Spin-Orbit Torques in Magnetic Janus Transition Metal Dichalcogenides

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Modern magnetic applications rely on precise control of spins in the matter. In magnets, this quantum degree of freedom is very robust against external perturbations, and it is therefore valuable for memory devices. The downside nowadays is in the speed. To change the state in magnetic-based memory is quite slow and inefficient, as it requires polarizing an electronic current first, which will serve as a torque source for switching the magnetization later. A promising solution to this problem is to use spin-orbit torque (SOT) [1,2]. The spin-orbit torque is an effect where a nonmagnetic substrate exerts a torque on a magnetic material through its interface due to the spin-orbit coupling (SOC). The most relevant spin-orbit interaction for SOT is the Rashba SOC, which requires the presence of an electric field perpendicular to the interface [2]. The Janus structures are systems with opposite surfaces possessing different properties and are then intrinsically Rasbhanic systems. A magnetic Janus monolayer will allow for Rashba SOC, Magnetism, and gate-tunability in a single system, making them very interesting for SOT-based memories. Transition metal dichalcogenides (TMDs) support the Janus phase [3] and magnetism[4-5], thus could be used for a mid-term realization of SOT-devices. In this work, I present large-scale numerical calculations of the torque efficiency in VSeTe within the linear-repose theory. We demonstrate that these heterostructures support field-like and anti-damping torques of comparable magnitudes. Also, we report on the presence of a different torque source that does not obey any typical symmetry, which we deemed as unusual. We demonstrate that torque efficiency in these systems is comparable with heavy metals in magnitude with the added feature of gate-tunability. Finally, we will show the effect of disorder simulated in large-scale systems consisting of 100.000 atoms obtained from Density Functional Theory.

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