Topological semimetals can generate sizable transverse thermoelectric figure of merit

January 3 2020

The thermoelectric conversion efficiency of a particular material is determined by the value of its thermoelectric figure of merit zT. It is a complex function of the absolute temperature and several pertinent transport properties including the Seebeck coefficient, the electrical and thermal conductivities. These quantities are usually measured in parallel to each other, reflecting the longitudinal thermoelectric effect.

Optimization of zT in conventional thermoelectric materials meets severe limitations. For instance, one comes from the charge compensation of electrons and holes that contribute oppositely to the Seebeck effect. The other is the Wiedemann-Franz law that fundamentally ties the electrical and the thermal conductivity, making independent optimization of the two quantities impossible.

A recent paper of J. S. Xiang et al. published in *Sci. China-Phys. Mech. Astron*. has demonstrated a much larger transverse figure of merit in a topological semimetal in low magnetic fields, relative to its longitudinal counterpart. This simply resembles the much larger transverse (Hall) conductivity over its longitudinal counterpart that is generically observed in many topological semimetals in low fields.

The large transverse zT values in topological semimetal benefit from some of its inherent features. These include the coexistence of electrons and holes which, in the case of transverse thermoelectricity, will contribute additively to each other, and the topologically protected high charge mobility is, to a large extent, free of the lattice imperfection.

Actually, the Dirac semimetal Cd3As2, which is focused in this paper, has a very high electron mobility in spite of its negligible lattice thermal conductivity for this reason.

More excitingly, topological semimetals can have excess transverse thermoelectric effect, known as anomalous Nernst effect, arising from the pronounced Berry curvature near the Fermi level. Furthermore, if one considers a magnetic topological semimetal, the large transverse thermoelectricity will appear in the absence of external field.

According to the paper, the transverse thermoelectric effect offers some more merits over its longitudinal counterpart: it does not require two (n and p) types of thermoelectric material for constructing one device because the electrical and thermal currents are orthogonal and decoupled in this case; high electrical conductivity and low thermal conductivity can be easily realized with an anisotropy compound.

More information: JunSen Xiang et al, Large transverse thermoelectric figure of merit in a topological Dirac semimetal, *Science China Physics, Mechanics & Astronomy* (2019). DOI: 10.1007/s11433-019-1445-4

Provided by Science China Press