Condensed Matter Theory Center Seminar

Friday, December 8
11:00 am – 12:15 pm
2205 John S. Toll Physics Building

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"The role of electron-electron interactions in disordered Dirac fermions"

Abstract: Condensed matter realizations of Dirac fermions are now ubiquitous. The most notable example is single monoatomic sheets of carbon called graphene, where its simplicity and ease of preparation has made it a textbook system to test theoretical models [1]. In this talk, I will address the question of what happens to Dirac fermions in the regime where electron-electron interactions are the dominant relaxation mechanism. First, using a combination of nonperturbative numerical and analytical techniques that incorporate both the contact and long-range parts of the Coulomb interaction, we identify the two previously discussed regimes: a Gross-Neveu transition to a strongly correlated Mott insulator, and a semi-metallic state with a logarithmically diverging Fermi velocity accurately described by the random phase approximation. Most interestingly, we show that experimental realizations of Dirac fermions span the crossover between these two regimes providing the physical mechanism that masks this velocity divergence [2]. Second, starting from a microscopic treatment of electron-electron, electron-phonon and electron-impurity interactions within the Random Phase Approximation, we demonstrate that monolayer and bilayer graphene both host two different hydrodynamic regimes where the system can be described as a classical liquid. We predict that the hydrodynamic window in bilayer graphene is stronger than in monolayer graphene, and has a characteristic `v-shape' as opposed to a `lung-shape'. Finally, we explore the consequences of these results on real experiments, and find that disorder-induced puddles continue to play a consequential role, even in these strongly interacting systems.

[1] **S. Das Sarma, S. Adam, E. H. Hwang, and E. Rossi, "*Electronic transport in two dimensional graphene*", Rev. Mod. Phys. 83, 407 (2011).**

[2] **H. Tang, J.N. Leaw, J.N.B. Rodrigues, I. F. Herbut, P. Sengupta, F.F. Assaad, and S. Adam, " *The role of electron-electron interactions in two-dimensional Dirac fermions*", Submitted *(2017).***

[3] **D. Y.H. Ho, I. Yudhistira, N. Chakraborty, and S. Adam, "*Microscopic theory for electron hydrodynamics in monolayer and bilayer graphene*", arXiv:1710.10272 (2017).**

Host: Sankar Das Sarma

Web: http://www.physics.umd.edu/cmtc/seminars.html