Novel effect of critical valence fluctuations in unconventional superconductivity of Ce-based heavy fermions and related compounds

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Abstract: For this decade, our group has developed a theory for unconventional superconductivity in Ce-based heavy fermion systems $CeCu_2(Ge,Si)_2$ which exhibits anomalous enhancement of superconducting transition temperature T_{sc} and non-Fermi liquid properties such as T-linear resistivity and huge enhancement of residual resistivity under pressure $P \sim P_v$ where the valence of Ce ion appears to change drastically [1,2]. Detailed experiments of $CeCu_2Si_2$ by Jaccard group at Univ. Geneve was explained in a unified way on a single assumption that the valence of Ce exhibits quantum critical valence transition or sharp crossover at $P \sim P_v$ [3].

After that, it turned out gradually that such a mechanism works also in other Ce-based heavy fermion systems such as $CeTIn_5$ (T=Co, Rh, Ir) which had been regarded as a typical example where only antiferromagnetic critical fluctuations play a crucial role [4]. A recent remarkable development is that the critical valence transition can be rather easily controlled by attainable magnetic field and explain a lot of anomalous properties of $CeIrIn_5$ and $CeRhIn_5$ [5]. This can resolve puzzles observed not only in these compounds but also in Yb-based heavy fermions such as $YbXCu_4$ (X=In, Ag, Cd, Au) and $YbRh_2Si_2$ which has been discussed as a typical example out of conventional understanding of antiferromagnetic quantum critical point.

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