MAR17-2016-020196

Abstract for an Invited Paper
for the MAR17 Meeting of
the American Physical Society

Optical manipulation of valley pseduospin in 2D semiconductors

ZILIANG YE, Stanford University

Valley polarization associated with the occupancy in the energy degenerate but quantum mechanically distinct valleys in the momentum space closely resembles spin polarization and has been proposed as a pseudospin carrier for future quantum information technologies. Monolayers of transition metal dichalcogenide (TMDC) crystals, with broken inversion symmetry and large spin-orbital coupling, support robust valley polarization and therefore provide an important platform for studying valley-dependent physics.(1) Besides optical excitation and photoluminescence detection, valley polarization has been electrically measured through the valley Hall effect(2) and created through spin injection from ferromagnetic semiconductor contacts.(3) Moreover, the energy degeneracy of the valley degree of freedom has been lifted by the optical Stark effect.(4, 5) Recently, we have demonstrated optical manipulation of valley coherence, i.e., of the valley pseudospin, by the optical Stark effect in monolayer WSe_2.(6) Using below-bandgap circularly polarized light, we rotated the valley pseudospin on the femtosecond time scale. Both the direction and speed of the rotation can be optically controlled by tuning the dynamic phase of excitons in opposite valleys. The pseudospin rotation was identified by changes in the polarization of the photoluminescence. In addition, by varying the time delay between the excitation and control pulses, we directly probed the lifetime of the intervalley coherence. Similar rotation levels have also been observed in static magneto-optic experiments.(7, 8) Our work presents an important step towards the full control of the valley degree of freedom in 2D semiconductors. The work was done in collaboration with Dr. Dezheng Sun and Prof. Tony F. Heinz.

(1) X. Xu et al. Nature physics **10**, 343 (2014).
(2) K. F. Mak et al. Science **344**, 1489 (2014).
(3) Y. Ye et al. Nature Nanotechnology **11**, 598 (2016).
(4) J. Kim et al. Science **346**, 1205 (2014).
(5) E. J. Sie et al. Nature Materials **14**, 290 (2014).
(6) Z. Ye et al. Nature physics, in press (2016). DOI:10.1038/nphys3891
(7) R. Schmidt et al. Phys. Rev. Lett. **117**, 077402 (2016).
(8) G. Wang, et al. Phys. Rev. Lett. **117**, 187401 (2016).