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Valley optoelectronics and spin-valley coupling: from graphene to monolayer group-VI transition metal dichalcogenides[1]

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The Bloch bands in many crystals have a degenerate set of energy extrema in momentum space known as valleys. The band-edge carriers then have an extra valley index which may also be used to encode information for device applications provided that dynamic control of valley index is possible. In this talk, we show that, when inversion symmetry is broken, a pair of valleys which are equivalent by time-reversal are distinguishable by their magnetic moment and Berry curvature. These quantities give rise to valley Hall effect and circularly-polarized valley optical transition selection rule both in graphene (where inversion symmetry can be broken in a controlled way in gated bilayers), and in monolayer group-VI transition metal dichalcogenides (where the 2D crystal has inherent structural inversion asymmetry). Moreover, in monolayer dichalcogenides, we find the electrons and holes at the band edges are described by massive Dirac Fermions with strong spin-valley coupling, which further results in valley and spin dependent optical selection rule, and coexistence of valley Hall and spin Hall effects. These phenomena make possible dynamic control of valley and spin by electric and optical means for device applications in monolayer dichalcogenides. We will report photoluminescence studies on dichalcogenide thin films, which show the first evidence on valley optical selection rule and optical valley pumping, and signature of the spin-valley coupling.

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