Collapse of superconductivity in a hybrid tin-graphene Josephson junction array

Zheng Han[1,2], Adrien Allain[1,2], Hadi Arjmandi-Tash[1,2], Konstantin Tikhonov[3,4], Mikhail Feigel'man[3,5], Benjamin Sacépé[1,2] and **Vincent Bouchiat**[1,2]

[1]Univ. Grenoble Alpes, Institut Néel, F-38042 Grenoble, France.
[2]CNRS, Institut Néel, F-38042 Grenoble, France.
[3]L. D. Landau Institute for Theoretical Physics, Kosygin street 2, Moscow 119334, Russia.
[4]Dept. of Condensed Matter Physics, The Weizmann Institute of Science, 76100 Rehovot, Israel.
[5]Moscow Institute of Physics and Technology, Moscow 141700, Russia.
E-mail: bouchiat@grenoble.cnrs.fr

Graphene has a great potential for implementation of tunable and high temperature 2D superconductor.

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. This situation is particularly interesting when the network of adsorbates can induce some electronic order within the underlying graphene substrate, such as magnetic or superconducting correlations [1]. We have experimentally studied the case of macroscopic graphene decorated with an array of superconducting tin clusters [2], which induce via percolation of proximity effect a global but tunable 2D superconducting state which critical temperature Tc can be tuned by gate voltage.

In these systems the transition towards a truly zero-resistance state exhibiting a well developed supercurrent, is strongly gate-tunable and is quantitatively described by Berezinskii-Kosterlitz-Thouless vortex unbinding, typical of a 2D superconductor [1]. Depending on the graphene disorder and charge carrier density on one side , density and order of the superconducting islands on the other side, many parameter controlling the transition can be independently adjusted allow to test different regimes.

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 [2], which features ressembles those found in granular superconductors. The extension is for diluted arrays in which superconducting dots covers less than 20% of the graphene surface. Interpretation of this metallic state in terms of quantum fluctuations is proposed. . We will show recent experimental results involving a set of dot deposited according to triangular arrays sparsely distributed on graphene, in which superconductivity is suddenly destroyed for a critical gate value caused by quantum fluctuations of the phase giving rise to an intermediate metallic state [4].

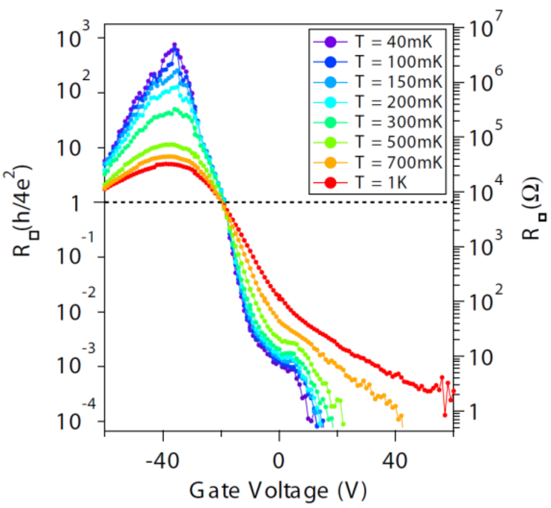

Fig. 1. Gate tuned superconductor to insulator transition in Tin decorated graphene. *Resistance Vs backgate voltage of a macroscopic graphene sheet decorated with array of tin nanoparticles. A global superconducting state is formed by percolation of proximity effect. Note that the auantum phase transition has a temperature independent critical point at the quantum of resistance. Adapted from ref3.*

References

1. M. Feigel'man et al. JETP Lett. , 88, 747, (2008).
2. B.M.Kessler, et al., Phys. Rev. Lett 104, 047001 (2010).
3. Adrien Allain, et al. Nature Materials, 11, 590–594, (2012).
4. Zheng Han, et al., Nature Physics, in press, (2014).