Quantum criticality and superconductivity in $CeCu_2Si_2$

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The heavy-fermion compound $CeCu_2Si_2$ displays unconventional superconductivity and is already at ambient pressure located in the vicinity of a quantum critical point (QCP) where long-range antiferromagnetism vanishes. Using elastic and inelastic neutron scattering we studied in detail the antiferromagnetic order and the spin excitations spectrum around the QCP. Antiferromagetism and superconductivity exclude each other on a microscopic scale. While for magnetically ordered samples critical slowing down of the spin fluctuations above T_N is observed, shows the normal state response of superconducting $CeCu_2Si_2$ an almost critical slowing down for $T \to 0$. Its temperature dependence and scaling behavior are in line with the expectations for an itinerant spin-density-wave QCP. This interpretation is substantiated by an analysis of specific heat data and the momentum dependence of the magnetic excitation spectrum. In contrast, the magnetic response in the superconducting state is characterized by a transfer of spectral weight to energies above a spin excitation gap. Our results strongly imply that the coupling of Cooper pairs in $CeCu_2Si_2$ is mediated by overdamped spin fluctuations.