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Optoelectronic Control of Spin and Pseudospin in Layered WSe_2[1]

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Coherent manipulation of spin-like quantum numbers facilitates the development of new quantum technologies. Layered transition metal dichalcogenides provide an ideal laboratory to exploit such dynamic control of spin, pseudospin, and their interplay. Here, we discuss two examples based on monolayer and bilayer WSe_2. Due to the inversion asymmetry in monolayer WSe_2, valley pseudospins, which index the degenerate extrema of the energy-momentum bands, possess circularly polarized optical selection rules. In addition to the generation of valley polarization through optical pumping of valley excitons, we demonstrate the creation of a coherent superposition between valley states in monolayer WSe_2 by linearly polarized excitation. On the other hand, bilayer WSe_2 provides an additional quantum degree of freedom, the layer pseudospin, which corresponds to layer polarization. In AB stacked bilayers, we find the real spin is locked to layer pseudospin for a given valley, which results in the suppression of spin relaxation and electrical control of spin Zeeman splitting without an applied magnetic field. Additionally, we obtain spectroscopic evidence of interlayer and intralayer trion species, an important step toward coherent optical control in van der Waals 2D heterostructures.

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