Stony Brook University
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Doctoral Defense Announcement

Abstract

Quantum Critical Behaviors in Magnetic Systems: Yb_3Pt_4, YFe_2Al_{10}, and Yb_2Pt_2Pb

By

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Quantum phase transitions have attracted a great deal of interest in the study of condensed matter physics. Normally, this refers to continuous transitions that occur at T=0, where the correlation length and time scales diverge, and universal scaling is observed close to the Quantum Critical Point (QCP). Quantum critical scaling differs from its classical counterpart in that the spatial dimension d is replaced by an effective dimension d+z, where z is the dynamical critical exponent. Here I will talk about the search for quantum criticality in magnetic compounds: Yb_3Pt_4, YFe_2Al_{10} and Yb_2Pt_2Pb.

Yb_3Pt_4 is a local moment antiferromagnet (AF) which orders at 2.4 K in zero field. The AF order could be suppressed until zero temperature by a magnetic field of about 1.9 T. A field temperature phase diagram was established, and it indicates that Yb_3Pt_4 was tuned to a critical end point (CEP) at T=0. The magnetic property could be explained well by the mean field theory, and it suggests that Yb_3Pt_4 was tuned to an AF-QCP, but with effective dimension d+z>4.

A remarkable behavior of quantum critical systems is the critical scaling near the QCP, where Fermi liquid (FL) physics usually break down. Here, in the transition metal YFe_2Al_{10}, strong divergence in magnetic susceptibility ($\chi \sim T^{-1.4}$) and magnetic specific heat ($C_M/T \sim -\log T$) was observed. Universal scaling was found in the magnetic susceptibility ($d\chi/dT=B^{-1.4}\varphi(T/B^{0.6})$) and specific heat ($\Delta C_M/T=\psi(T/B^{0.6})$). This indicates that YFe_2Al_{10} may locate close to a QCP without tuning. Further scaling analysis indicates that the spatial dimension d is equal to the dynamical exponent z at this QCP.

Yb_2Pt_2Pb is a frustrated magnet which crystallizes in a 2D Shastry-Sutherland lattice (SSL). Thermodynamic properties indicate that this system is located close to an AF – spin liquid (SL) QCP. However, single crystal neutron scattering experiments suggests that Yb_2Pt_2Pb may be dominated by the one dimensional physics, where Yb moments are coupled along the crystal c direction, and spinons like excitations were observed.

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