Quantum dynamics of vortices in long junctions

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ABSTRACT

In the second lecture I will focus on quantum properties of Josephson vortices in ultra-narrow long Josephson junctions. In narrow junctions a vortex is expected to behave as a macroscopic quantum particle with a spatial extent of several micrometers which may tunnel through a potential barrier created in the junction [1]. Our recent experiments that demonstrate quantum tunneling and energy level quantization of a individual vortices in long Josephson junctions will be presented.

The quantum properties of a single vortex trapped in the long Josephson junction can be traced by investigating the statistics of the escape from a potential well. The crossover from thermal activation to quantum tunneling is typically observed at the temperature of about 100 mK. Measurements of vortex escape from a potential well in the presence of microwave radiation clearly indicate discrete energy levels of the vortex. In agreement with theoretical expectations, both the tunnelling rate and the energy level separation can be tuned by the externally applied magnetic field.

The potential energy profile for vortices can be tailored by applying spatially-nonuniform magnetic fields to the long Josephson junction. A quantum state of a vortex in an artificially created potential can be used in order to implement a particular type of superconducting qubits named vortex qubits [2, 3]. Our qubit prototype is the heart-shaped long Josephson junction, for which rather simple state preparation and readout procedures have been already verified experimentally [3]. In these qubits the external magnetic field is uniform and the spatially-dependent potential profile for a vortex is tailored by shaping the long junction into a heart form. In the final part of this lecture I will discuss issues related to decoherence, which are common to all superconducting flux-based qubits.

References

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