normal and a superconducting reservoir. Our results are to our knowledge the first obtained with normal-superconducting quantum dots in the drag regime. This setup is of utmost interest in studies on Andreev reflection, where an electron is transformed, upon tunneling from a normal lead, into a Cooper pair in the superconductor. This allows for many-body quantum superposition states in the dot, which have a strong impact in the drag physics, as our calculations demonstrate. Whereas drag currents in normal coupled dot systems are determined by rather uncontrolled energy-dependent tunnel asymmetries, we find that the Andreev-Coulomb drag gives rise to more robust signals, which can be significantly manipulated with external parameters (gate voltages, temperature or pairing coupling). Thus, we believe that our proposal can be easily realized with present experimental techniques.

The Coulomb drag effect is nowadays also explored for its application to energy harvesting and heat management in quantum conductors. Since quantum dots can serve as qubit platforms and coupled nanoconductors can work as ultrasensitive charge sensors, our proposal is also of interest for the investigation of quantum backaction effects. Finally, the system we consider has analogies with the ratchet effect, which would raise questions on the role of pair tunneling in quantum thermodynamics theories.

[1] Andreev-Coulomb Drag in Coupled Quantum Dots. S. Mojtaba Tabatabaei, David Sanchez, Alfredo Levy Yeyati, and Rafael Sanchez. Phys. Rev. Lett. 125, 247701 (2020)