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Quantum critical points and novel phases in heavy fermion metals[1]

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Quantum criticality arises from competing interactions of correlated systems that favor rivaling ground states. It not only influences physical properties over a wide temperature and parameter ranges, but also gives rise to a plethora of new quantum phases. Magnetic heavy fermion metals represent a prototype system in this context, and have in particular provided the setting to study local quantum criticality that involves not only order-parameter fluctuations but also a Kondo breakdown [1]. Surprisingly, recent theoretical and experimental developments have revealed some unusual phases proximate to the heavy-fermion quantum critical points, thereby opening up an entirely new frontier on the relationship between quantum criticality and novel phases [1]. I will summarize the relevant recent experiments [2] and discuss them within the framework of a global phase diagram that was put forward several years ago [3] and has recently been discussed more extensively [4,5]. Our theoretical studies emphasize the interplay between two effects. One is the Kondo screening and its breakdown, and the other is the fluctuations in the quantum magnetism of local moments alone. The insights gained from these studies of the well-defined quantum criticality in heavy fermions may have broader relevance. Such implications will be discussed, in particular on the interplay between metallic antiferromagnetism, electronic localization and unconventional superconductivity.

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