Highlights

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Macroscopic quantum tunnelling in spin filter ferromagnetic Josephson junctions

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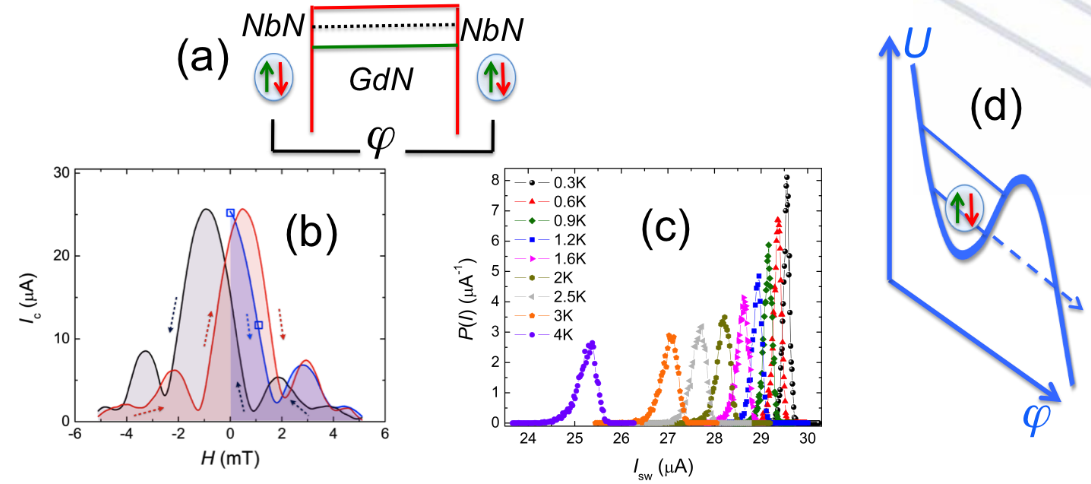
Macroscopic quantum tunneling (MQT) is a pre-requisite for the possible use of a junction in quantum circuits and qubits. This experiment is the first observation of MQT in superconductor (S) - ferromagnet (F) - S Josephson junctions (JJs). The coexistence of these two (S and F) ordered phases combined to other unconventional unique features as spin filter properties and triplet superconductivity, is extremely inspiring for new quantum functionalities and for innovative applications. The use of Gadolinium Nitride (GdN) ferromagnetic insulator (FI) as a barrier is the key of the Cambridge S-F-S JJs to obtain an effective tunnel barrier able to activate spin-filtering and a series of magnetic behaviors. Through measurements of switching current distributions and the expertise of the Napoli team on the quantum physics of superconducting junctions, we show a clear transition from thermal to quantum regime at a crossover temperature of about 100 mK. Our result paves the way to the active use of spin filter JJs in quantum technologies and hybrid devices.



(a) Schematic illustration of the spin-splitting of tunnelling barrier height in the GdN layer below the Curie temperature. (b) Magnetic field pattern of a spin filter JJ. The black and red curves show a distinctive shift of the absolute maximum of the critical current, arising from the hysteretic reversal of the FI barrier. (c) Measurements of switching current distributions as a function of temperature. Below 100 mK, the switching distributions saturate indicating the transition to the macroscopic quantum tunneling regime, qualitatively sketched in panel (d).