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Valley and spin currents in 2D transition metal dichalcogenides[1]

WANG YAO, The University of Hong Kong

In two-dimensional (2D) transition metal dichalcogenides (TMDs), carriers are indexed by both the spin and the valley pseudospin (labelling the degenerate band extrema in momentum space). 2D TMDs is therefore an ideal laboratory for exploring these internal quantum degrees of freedom for new electronics, and controlling the flow of spin and pseudospin is at the heart of such applications. We will discuss two mechanisms for generating spin and valley currents of electrons in 2D group-VIB TMDs: (I) the valley and spin Hall effects arising from the Berry curvatures; and (II) the nonlinear valley and spin currents arising from Fermi pocket anisotropy. The two effects have distinct scaling with the electric field, and different dependence of the current direction on the field direction and crystalline axis. We will discuss the possibility to observe and distinguish the two effects as distinct patterns of polarized electroluminescence at p-n junction in 2D TMDs. The nonlinear current response also makes possible the generation of pure spin and valley flows without net charge current, either by an AC bias or by an inhomogeneous temperature distribution. We will also discuss the valley Hall effect of charged excitons in monolayer TMDs, which arises from the effective coupling of the excitonic valley pseudospin to its center of mass motion by the exchange interaction between the electron and hole constituents.

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