Chiral zero sound found in Weyl semimetals

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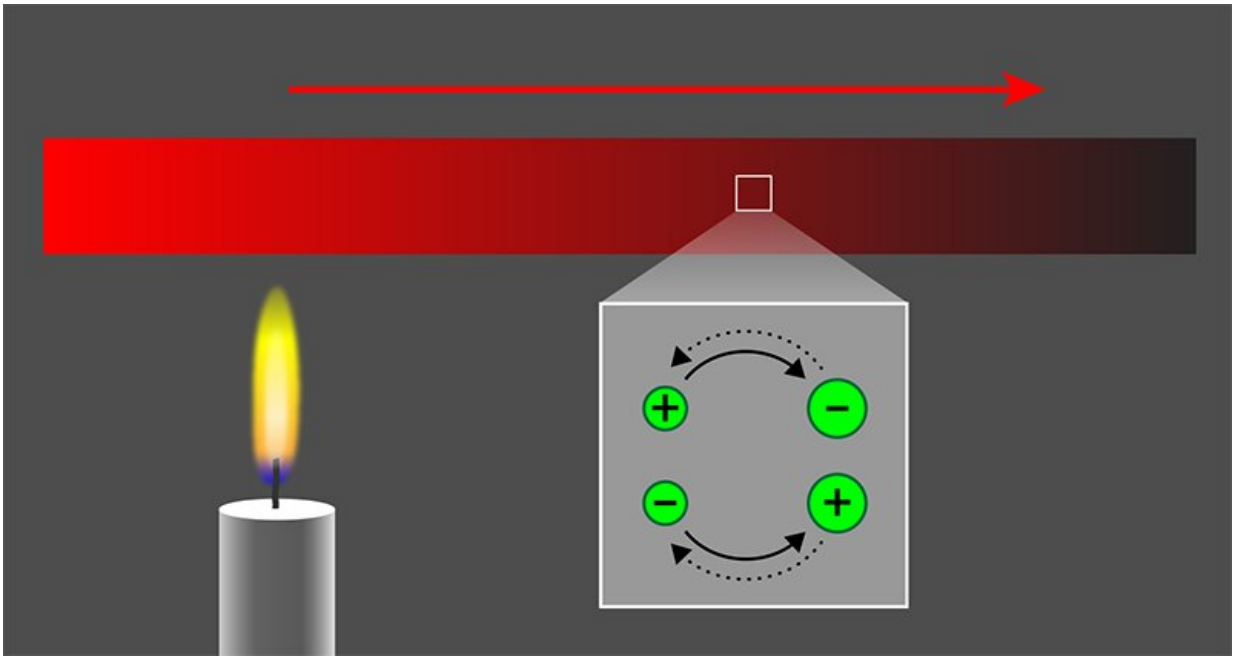

In a typical metal, electrons will move from a hot region to a cold one, carrying both heat and charge. In Weyl semimetals, however, the electrons near the Weyl points form quasiparticles that, in a magnetic field, can contribute to heat conduction without transporting charge [1, 2]. This charge-less transport arises because the contribution of charge from two pairs of Weyl points cancel each other out (inset). Credit: APS/Alan Stonebraker

A pair of researchers at the Hong Kong University of Science and Technology has found that a chiral zero sound (CZS) effect can be induced in Weyl semimetals. In their paper published in the journal

Physical Review Letters, Zhida Song and Xi Dai describe their experiments with Weyl semimetals and what they found.

Weyl semimetals have only recently been discovered, though they were predicted to exist in 1929 by Herman Weyl. They are topological materials in which electronic excitations exhibit massless behavior. Prior research has shown that fermions that adhere to Weyl's theorem exist as quasiparticles in some solids—those that have electron energy bands that cross at points close to the Fermi energy.

Notably, they behave differently than electrons in metals—they exhibit the chiral magnetic effect. This effect is observed when a Weyl metal is exposed to a magnetic field—a current is generated where positive and negative particles move in parallel and anti-parallel to the magnetic field. In such situations, the flow of current is zero because the particles cancel each other out. This changes, however, when the semimetal is placed in a parallel electric current resulting in a quasiparticle flow—an effect known as the chiral anomaly. In this new effort, Song and Dai have shown that the chiral magnetic effect can also lead to a phenomenon called the chiral zero sound (CZS), a newly discovered heat transport mechanism that can be seen in Weyl semimetals.

Zero sound comes about due to vibrations, but it is carried by the momentum distribution of electrons when they exist near the Fermi Level. The study reports that they have existed all along, occurring when researchers place a Weyl semimetal in a magnetic field—now, the researchers have observed them in action. They report that the effect contributes to the thermal conductivity of such materials. They also note that its velocity can be modulated by altering the magnetic field. And they note that the effect can be measured using a variety of techniques, such as employing pump and probe. They describe their discovery as a "completely new sound mode carried by Weyl fermions under a magnetic field."

More information: Zhida Song et al. Hear the Sound of Weyl Fermions, *Physical Review X* (2019). DOI: 10.1103/PhysRevX.9.021053 . On *Arxiv*: arxiv.org/abs/1901.09926