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NEBRASKA CENTER FOR MATERIALS AND NANOSCIENCE
2015 SEMINAR SERIES PRESENTS

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Co-sponsored with the Department of Physics and Astronomy

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Spin transport in 2D crystals and in elemental semiconductors with multivalley band structure

Professor Hanan Dery

Group theory is a powerful tool to investigate spin-dependent transport and optical properties. It allows one to identify important processes and to define the physics with a minimal set of material dependent parameters.

In the first part of the talk, I will present our recent findings for the spin transport in 2D membranes including monolayer transition-metal dichalogonides and graphene [1]. I will focus on spin flips induced by flexural phonons (Fig. 1), and show that the spin relaxation is ultrafast for electrons in freestanding membranes while being mitigated in supported membranes. This behavior is universal in 2D membranes that respect mirror symmetry and it leads to a counterintuitive inverse relation between mobility and spin relaxation.

In the second part of the talk, I will discuss the spin relaxation in elemental semiconductors such as Si and Ge [2-4]. Taking into account the multivalley nature of their conduction bands and using basic symmetry arguments, it is shown that the dominant spin-flip process is governed by electron scattering between valleys that cannot be connected by time-reversal opeation. For the case of heavily doped silicon, I will show how the spin-flip amplitude is dominated by short-range scattering off the central-cell potential of impurities after which the electron is transferred to a valley on a different axis in k space (Fig. 2).

From the physical insights gained from the theory, we provide guidelines to significantly enhance the spin lifetime in semiconductor spintronics devices.

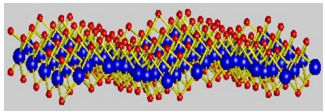

Figure 1. Flexural phonons in monolayer MX_2.

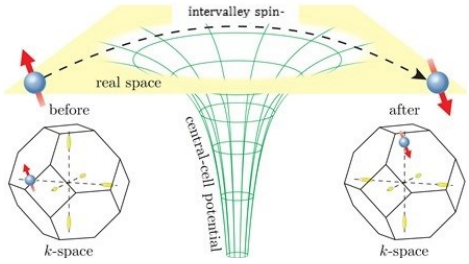

Figure 2. Spin flip due to short-range intervalley scattering off impurities in silicon.

References:
Yang Song and Hanan Dery, *Transport Theory of Monolayer Transition-Metal Dichalcogenides through Symmetry*, Phys. Rev. Lett. **111**, 026601 (2013).
Pengke Li and Hanan Dery, *Spin-Orbit Symmetries of Conduction Electrons in Silicon*, Phys. Rev. Lett. **107**, 107203 (2011).
Pengke Li, Jing Li, Lan Qing, Hanan Dery, and Ian Appelbaum, *Anisotropy-Driven Spin Relaxation in Germanium*, Phys. Rev. Lett. **111**, 257204 (2013).
Yang Song, Oleg Chalaev, and Hanan Dery, *Donor-Driven Spin Relaxation in Multivalley Semiconductors*, Phys. Rev. Lett. **113**, 167201 (2014).

Host:
Professor Kirill Belashchenko

Department of Physics & Astronomy

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Thursday, September 24, 4:00 pm | 136 Jorgensen Hall

Refreshments at 3:30pm | Jorgensen Hall 1st Floor Vending Area