

B-type Quadratic Planar Hall Effect as a Probe of Altermagnetic Order

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Conventional transport and optical responses, such as the Hall effects, can only distinguish material phases with substantially different symmetries. However, many quantum materials host competing phases with similar structures, making them difficult to differentiate using conventional transport or optical measurements. Guided by symmetry principles, we introduce a B-type quadratic planar Hall effect (B2-PHE), which features a planar Hall response that scales quadratically with the applied magnetic field. We reveal that B2-PHE originates from the interplay among external magnetic fields, intrinsic magnetic order, and quantum geometric properties of the electronic bands. Remarkably, B2-PHE is highly sensitive to the underlying magnetic order. Using the highly debated altermagnetic candidates KV₂Se₂O and RuO₂ as representative examples, we show that B2-PHE emerges in their altermagnetic phases and is symmetry-forbidden in their antiferromagnetic (nonmagnetic) phases. The B2-PHE can be detectable under an external magnetic field on the order of 1 Tesla. These findings establish B2-PHE as an experimentally convenient and potentially unambiguous probe for identifying altermagnetic order, which is otherwise difficult to realize.