Interplay of superconductivity, quantum criticality and f-electron localization in rare-earth based 122 systems

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Both $CeCu_2Si_2$ and $YbRh_2Si_2$ crystallize in the tetragonal $ThCr_2Si_2$ structure. Recent neutron-scattering results on normal-state $CeCu_2Si_2$ reveal a slowing down of the quasielastic response which conforms to the scaling expected for a quantum critical point (QCP) of itinerant, i.e., three-dimensional spin-density-wave (SDW) type. This interpretation is in full agreement with the non-Fermi-liquid behavior observed in transport and thermodynamic measurements. The momentum dependence of the magnetic excitation spectrum reveals two branches of an overdamped dispersive mode whose coupling to the heavy charge carriers is strongly retarded. These overdamped spin fluctuations are considered the driving force for superconductivity in $CeCu_2Si_2$ (T_c = 600 mK).

The weak antiferromagnet $YbRh_2Si_2$ (T_N = 70 mK) exhibits a magnetic-field induced QCP at B_N = 0.06 T ($B \perp$ c) but no superconductivity above T = 10 mK. The magnetic QCP appears to concur with a breakdown of the Kondo effect as concluded from, e.g., the field dependencies of both Hall coefficient and thermoelectric power as well as from a significant violation of the Wiedemann-Franz law. Doping-induced variations of the average unit-cell volume result in a detachment of the magnetic and electronic instabilities.

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