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Gate tunability and collapse of superconductivity in hybrid tin-graphene Josephson junction arrays

VINCENT BOUCHIAT, NEEL Institute, CNRS-Grenoble

The accessible and surface-exposed 2D electron gas offered by graphene provides indeed an ideal platform on which to tune, via application of an electrostatic gate, the coupling between adsorbates deposited on its surface. We have experimentally studied the case of graphene transistors which channel is decorated with an array of superconducting tin nanoparticles. They induce via percolation of proximity effect a global 2D superconducting state which critical temperature Tc can be tuned by gate voltage. When the Graphene show strong disorder, it is possible to tune via the applied gate voltage the system towards an insulating state, demonstrating the possibility to trigger a superconducting to insulator transition [1], which features ressembles those found in granular superconductors. In this work, graphene monolayers are surface-conjugated to regular arrays of superconducting disk-shaped metal islands, whose inter-island distances were patterned to be in the quasi-ballistic limit of the underlying 2D electron gas. Arrays can be made on a large range of geometry and density, up to the highly diluted limit with less than 5% surface coverage and few micrometers in between islands. In the lower temperature limit (<100 mK) , despite of the long distance (2 microns) in between islands, a supercurrent was observed among the whole graphene sheet. Interestingly, the superconducting state vanishes exponentially in gate voltage and rests in a metallic state [2], caused by quantum fluctuations of phase is found for diluted and regular arrays. This peculiar behaviour provides evidence for recently developed theory, and may provide a hint to the understanding of long-standing issue of “zero-temperature” bosonic metallic state. [1] A. Allain, et al. Nat. Mat.,**11**, 590, (2012). [2] Z. Han et al., Nat. Phys. **10**, 380 (2014).