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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]

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