Wide-angle nonreciprocal thermal radiation based on Weyl Semimetals

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Abstract:

The origin of Kirchhoff's law lies in Lorentz reciprocity in Maxwell's equations, which has been theoretically and experimentally violated with electromagnetic metamaterials. Thus, breaking Kirchhoff's law to achieve nonreciprocal thermal radiation has become a recent hot topic for better control of thermal radiation in terms of spectrum, directionality, and polarization in energy harvesting, infrared imaging, infrared camouflage, and thermal management.

Here, we present TE- and TM-polarized wide-angle nonreciprocal emitter. With optimized azimuthal angle, the emitter realizes asymmetric wide-angle emissivity in mid-infrared. Importantly, we obtain superior results for wide-angle high emission and low absorption with an azimuth range of 20-80°. Leveraging the competitive mechanisms among multiple modes within the hybrid system, dynamic modulation of nonreciprocal intensity can be realized. This work carries significant practical implications for the development of dynamically tunable devices for nonreciprocal energy harvesting and conversion.

References:

1. Liu M, et al., "Broadband mid-infrared non-reciprocal absorption using magnetized gradient epsilon-near-zero thin films", *Nat Mater.* **2023**, 22, 1196-1202.
2. Ghanekar A, et al., "Violation of Kirchhoff's law of thermal radiation with space–time modulated grating", *ACS Photonics*, **2022**, 9, 1157–1164.
3. Z. Gu, et al., "Near-unity nonreciprocal thermal radiation in biaxial van der Waals material-Weyl semimetal heterostructures", *Int. Commun. Heat Mass Transf.* **2024**, 153, 107346.

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