Generating valley current and magnetoelectricity in MoS_2

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Atomically thin crystals, such as monolayer transition metal dichalcogenides (TMDs), provide a new platform to investigate the electrons in low dimensional solid state systems. In these materials, two inequivalent energy band extrema occur at the edges of the Brillouin zone, known as valleys, which serve as a binary degree of freedom of electrons similar like spins [1]. The unique control of valley pseudospins by optical and electrical means are not only fundamentally interesting, but may also find applications in valley-based electronics and optoelectronics [2,3].

In this talk, we discuss methods to manipulate the valley polarization in 2D TMD materials. First, we describe the observation of the valley Hall effect in monolayer molybdenum disulfide (MoS_2), in which the valley current is generated transverse to the charge current. We use optical techniques to directly image the valley polarization accumulated at the edges of MoS_2 channel with spatial resolution [4]. We will also discuss the possibility to tune the valley Hall conductivity by controlling the crystal's inversion symmetry in bilayer. Second, we apply strain to monolayer MoS_2 to break the crystal's 3-fold rotational symmetry which leads to the generation of valley magnetoelectricity [5]. The observed valley magnetization switches the sign when the in-plane bias direction flips and the magnitude scales with the amount of channel current. We discuss the dependence of the observed magnetization on bias, gate, strain direction, and external magnetic fields.

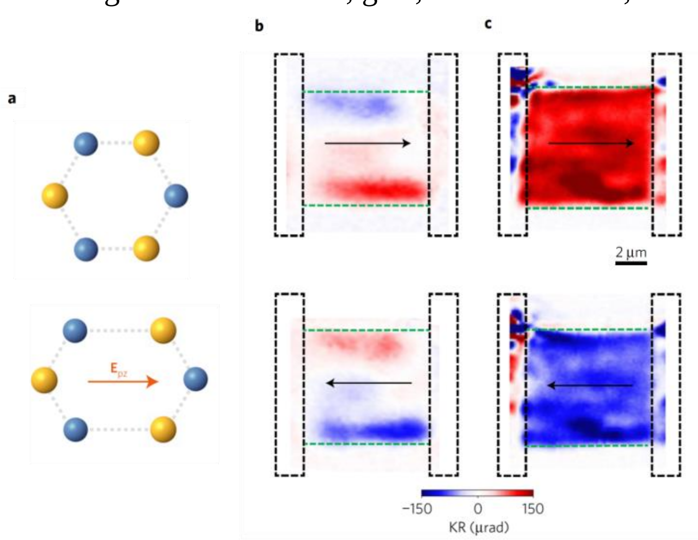

Figure 1. (a) MoS_2 crystal (above) in pristine form and (below) under strain with piezoelectric field (E_{pz}). (b,c) Scanning Kerr rotation microscopy on monolayer MoS_2 (b) without and (c) with strain.

[1] D. Xiao, W. Yao and Q. Niu, Phys. Rev. Lett. **99**, 236809 (2007).
[2] J.R. Schaibley, H. Yu and G. Clark, et al., Nat. Rev. Mater. **1**, 16055 (2016).
[3] K.F. Mak and J. Shan, Nat. Photon. **10**, 216 (2016).
[4] J. Lee, K.F. Mak and J. Shan, Nat. Nanotech. **11**, 421 (2016).
[5] J. Lee, Z. Wang, H. Xie, K.F. Mak and J. Shan, Nat. Mater. **16**, 887 (2017).

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