Poster-1-10

Superconductivity in Atomically Thin Films: Diodes and 2D Critical State Model

Vadim Geshkenbein,[1] Filippo Gaggioli,[1] Gianni Blatter,[1] and Kostya Novoselov[2]

[1] *Institut für Theoretische Physik, ETH Zurich, CH-8093 Zurich, Switzerland*
[2] *Institute for Functional Intelligent Materials, National University of Singapore, 117544, Singapore*

A superconducting diode carries dissipationless supercurrents in one direction, but resistive normal currents at finite voltages in the opposite direction, a phenomenon that occurs when the critical current is different in magnitude depending on the polarity. They offer perfect voltage rectification if an alternating current of magnitude between these values is applied. Despite the similar names coined, diodes and superconducting diodes have key symmetry differences due to their vastly different microscopic physics [1]. The comprehensive understanding of superconductivity is a multi-scale task that involves several levels, starting from the electronic scale determining the microscopic mechanism, going to the phenomenological scale describing vortices and the continuum-elastic scale describing vortex matter, to the macroscopic scale relevant in technological applications. The prime example for such a macro- phenomenological description is the Bean model that is hugely successful in describing the magnetic and transport properties of bulk superconducting devices. Motivated by the development of novel devices based on superconductivity in atomically thin films, such as twisted-layer graphene, here, we present a simple macro-phenomenological description of the critical state in such two-dimensional (2D) thin films. While transverse screening and demagnetization can be neglected in these systems, thereby simplifying the task in comparison with usual film- and platelet shaped samples, surface- and bulk pinning are important elements to be included. We use our 2D critical state model to describe the transport and magnetic properties of 2D thin-film devices, including the phenomenon of non-reciprocal transport in devices with asymmetric boundaries and the superconducting diode effect.

[1] P. J. W. Moll and V. B. Geshkenbein, Nature Physics 19, 1379 (2023).