Graphene as an Open Platform for Tuning 2D Electronic Transitions

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Graphene is a recently realized two-dimensional (2D) crystal with many interesting properties including a band structure that allows the carrier concentration to be tuned continuously between electrons and holes. The easily accessible 2D electron gas in graphene provides an ideal platform on which to tune, via application of an electrostatic gate, the coupling between electronically ordered dopants deposited on its surface. Simple self-assembly methods can lead to study other electronic order parameters such as superconductivity, ferro/antiferromagnetism, charge/spin density waves.

To demonstrate this concept, we have chosen to study an array of superconducting clusters deposited on graphene capable to induce via the proximity effect [1] a gate tunable superconducting transition. Using a simple fabrication procedure based on metal layer dewetting, we have produced doped graphene sheets decorated with a non percolating network on nanoscale tin clusters. This hybrid material displays a two-step superconducting transition. The higher transition step is gate independent and corresponds to the transition of the tin clusters to the superconducting state. The lower transition step towards a real zero resistance state exhibiting a well developed super current, is strongly gate-tunable and is quantitatively described by Berezinskii-Kosterlitz-Thouless 2D vortex unbinding [2,3].

We report the details of this transition [4] and ground state properties of this system as a function of gate voltage, applied bias current and magnetic field.

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[4] Kessler et al. , Phys. Rev. Lett., 104, 047001 (2010).