量子物理学･ナノサイエンス第 373 回セミナー

Quantum kinetic theory of the orbital magnetic moment of Bloch electrons

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概　要

The orbital magnetic moment (OMM) of Bloch electrons has been known for a long time for over half a century, and a well established semiclassical description of it exists. It has come under renewed scrutiny recently as part of a general effort to understand angular momentum dynamics in systems in which spin-orbit interactions are absent or negligible - including graphene, transition metal dichalcogenides, and topological antiferromagnets. Yet despite intense interest in the OMM its fundamental properties are poorly understood. At present there is no quantum mechanical theory of the OMM, part of the problem being that dealing with the position operator between Bloch states is non-trivial. This is a significant gap: without knowing when the OMM is conserved, for example, we cannot discuss meaningfully orbital currents and the orbital Hall effect.

In this talk I will present two recent results from our group. The first is related to the orbital Hall effect. The theory of the orbital Hall effect (OHE), a transverse flow of orbital angular momentum in response to an electric field, has concentrated overwhelmingly on intrinsic mechanisms. We have determined the full OHE in the presence of short-range disorder using 2D massive Dirac fermions as a prototype. We find that, in doped systems, extrinsic effects associated with the Fermi surface (skew scattering and side jump) provide ≈95% of the OHE. This suggests that, at experimentally relevant transport densities, the OHE is primarily extrinsic.

In the second part I will introduce a quantum mechanical theory of the OMM due to intrinsic mechanisms. The theory is based on the density matrix and quantum Liouville equation.

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