Optical control of exciton valley polarization in MoS$_2$

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Atomic monolayers of transition metal dichalcogenides have emerged as an interesting class of 2-dimensional (2D) crystals beyond graphene. In particular, the isoelectronic family of MoS$_2$, MoSe$_2$, WS$_2$ and WSe$_2$ monolayers are direct band gap semiconductors.$^{1,2}$ Unlike graphene, because of the lack of inversion symmetry and the presence of strong spin-orbit interactions, the fundamental energy gaps of these compounds are located at two inequivalent high-symmetry valleys in the Brillouin zone (K and K$'$) with coupled valley and spin degrees of freedom.$^3$ This electronic property makes them unique from conventional semiconductors. In this talk, we will discuss the properties of MoS$_2$ atomic layers as a prototype. Through characterization of the optical properties of the material as a function of thickness, we show that quantum confinement effects lead to a crossover in MoS$_2$ from a bulk indirect gap semiconductor to a direct gap semiconductor at monolayer thickness.$^4$ With this basic property established, we show that complete valley polarization of the excitons in monolayer MoS$_2$ can be achieved by optical pumping with circularly polarized light.$^5$ Furthermore, this polarization can be retained for longer than 1ns. Our results thus highlight the great potential of this material family for studies of valley and spin Hall physics.$^6$


$^3$Ibid.

$^4$Mak, PRL 105, 2010
