Dynamics and Transport of Orbital Angular Momentum in Solids

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Roles of orbital angular momentum of electrons in solids have been ignored for a long time because of the orbital quenching. However, recent theoretical and experimental reports imply that orbital angular momentum is not quenched in nonequilibrium. Furthermore, it is claimed that the orbital degree of freedom is crucial for anomalous spin transport phenomena such as spin Hall effect. Therefore, understanding the dynamics of orbital angular momentum has become important in the aspect of both fundamental science and spintronic applications. However, it has been believed that the dynamics of orbital angular momentum and that of spin angular momentum are qualitatively similar, so it is difficult to separate those contributions experimentally.

In this work, we point out a fundamental difference between the orbital and spin angular momenta by revealing a hidden degree of freedom of the orbital angular momentum, which we call the orbital angular position. It mediates the oscillation of the orbital angular momentum even without breaking time-reversal or spatial-inversion symmetry, which is impossible for spin. Our quantum Boltzmann approach indicates that considering the orbital angular position is essential for theoretical description of orbital transport. Also, we propose several experimental methods to measure the distinct dynamics of orbital angular momentum.

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