Orbital Hall insulating phase in transition metal dichalcogenide monolayers

Luis M. Canonico A.
Tarik P. Cysne, Alejandro Molina-Sanchez, R. B. Muniz, and Tatiana G. Rappoport
ICN2, Universitat Autònoma de Barcelona, Edifici ICN2 Campus de la, Av. de Serragalliners, s/n, 08193 Bellaterra, Barcelona, Spain.
luis.canonico@icn2.cat

The orbital-Hall effect (OHE), in resemblance to the spin-Hall effect (SHE), refers to the creation of a transverse flow of orbital angular momentum (OAM) that is induced by a longitudinally applied electric field [1]. It has been explored mostly in three-dimensional metallic systems, where it can be quite strong [2]. However, recent theoretical results have predicted the existence of OHE in 2D insulating systems, suggesting that this effect could possibly be found in other elements of this class of systems [3]. Differently from the SHE, the OHE does not rely on strong spin-orbit coupling (SOC) [2],[4]. It can be linked to orbital textures in reciprocal space, where the OAM and the carrier momentum are locked (similar to the locking between the spin and carrier momentum observed due to the Rashba-Edelstein effect), which are present in a diverse pool of materials [4].

We showed that the 2H transition metal dichalcogenide (TMD) monolayers, such as MoS_2 and WSe_2, are orbital-Hall insulators. They exhibit large orbital-Hall conductivity plateaux within their semiconducting gaps, where the spin-Hall conductivity vanishes. Our results open the possibility of using TMDs for orbital-current injection and orbital torque transfer that surpass their spin-counterparts in spin-orbitronic devices. The orbital-Hall effect in TMD occurs even in the absence of spin-orbit coupling. It can be linked to exotic momentum-space Dresselhaus-like orbital textures, analogous to the spin-momentum locking in two-dimensional Dirac fermions that arise from a combination of the orbital attributes and lattice symmetry.

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FIGURE

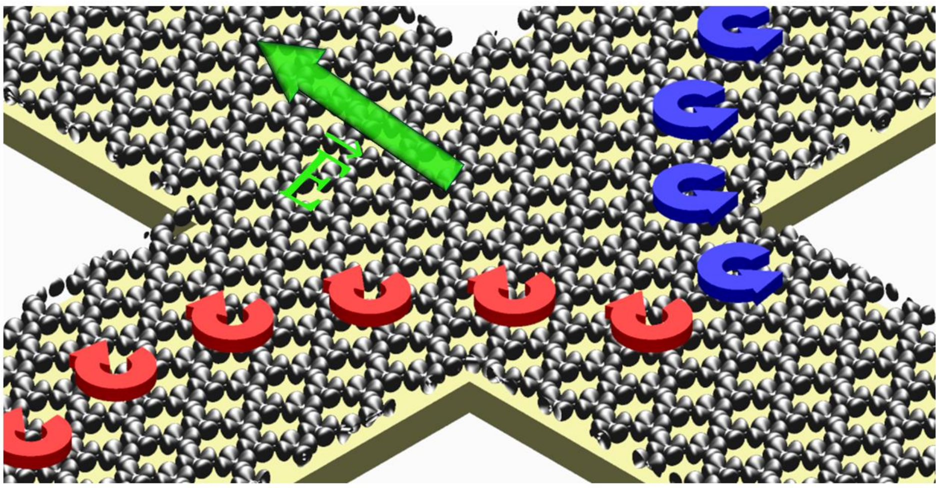

Figure 1: Schematic representation of the orbital-Hall effect in a Hall bar.