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# Towards a better understanding of emergent materials

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Emergent dynamics of solids has been the focus of research in condensed-matter physics for the past decades. The interest is due to the fact that condensed-matter physics is expected to serve both technological application and answer fundamental questions: On one hand, it should provide guide lines for material design which implies that theory should give quantitative microscopic predictions. On the other hand, the large number of interacting degrees of freedom can lead to novel states of matter with unusual often enigmatic properties whose characterization require the development of new concepts and methods.
In this talk, I will start with a historic overview. The main part will be devoted to materials with heavy fermions. Since their discovery almost half a century ago, heavy fermion systems have been a continuous source of surprising discoveries often challenging the theoretical understanding at the time. While heavy fermion systems in their "normal"state can be approximately described as Fermi liquids and therefore share common qualitative properties it is important to emphasize that there are different routes to heavy fermions. The focus of the present talk will be on intermetallic lanthanide (4f) and actinide (5f) compounds. I will present results on the recently discovered compound CeRh2As2 [1] that exhibits a complex phase diagram with rather unusual states at low temperatures. A prominent example is multi-phase superconductivity which seems to develop inside a normal state involving by itinerant multi-polar order [2]. The narrow quasiparticle bands arise from the Ce-4f degrees of freedom via the Kondo effect. We conjecture that the Kondo-induced quasi-quartet CEF ground state [3] in combination with pronounced nesting features of the Fermi surface [4,5] may give rise to ordered states involving multipolar degrees of freedom [6]. Consequences of topologically protected inter-band pairing in close analogy to UPt3 [7] will be discussed.

References

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