

Dirac charge in antiferromagnetic topological semimetals

Kohei Hattori¹, Hikaru Watanabe² and Ryotaro Arita^{2,3}

¹ *Department of Applied Physics, The University of Tokyo, Tokyo 113-8656, Japan*

² *Department of Physics, The University of Tokyo, Tokyo 113-8656, Japan*

³ *Center for Emergent Matter Science, RIKEN, Saitama 351-0198, Japan*

Topological semimetals are characterized by topologically protected gapless electronic nodes—Dirac or Weyl nodes [1]. The nontrivial band topology of these materials underpins a range of optical phenomena [2]. Notably, in Weyl semimetals, the circular injection current—an optical rectification mechanism that converts circularly polarized light into a dc photocurrent—can exhibit quantization governed by the Berry-curvature monopole, i.e., the Weyl charge [3]. In this sense, topological nodes can generate emergent, charge-like degrees of freedom and thereby produce nontrivial transport responses.

In this study, we investigate the emergence of a “Dirac charge” in antiferromagnetic Dirac semimetals and propose a photocurrent-based route for its experimental detection [4]. By analyzing the Berry curvature defined in spin space as well as in a mixed spin–momentum parameter manifold, we show that the Dirac charge acts as a source or sink of Berry curvature in this generalized space. We further demonstrate that this Dirac charge can be probed via photocurrents driven by a spin–charge–coupled electromotive force. As a concrete illustration, we carry out both analytical calculations and real-time simulations for a prototypical antiferromagnetic Dirac semimetal model, revealing that the Dirac charge plays a significant role in the photocurrent generation. Our results elucidate the hidden properties of the Dirac charge and clarify its physical implications.

[1] N. Armitage *et al.*, Rev. Mod. Phys. **90**, 015001 (2018).

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[3] F. de Juan *et al.*, Nat. Commun. **8**, 15995 (2017).

[4] K. Hattori *et al.*, Phys. Rev. Lett. **136**, 046603 (2026).