Introduction to Low-Temperature Physics of Graphene

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An atomically-thin carbon monolayer (graphene) offers the unique possibility to test predictions of relativistic quantum mechanics in a condensed phase [1]. Recently, theoretical results [2] concerning its universal conductivity ($\sigma_0 = 4e^2/h$) and sub-Poissonian shot noise ($\mathcal{F} = 1/3$) have been confirmed experimentally [3] for wide, rectangular samples (the *pseudodiffusive* transport). For narrow (nanoribbon-like) samples, however, a discrepancy between theory and experiment is observed and usually attributed to boundary effects, which are negligible only for wide samples. We show [4] the conformal mapping technique makes possible to extend the theory on sample geometries, for which boundary effects are eliminated (the Corbino setup) or suppressed, as the main current flows far away from the edges. We expect the predictions for such geometries will agree with the experiment in wide range of sample parameters, allowing one to observe crossover from the pseudodiffusive to the *tunneling* regime, characterized by the conductance $G \approx (1-\mathcal{F}) \times se^2/h$, with s depending only on the system symmetry class.

In a remaining part of the talk, we focus on the additional spin-like degree of freedom (*valley* index) present in graphene and its role for spectral statistics [5], and other signatures of quantum chaos [6]. We finally overview the effects taking place on the interface between graphene and standard BCS superconductor [7], such as *specular* Andreev reflection and Andreev retroreflection, and briefly discuss possible scenarios for high-temperature superconductors, including consequences of the *triplet-pairing* mechanism.

References:

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