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Radiation Detection Technique based on new Tunable Flux Array Device

In a recent research, a nanometric pattern of niobium islands implemented as a controllable regular fluxon-array was used to investigate the phase transitions with stable and metastable states (vortex insulator-vortex metal state) in competing regular vortex configurations [Nicola Poccia, Tatyana I. Baturina, Francesco Coneri, Cor G. Molenaar, X. Renshaw Wang, Ginestra Bianconi, Alexander Brinkman, Hans Hilgenkamp, Alexander A. Golubov, Valerii M. Vinokur, Science , 349 (2015) 1202].
These structures (80μmx80μm) (300X300=90000 Nb islands) were produced at 'MESA Institute for Nanotechnology, University of Twente'. In detail, this device is realized on a silicon/silicon oxide substrate where is grown a metallic gold template with four contacts. On this 'template'an array of niobium superconducting islands is realized with a period around 270nm. The island diameter is 220nm, the separation is 47 nm and the island thickness is 45 nm. An applied magnetic field (0-100mT) can induce the localization of different magnetic-vortex arrays between the superconducting islands, because of the weak superconductivity proximity effect. A simple I-V technique controls the dynamic state of the superconducting system.
Our idea is to use this new nanometric superconducting device as a radiation detector. In fact, it is possible to select a particular 'flux array configuration'with an applied magnetic field and to monitor the induced variations in the flux-array structures by incident radiation with a simple I-V measurement at 1.4-4.2K fixed temperature. The breaking of a cooper pair should trigger the transitions to a state with different flux configuration. Hence, the system should be sensitive to energy of the order of few meV.
Three analysis types are possible by monitoring: 1) the dynamic resistivity variation dV/dI between superconducting-normal state (bolometric effect); 2) the dynamic resistivity variation between two different competing stable flux-array configurations (non-bolometric effect); 3) the dynamic resistivity variation between vortex metallic-vortex insulator state in a fixed flux array (non-bolometric effect); the latter effect, should have a faster response. Moreover, this new superconducting device can be a promising new kind of single-photon detector. The technology to achieve this device is similar to that used for the well-known nanowire single-photon detectors that offer high efficiency, low dark counts, excellent timing resolution. In our case we also have an additional fine control on detectable energy through an additional control parameter: the magnetic field that fixes possible different array-configurations in the device.

Summary

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