PhD position — "Pseudomagnetic Fields and Pseudospintronics in Strain-Engineered Two-Dimensional Semiconductors" (AG Bolotin @ Free Univ. Berlin)

Group profile: The Bolotin lab @ Free University Berlin (bolotingroup.com) specializes in quantum electronics and optoelectronics of two-dimensional materials. We strive to understand fundamental quantum mechanical behaviors of these materials as well to find their new applications.

Project description: Monolayer transition metal dichalcogenides (TMDs), materials such as molybdenum disulfide (MoS_2), are atomically thick semiconductors related to their famous cousin graphene. When a photon is absorbed by a TMD, an exciton — a hydrogen-like optically-active bound state of an electron and a hole — is formed. Excitons in TMDs have been the topic of hot research interest because of their stability at room temperature, non-hydrogenic spectra and strong interactions [1]. It recently became evident that in addition to spin, the excitons in TMDs are described by a new quantum number, "pseudospin", associated with the valley degree of freedom. Experimental demonstrations of pseudospin manipulation via optical and electrical means led to proposals to use it towards information technology [1]. Very recently, it has been predicted that the pseudospin experiences an effective "pseudomagnetic" field in mechanically strained TMDs. The effects of that field are similar to effects of normal magnetic field acting on conventional spin. However, the strain-induced pseudomagnetic field have been predicted to reach hundreds of Tesla in realistic samples [2]. *The goal of this project is to generate pseudomagnetic fields in TMDs experimentally and to study and exploit its properties.*

Position description: You will produce controllably strained TMD samples and observe signatures of pseudomagnetic fields including the energy splitting between "up" and "in-plane" pseudospin orientations, interactions between spin and pseudospin, and pseudospin precession. Specifically, you will carry out the following tasks:

- **Nanoscale fabrication/strain engineering.** You will grow and produce various TMDs and develop strategies to pattern, electrically contact, or suspended them. You will induce strain in TMDs by "pushing" them with a custom all-electrical low-temperature atomic force microscope (AFM) inside a measurement cryostat that will be fine-tuned during the project.
- **Optoelectronic measurements.** You will use a combination of sensitive photocurrent spectroscopy [3] and Kerr microscopy to measure static and dynamical behaviors of spin and pseudospin in 2D materials. You will also work on implementing time-resolved ultrafast measurements of pseudospin precession.
- **Theoretical modeling.** You will develop numerical and simple analytical models to guide the project and to interpret its results.

In a long-term perspective, this project may serve as a stepping stone towards new types of information technologies utilizing new degrees of freedom, such as spin and pseudospin, as carriers of information. You will also interact with and teach Bachelor and Masters students.

Desired/Required Experience:

- Masters degree in condensed matter physics or related discipline
- Experience in nanofabrication or low-temperature/vacuum measurements is a big plus
- Experience in optical or electrical transport measurements/techniques, Labview or COMSOL programming experience are desirable but are not required

Please submit your application with reference code PhD-Strain2DMat-2017 to Prof. Kirill Bolotin (kirill.bolotin@fu-berlin.de) until 31 Dec 2017.

[1] Xu et al., Nature Phys 10, 343 ('14); [2] Yu et al., Nat Comms 5, 3876 ('14); [3] Klots et al., Sci Rep 4, 6608 ('14)