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Berry Curvature Driven Anomalous and Spin Hall Effect in Ferromagnetic Janus Material

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The ability to generate and control spin current efficiently is a central challenge for advancing next-generation spintronic technologies. While nonmagnetic materials typically host spin Hall conductivity (SHC) [1] and ferromagnets are studied for anomalous Hall conductivity (AHC) [2], realizing both effects within a single material system remains rare and highly desirable for multifunctional applications. In this work, we investigate a ferromagnetic Janus transition metal dichalcogenide (TMD) as a platform for coexisting AHC and SHC. The Berry curvature and the spin Berry curvatures are computed within the Kubo formalism to quantify the anomalous and spin Hall conductivities. The intrinsic structural asymmetry of Janus systems enhances spin-orbit coupling (SOC), while ferromagnetic ordering breaks spin degeneracy in the Janus system. Our results reveal an intrinsic AHC driven by magnetization and a finite SHC arising from the redistribution of spin Berry curvature, highlighting promising opportunities for designing low-power, next-generation spintronic devices.

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