Max-Planck-Institut für Struktur und Dynamik der Materie

Max Planck Institute for the Structure and Dynamics of Matter

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CFEL Seminar room III (Bldg. 99)

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Quantum Spin-quantum Anomalous Hall Effect with Tunable Edge States in Sb Monolayer-based Materials

The quantum anomalous Hall (QAH) effect, quantum spin Hall (QSH) effect and (quantum) valley Hall ((Q)VH) effect have attracted considerable attention in condensed matter physics and material science. Generally, only one of the QAH, QSH, and QVH effects can be realized in a specific system. It would be very interesting if these three effects can be achieved in one single system. In this talk, I shall represent this interesting imagination may be realized in Sb monolayer-based materials, where the QAH state occurs at one valley and the QSH state occurs at the other valley, called quantum spin-quantum anomalous Hall (QSQAH) effect.

A drastic staggered exchange field induced by the magnetic atoms or substrates, together with the spin-orbit coupling (SOC) interactions from Sb px and py orbitals, is found to generate the QSQAH effect in the system. Topological transitions from QAH states to QSQAH states and then to QSH states are achieved by tuning the SOC strength and/or the exchange field. A tight-binding model is constructed to understand the underlying physical mechanism of the QSQAH effect and the topological transitions. The study of the edge states in the QSQAH insulators reveal dissipationless chiral charge edge states related to one valley emerge along both sides of the sample, while low-dissipation spin edge states related to the other valley flow only along one side of the sample. These edge states can be tuned flexibly by polarization-sensitive photoluminescence controls and/or chemical edge modifications. Such flexible manipulations of the charge, spin, and valley degrees of freedom of electrons provide a new route towards applications in electronics, spintronics, and valleytronics.

Host: Angel Rubio

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