Relationship between quantum criticality and superconducting upper critical field in Ni-doped CeCoIn5

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We present the emergence of the quantum critical point (QCP) coupled with the superconducting (SC) upper critical field in Ni-doped heavy-fermion superconductor CeCoIn5. In CeCo1-xNixIn5, the substitution of Ni for Co monotonically reduces the SC transition temperature Tc from 2.3 K (x = 0) to 0.8 K (x = 0.20), and the SC order then disappears above the critical Ni concentration of x = 0.25 [1]. The non-Fermi-liquid (NFL) behavior is realized at this critical doping level, characterized by the -lnT dependence in specific heat divided by temperature and the weak diverging behavior in magnetization [2]. The NFL features above resemble those seen around Hc2 in pure CeCoIn5 [3,4], and therefore, it is interesting to clarify the connection of the quantum criticality between pure and 25%Ni-doped CeCoIn5. To verify this, we have investigated the NFL states for Ni-doped CeCoIn5 by performing electrical resistivity measurements with the c-axis magnetic field. Displayed in the Figure is low-temperature electrical resistivity for CeCo0.75Ni0.25In5, plotted as a function of T2. A feature of concave downward occurs in the T2 plot for the temperature variations of electrical resistivity in a weak field range, reflecting the NFL state originating from the quantum critical fluctuations. The resistivity exhibits a crossover between the NFL state and the Fermi-liquid (FL) state, the latter of which is recognized by the T2 dependence in the resistivity. Their boundary for T=0, regarded as the QCP, is found to coincide with Hc2 (≈0). Furthermore, the A coefficient of the T2 term in the resistivity, estimated in the FL region, exhibits diverging behavior by reducing the magnetic field toward Hc2. Similar features in the resistivity also appear in the other Ni concentrations for x less than 0.25. Those experimental results provide evidence that the emergence of the QCP is always coupled with the breakdown of the SC state at Hc2. It is hence suggested that the quantum critical fluctuations of pure and 25%Ni-doped CeCoIn5 originate from the identical hidden order parameter.

References