

Magnetic quantum phase transitions

Löhneysen v., Hilbert^{1,2}

¹*Physikalisches Institut, Universität Karlsruhe, D-7128 Karlsruhe, Germany*

²*Forschungszentrum Karlsruhe, Institut für Festkörperphysik, D-76021 Karlsruhe, Germany*

In a number of metallic systems with strong electronic correlations, long range magnetic order can be tuned to zero temperature by an external parameter such as pressure, chemical composition or magnetic field. At such a quantum phase transition (QPT), the quantum energy of critical fluctuations becomes a relevant energy compared to the thermal energy, leading to unusual non-Fermi-liquid (NFL) behavior in thermodynamic and transport properties, and possible new phases. We will discuss two examples of unusual feature near a QPT: (i) Highly anisotropic magnetic fluctuations in $\text{CeCu}_{6-x}\text{Au}_x$ observed by inelastic neutron scattering arise when approaching the QPT occurring at $x = 0.1$, despite the fact that long range-incommensurate order for $x \geq 0.15$ is three-dimensional. These fluctuations extend over a large concentration range $0 \leq x \leq 0.2$ on either side of the QPT. (ii) In MnSi the QPT can be tuned by hydrostatic pressure p . The long-wavelength helical magnetic order at $p = 0$ (wavelength 180 \AA) it retains its periodicity when approaching the QPT but loses its orientation, as observed via elastic neutron scattering under pressure. This “partial melting” is reminiscent of orientational order in chiral liquid crystals and presents a truly novel magnetic phase. How this partial order is related to the NFL behavior in the electrical resistivity has yet to be established. We speculate that the appearance of new phases arises from the “electronic softness” of matter a QPT, due to competing interactions, thus resembling features of soft matter.