Unconventional quantum criticality, anomalous metal with strong valence/orbital fluctuations

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In strongly correlated electron systems, quantum criticality normally emerges on the border of magnetism accompanied by critical spin fluctuations. In particular for the 4*f* electron based heavy fermions, it has been discussed using Doniach type picture based on the Kondo lattice with integer valence. Here we discuss unconventional type of quantum criticality and anomalous metallic phases found with strong valence and orbital fluctuations. The first material is the Yb based heavy fermion superconductor β-YbAlB4. Interestingly, this exhibits a zero field quantum criticality without tuning as the first example in a metal [1]. Doping and pressure effects indicate no magnetic phase in the immediate vicinity of the ambient pressure quantum criticality. The instability associated with electronic structure or valence may be the origin of the novel quantum criticality. Secondly, we will discuss the anomalous metallic phase found in the Pr based cubic compounds $Pr\mathit{Tr}_2Al_{20}$ (*Tr*: transition metal) [2,3]. These allow us to study the competition between the strong hybridization effects and quadrupolar ordering. Orbital fluctuations under strong hybridization with conduction electrons suppresses orbital ordering and lead to prominent non-Fermi liquid behavior, suggesting the possibility of a nonmagnetic type of Kondo effect.

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