MAR16-2015-004873

Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

Theory of classical and quantum transport in monolayers of MoS_2[1]

SHAFFIQUE ADAM, Yale-NUS College, 16 College Avenue West, Singapore 138527, Singapore

From the family of new van der Waals materials, the class of layered transition metal dichalcogenides has emerged as a particularly interesting system due to the inherent spin and valley degrees of freedom. In this talk we focus on the interplay between these degrees of freedom and the different types of disorder in monolayers of molybdenum disulphide. Within the semiclassical Drude-Boltzmann formalism, treating the screening of impurities with the random phase approximation, we demonstrate that different scattering mechanisms such as charged impurity scattering, intervalley scattering, and phonons provide different signatures in electronic transport. This allows us to conclude, for example, that in CVD-grown monolayers of MoS_2, intervalley scattering dominates over other mechanisms at low temperatures [1]. Interestingly, charged impurities generate spatial inhomogeneity in the carrier density that results in a classical disorder-induced magnetoresistance that can be observed at room temperature [2]. However, at lower temperatures, in this regime of strong intervalley scattering, we predict that the quantum phase-coherent corrections to the conductivity results in a one-parameter crossover from weak localization to weak anti-localization as a function of magnetic field, where this crossover is determined only by the spin lifetime. By comparing with available experimental data [3], we show that this combined framework allows for a novel way to measure the spin-relaxation in monolayers of MoS_2. We find that the spin scattering arises from the Dyakonov-Perel spin-orbit scattering mechanism with a conduction band spin-splitting of about 4 meV, consistent with calculations using density functional theory. REFERENCES: [1] "*Transport Properties of Monolayer MoS_2 Grown by Chemical Vapor Deposition*", H. Schmidt, S. Wang, L. Chu, M. Toh, R. Kumar, W. Zhao, A. H. Castro Neto, J. Martin, S. Adam, B. Özyilmaz, and G. Eda, *Nano Lett.* **14**, 1909 (2014); [2] "*Disorder induced magnetoresistance in a two dimensional electron system*", J. Ping, I. Yudhistira, N. Ramakrishnan, S. Cho, S. Adam, M. S. Fuhrer, *Phys. Rev. Lett.* **113**, 047206 (2014); [3] "*Quantum transport and observation of Dyakonov-Perel spin-orbit scattering in monolayer MoS_2*", H. Schmidt, I. Yudhistira, L. Chu, A. H. Castro Neto, B. Özyilmaz, S. Adam, G. Eda, arXiv:1503.00428, (2015).

[1] Work done in collaboration with Indra Yudhistira and the experimental groups of Goki Eda (NUS), Michael Fuhrer (Monash) and Roland Kawakami (Ohio State), and funded by Singapore National Research Foundation and Ministry of Education.