

Disentangling Orbital and Valley Hall Effects in Bilayers of Transition Metal Dichalcogenides

Luis M. Canonico A.

Tarik P. Cysne, Marcio Costa, M. Buongiorno Nardelli, R. B. Muniz, 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) is the orbital angular momentum analogue of the spin Hall effect (SHE) and refers to the appearance of a transverse orbital angular momentum current after applying a longitudinal electrical field [1]. Recently it has been predicted that the 2H monolayers of transition metal dichalcogenides (TMD) exhibit relatively large orbital Hall conductivity within their semiconducting energy gap, where the spin Hall conductivity vanishes [2,3]. However, since the valley Hall effect (VHE) in these systems also generate a transverse flow of orbital angular momentum, it becomes experimentally challenging to differentiate between these two effects in these materials. The VHE requires an inversion symmetry breaking to occur, and this happens in the monolayer TMD but not into the bilayer. Using density functional theory (DFT) calculations, we demonstrated the bilayers of the 2H-MoS₂ exhibits sizable orbital Hall conductivity signals in its insulating state without SHE and VHE. Using low-energy models, we further explored the transport properties of these systems. We topologically characterized the orbital Hall insulating phase in TMD monolayers and bilayers in terms of orbital Chern numbers whose values are related to the edge states in nanoribbons. Our results strongly suggest that bilayers of TMDs are highly suitable platforms for direct observation of the orbital Hall insulating phase in two-dimensional materials.

REFERENCES

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FIGURES

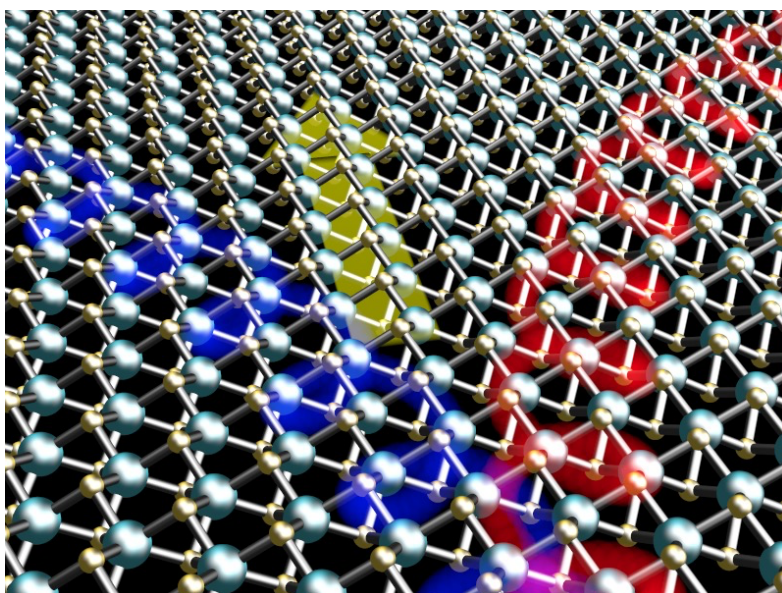


Figure 1: Schematic representation of the orbital-Hall effect in MoS₂.