Einladung zum Physikalischen Kolloquium im Wintersemester 2021/22

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Kein Zugangscode notwendig

Interesting states of solid-state matter in extreme magnetic fields

Strong electronic interactions in condensed-matter systems often lead to unusual quantum phases, that emerge from its quantum mechanical nature and manifest in macroscopic physical properties. Often referred to as emergent phenomena, these involve changes to the very identity of the stuff such as transforming an insulator into a metal, or an ordinary metal into a protected conductor of electrical resistance fixed to a ratio of universal constants or even exactly zero-resistance in superconductors, or a non-magnetic solid into a magnet which in turns becomes a protected solid or super solid. Some of these novel phases have already changed our lives, as they make the essence of devices we use for communication, transport, energy harvesting and storing, research tools, etc. However, understanding or even studying these theoretically and experimentally are tasks of monumental difficulty. Magnetic fields, coupling to electrons in matter yet subtle otherwise, are a powerful tool in this quest.

One such phase occurs in the Kondo insulator YbB12, [1] the insulating state of which originates in strong electronic interactions and at once exhibits, astonishingly, phenomena that are characteristic of metals. To understand these phenomena, we study their evolution when characteristic electronic energy-gap of the Kondo insulator state is suppressed by a large magnetic field a million times stronger than Earth's. Here I will show how electric and magnetic quantum oscillations, a hallmark of metallicity, are observed in the insulating state and gradually vanish in the high-field metallic state in YbB12. By tracking the quantum realm of the material, we conclude that the same quasiparticle band gives rise to quantum oscillations in both insulating and metallic states. These data are understood most simply by using a two-fluid picture in which hypothetical charge-neutral quasiparticles—contributing little or nothing to charge transport—coexist with charged fermions. Implications will be discussed for this new state of matter that conducts heat like a metal and shows some of the hallmarks of fermionic quantized states, yet in the absence of free charge.

[1] Z. Xiang et al., Nature Physics 17, 788 (2021).

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