**High Resolution Study of Magnetic Ordering at Absolute Zero.**

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**Recommended and a Commentary by Chandra Varma, University of California, Riverside.**

A large body of experimental work on cuprate superconductors, heavy fermions and other rather complicated materials in the last decade has raised interesting new questions about the critical behavior of phase transitions near T=0 , i.e. about quantum critical points (QCP). Unlike Classical phase transitions where dynamics is fixed by the static correlations and phenomenological considerations for the damping of fluctuations, the dynamics near QCP's must be determined from the quantum-mechanical equations of motion; indeed questions about the static correlation functions can only be answered if the dynamics is understood.

The theoretical ideas on this problem, due to Moriya and others, were put in the language of critical phenomena by Hertz. The theory closely follows the formulation of classical critical phenomena; quantum-mechanics is introduced in the slowly varying variables, the magnetic fluctuations for instance for magnetic transitions, through considering time as an extra dimension with a finite length set by the inverse temperature of measurements. Temperature acts as a cut-off since it determines the quantum-classical crossover. The physics of this crossover is the physics of decoherence, an important and interesting problem in itself. The effective dimension of the problem is d+z, where z is determined by the dispersion relation (ω ~ k^z) of the critical fluctuations.

This theory is a consistent theory in the sense that corrections to it calculated within its basic assumptions are shown to be negligible. It has however the problem that its predictions by and large do not agree with experiments on almost any metal studied even when the temperature dependence of decoherence is introduced as an adjustable phenomenological function with z often varied at will.

One possibility for this difficulty may well be that the materials studied are very complicated and beset with slow irrelevant behavior which the theory does not capture and which are hard to separate in the analysis of the data. A more interesting possibility is that the universality classes of classical critical phenomena does not encompass quantum critical phenomena or at least quantum critical phenomena which involves fermions. Integrating over the Fermions to get the slow quasi-classical variables may put one in a domain from which the correct behavior is not accessible and from which even the fact that one is in trouble is not revealed by perturbative calculations.

In this situation, careful measurements in simple materials, and the application of lessons learnt in analysis of experimental data for classical critical phenomenon, would be most helpful. The experiments of Lee et al on Cr-V alloys where they can tune through the anti-ferromagnetic quantum critical point by careful variation of pressure are therefore most welcome. This is the simplest system studied so far for a QCP in a metal. Only resistivity and Hall effect are studied; thermodynamic measurements would be an additional help. So would some means of measuring directly the spectrum of fluctuations. Several puzzles have been highlighted including the difference in the deduced temperature dependence of the longitudinal and transverse conductivities. To this reader the suspicion from data in other metals that quantum critical phenomena requires a fundamental new insight is strengthened.