On-line SPICE-SPIN+X Seminars

Wednesday, 26th October 2022, 15:00 (CET)

The seminar will be via Zoom (Meeting ID: 820 1201 3378) and live streamed in the SPICE YouTube Channel.

James McIver,
MPSD and Columbia University

Ultrafast optoelectronic probes of quantum materials

Ultrafast optoelectronic circuits offer new opportunities for investigating the electrical response of microstructured quantum materials and heterostructures on femtosecond timescales and at terahertz frequencies. Based on waveguides and laser-triggered photoconductive switches, these circuits can be used to directly probe the ultrafast flow of electrical currents in materials [1], or perform near-field spectroscopy on length scales orders of magnitude smaller than the diffraction limit [2]. In this talk, I will show how using this circuitry we observed an anomalous Hall effect in graphene driven by a femtosecond pulse of circularly polarized light [3]. The dependence of the anomalous Hall effect on a gate potential used to tune the Fermi level revealed multiple features that reflect the formation of photon-dressed ('Floquet-engineered') topological band structure [4], similar to the band structure originally proposed by Haldane [5]. This included an approximately 60 meV wide conductance plateau centered at the Dirac point, where a gap of equal magnitude was predicted to open. We found that when the Fermi level was tuned within this plateau, the anomalous Hall conductance saturated around 1.8 ± 0.4 e^2/h.

In the second part of the talk, I will share our progress on using these ultrafast circuits to perform near-field time-domain terahertz spectroscopy on graphene heterostructures, where we observe a coherent plasmonic response that can be tuned with electrostatic gating. This near-field technique, which we are extending to mK temperatures and strong magnetic fields, could be used to investigate a wide range of topological and strongly correlated phenomena in microstructured quantum materials and heterostructures that often fall on the gigahertz-terahertz energy scale.

[1] D.H. Auston, *Appl. Phys. Lett.* **26**, 101–103 (1975)
[2] Z. Zhong *et al.*, *Nature Nano.* **3**, 201-205 (2008)
[3] J.W. McIver *et al.*, *Nature Physics* **16**, 38 (2020)
[4] T. Oka & H. Aoki. *Phys. Rev. B* **79**, 081406 (2009)
[5] F.D.M. Haldane, *Phys. Rev. Lett.* **61**, 2015 (1988)