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Evidence of f-electron localization at a heavy-fermion quantum critical point

FRANK STEGLICH, Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

The prototypical heavy-fermion compound $YbRh_2Si_2$ exhibits a magnetic-field (B) induced antiferromagnetic quantum critical point (QCP) at B_c ($\perp$c) $\approx$ 60 mT. As inferred from transport and thermodynamic measurements a quantum-critical energy scale, $k_B T^*(B)$, indicating a crossover of the Fermi surface, has been established for this system [1]. Upon extrapolating finite-temperature (T) data to $T = 0$, one concludes (i) a vanishing of $T^*(B)$ [2] and (ii) an abrupt drop in the (normal) Hall coefficient $R_H(B)$ [2, 3] at $B = B_c$, verifying the proposal of a Kondo destroying QCP [4,5]. The dynamical processes underlying this apparent break-up of the Kondo singlets have been explored [6-8] by studying the Lorenz ratio L/L_0 as a function of $T$and B. Here, $L = \rho/w$ is the ratio of the electrical (ρ) and thermal ($w = \mathrm{L}_0 T/\kappa$) resistivities, with κ being the thermal conductivity and $\mathrm{L}_0 = (\pi \mathrm{k}_B)^2/3\mathrm{e}^2$ Sommerfeld's constant. By properly taking care of bosonic (magnon/paramagnon) contributions to the heat current which exist at finite temperature only, extrapolation of the measured data to $T = 0$ yields a purely electronic Lorenz ratio $L/\mathrm{L}_0 = 1$ at $B \neq B_c$. At $B = B_c$, we extrapolate $L/\mathrm{L}_0 \approx 0.9$. Therefore, the Wiedemann Franz (WF) law holds at any value of the control parameter B, except for the field-induced QCP [6], as is also illustrated by a pronounced heating of the sample when measuring the low $-\ T$ electrical resistivity in the vicinity of the critical magnetic field [8]. This violation of the WF law is ascribed to scatterings of the electronic heat carriers from *fermionic* quantum-critical fluctuations, namely those of the Fermi surface. Work done in collaboration with H. Pfau, S. Lausberg, P. Sun, U. Stockert, M. Brando, S. Friedemann, C. Krellner, C. Geibel, S. Wirth, S. Kirchner, E. Abrahams and Q. Si.

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