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Quantum Anomalous Hall Effect in Magnetic Semiconductors

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In the quantum anomalous Hall effect, dissipationless charge currents are carried by chiral edge states and the Hall conductance is quantized, similar to the quantum Hall effect. Different from the conventional quantum Hall effect that requires strong magnetic fields, the quantum anomalous Hall effect is induced by strong exchange coupling between electron spin and magnetic moments in magnetic materials, so it can be realized at zero magnetic field, enabling the potential application of electronic devices with low energy consumption. Recent experiments on Cr or V doped BiSbTe thin films has observed the quantized Hall conductance at zero magnetic field and confirmed this novel effect. In this talk, I would like to discuss our recent work on the quantum anomalous Hall effect in magnetic semiconductors. I will first introduce two key ingredients, inverted band structures and ferromagnetic insulators, for the quantum anomalous Hall effect in realistic magnetic materials. Then, based on these two ingredients, I will discuss different classes of materials for the quantum anomalous Hall effect, focusing on magnetically doped InAs/GaSb quantum wells and magnetically doped LaOSbSe2 films. For magnetically doped InAs/GaSb quantum wells, we will show how band edge singularity can enhance spin susceptibility and lead to the quantum anomalous Hall state at a relatively high critical temperature. For magnetically doped LaOSbSe2 films, we find the quantum anomalous Hall effect can be tuned electrically by a gate voltage and identify layer dependent spin texture as the underlying physical reason. Finally, we will also discuss disordered transport and anisotropic magnetoresistance in the quantum anomalous Hall regime.

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