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Quantum phase transitions - hard matter getting soft?

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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 or 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 features near a QPT: (i) Highly anisotropic magnetic fluctuations in $CeCu_{6-x}Au_x$ 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 larger concentration range $0 \leq x \leq 0.2$ on either side of the QPT. (ii) MnSi is a particularly clean system where the QPT can be tuned by hydrostatic pressure. The long-wavelength helical magnetic order (wavelength 180 Å) 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 liquid crystals and presents a truly novel magnetic phase. How this partial order is related to the NFL behavior observed in the electrical resistivity has yet to be established. We speculate that the appearance of new phases arises from the "electronic softness" of matter near a QPT, arising from competing interactions.

Keywords : Non-Fermi-liquids, critical flucutations, quantum phase transitions