Symmetry manipulation of spin currents in van der Waals heterostructures

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The generation of a spin current and its role in magnetization dynamics are central topics in spintronics. Over the last decade, there have been intensive studies on the electrical generation of a spin current through charge-to-spin conversion. In spin-orbit coupled materials under an applied electric field, it is known that a transverse spin current can be generated by the spin Hall effect, providing an effective means to manipulate magnetic states. However, the spin Hall effect is subject to symmetry constraints, hindering magnetic switching without an external magnetic field.

In this talk, I will review the symmetry constraints of electrically generated spin current and demonstrate that an effective way to resolve this issue is by exploiting crystalline asymmetry in certain materials, such as WTe_2. Unfortunately, the spin-to-charge conversion efficiency in WTe_2 is much lower than in conventional transition metals like Pt. Here, we propose a van der Waals heterostructure, $WTe_2/PtTe_2$, as an efficient spin source that not only avoids the symmetry constraint but also exhibits a high effective spin Hall conductivity. We introduce a novel spin-to-spin conversion mechanism for the high spin Hall conductivity in the $WTe_2/PtTe_2$ multilayer and show that spin-to-spin conversion opens new possibilities in spintronics, which are difficult to be achieved with conventional charge-to-spin conversion mechanism.