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# Thermoelectric phenomena in topological materials

Three-dimensional topological semimetals are a new class of quantum materials characterized by a non-trivial bulk and surface states. Electronic bands in their structure crosses at gapless points, whose vicinity is populated by unique relativistic-like quasiparticles. As a result, we observe in these materials a kaleidoscope of unusual electronic properties, and among the standard methods of revealing them are measurements of charge transport. These are meaningful and relatively easy to perform but a more in-depth analysis often requires additional experimental evidence. As such, the thermoelectric transport measurements provide an exceptional tool to probe the electronic properties of topological semimetals with high sensitivity indicated by the Mott - Jones relation. In this thesis I have focused on the three types of quantum effects observed in transport phenomena. Specifically, these are quantum oscillations (QOs), the anomalous Hall effect (AHE), the anomalous Nernst effect (ANE) and the chiral anomaly.

The key characteristics of fermions in topological semimetals can be studied by quantum oscillation measurements. Here, we present a detailed analysis of QOs in $TaAs_2$, where we observed an unusual temperature ($T$) evolution of the fundamental frequency β and its second harmonic 2β amplitudes. Namely, in the oscillatory Nernst signal the former disappears completely at $T \approx 25$ K, while 2β frequency is still present. We attribute this behavior to a temperature-induced spin-zero effect derived from the temperature evolution of the Landé g-factor. Subsequently, the $T$ - dependence of the g-factor may reflect evolution of the spin-orbit coupling, which in the case of $TaAs_2$ can go hand in hand with a change a topology of the electronic system.

One important feature of Weyl fermions is the accompanying Berry curvature (BC), which acts like an effective magnetic field leading to the appearance of intrinsic AHE and ANE. In the ferromagnetic phase of Weyl semimetal CeAlSi, we detected a sign change in the anomalous Hall conductivity (AHC) from positive to negative, when the magnetic field ($B$) was rotated from the hard to easy axis. This sign reversal in AHC was attributed to the reconstruction of the electronic structure and a change in associated BC driven by spin reorientations. Additionally, the anomalous Nernst conductivity (ANC) was detected when $B$

was oriented along the hard axis. Significant AHC and ANC persisted in the paramagnetic phase of CeAlSi, and their temperature dependence can be described by the presence of the Weyl points near the Fermi level.

The evidence for the chiral anomaly in the Weyl system based solely on charge transport measurements, i.e. observation of the negative longitudinal magnetoresistance (NLMR), has sometimes been questioned due to the possible contribution of the current jetting effect. Here, we demonstrate that the pumping of chiral fermions between Weyl cones can be observed in the topological Dirac semimetal $\alpha$-Sn using combined electrical and thermoelectric transport studies. The latter is expected to be robust to external artefacts. The experimental evidence of the chiral anomaly were detected in both measurements – NLMR and negative slope of the thermopower were observed at low temperatures when the magnetic field was parallel to the applied electric field ($E$) or the thermal gradient ($\nabla T$). Furthermore, the angular variation of resistivity and thermopower confirmed the rapid diminishing of anomalous chiral current when magnetic field was tilted away from the applied E or $\nabla T$. We also showed that at high temperature the intervalley Weyl scattering time decreases, and as a consequence $\alpha$-Sn in this range is no longer in the chiral limit.

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