Real-space Calculation of Orbital Responses in Disordered Materials

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The orbital-Hall effect (OHE) refers to the transverse flow of orbital angular momentum due to a longitudinally applied electric field. Recently two experimental groups independently confirmed its existence through magneto-optical Kerr rotation measurements in Ti [1] and Cr [2]. To date, most of those experimental results on the electrical generation of orbital currents and their application concentrate on three-dimensional (3D) systems. Nonetheless, the tunability in the properties of two-dimensional (2D) materials and the prospect of developing ultra-compact light-metal-based orbitronics devices has gained significant attention. For instance, theoretical works predicted that 1H transition metal dichalcogenides (TMDs) could host orbital-Hall insulating phases [3-4] characterized by an orbital Chern number and in-gap OAM-carrying edge [5].

However, despite all the theoretical and experimental development, for practical applications of orbitronics, it is critical to understand the role of the disorder, which is inherent to the fabrication of any device in the generation and relaxation of orbital currents and nonequilibrium densities. In my talk, I will present our new efficient linear-scaling method that allows the real-space computation of the orbital Hall conductivity and other electrical orbital responses in disordered materials from the Berry phase theory of magnetization [6] in systems approaching experimentally relevant scales and geometries.

References

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Figures

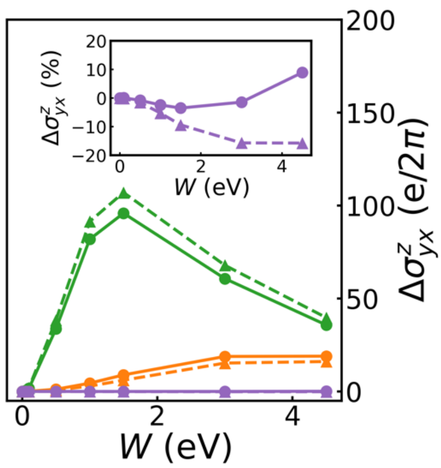

Figure 1 Variation of the OHE with the disorder strength W, for EF=- 2.8 eV (Green), EF=-1.1 eV (orange), and EF=0.0 (purple), where the solid and dashed lines correspond to the trivial (t2=0.0 and VAB=1.0) and topologically nontrivial (t2=1.0 and VAB=0.0) phases of the Haldane model, respectively. Inset: Percentage of variation of the OHC concerning the case with W=0 for the topologically trivial and nontrivial phases.