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Tuning the ferromagnetic tri-critical point and quantum critical point in $Ce(Pd_{1-x}Ni_x)_2P_2$ under high magnetic fields

Lai, Y. (FSU, NHMFL); Winter, L.E. and Weickert, D.F. (NHMFL-LANL); Baumbach, R.E., (FSU, NHMFL) McDonald, R.D. (NHMFL-LANL)

Introduction

We recently uncovered a ferromagnetic quantum phase transition in the alloy series $Ce(Pd_{1-x}Ni_x)_2P_2$ near $x_{cr} \approx 0.7$. This is uncommon amongst Ce-based Kondo lattices, which often order antiferromagnetically and may host antiferromagnetic quantum critical points after appropriate tuning (e.g., using pressure, chemical substitution, or magnetic field) [1]. Thus, the $Ce(Pd_{1-x}Ni_x)_2P_2$ series provides the rare opportunity to study phenomena associated with ferromagnetic quantum fluctuations and to contrast them with predictions from different theories: such as that proposed by Belitz, Kirkpatrick, and Vojta (BKV) [2-5]. In particular, the BKV theory predicts that for clean systems there is a tri-critical point separating a high temperature line of second order phase transitions from a low temperature line of first order phase transitions, where the application of a magnetic field produces wing-like second order phase boundaries that intercept zero temperature. With increasing disorder (e.g., through alloying), the tri-critical point is pushed to zero temperature: i.e., the second order phase boundary extends all the way to zero temperature. Such behavior might be expected near x_{cr} in the disordered metal series $Ce(Pd_{1-x}Ni_x)_2P_2$. Here we report results from magnetoresistance and tunnel diode oscillator measurement on the doping samples close to the critical region.

Experimental

In order to investigate the high field phase diagram and the accompanying electronic/magnetic behavior, we carried out magnetoresistance measurements using samples shaped using the focused ion beam (FIB) method, torque magnetometry (on polished and aligned samples), and tunnel diode oscillation (TDO) measurements on aligned samples for $Ce(Pd_{1-x}Ni_x)_2P_2$ for $x \approx x_{cr}$. Measurements were performed for fields H < 65 T and temperatures 500 mK < T < 10 K.

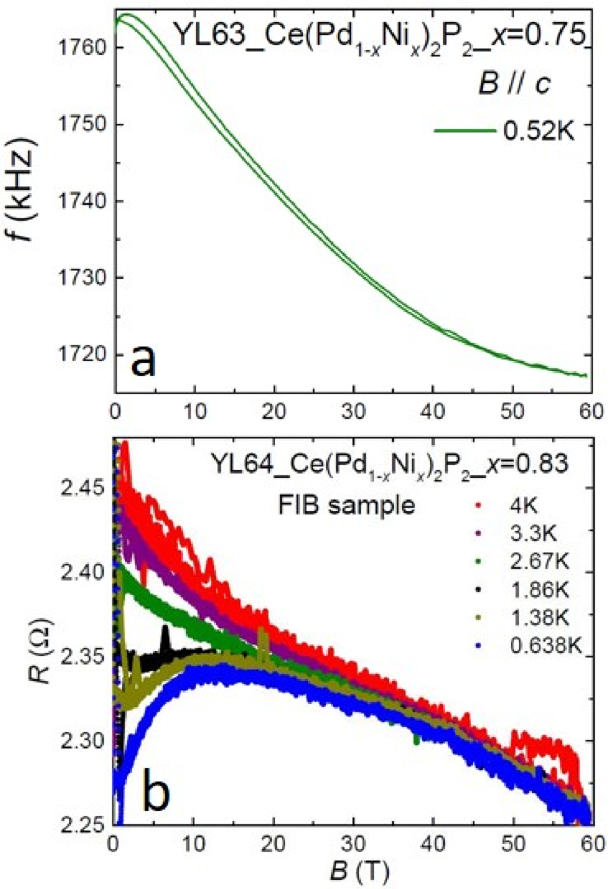

Fig.1 Magnetoresistance and TDO measurement for selected concentration

Results and Discussion

Results from TDO measurements in fields up to 65 T for $x = 0.75$ are shown in Fig. 1a. No evidence for quantum oscillations or field induced phase transition are seen, and similar results were found for the end-member compounds $CePd_2P_2$ and $CeNi_2P_2$. We speculate that cleaner samples, lower T and larger H are needed to observe quantum oscillations.

Results of magnetoresistance measurement of $x = 0.83$ are shown in Fig. 1b, where the data shows crossover-like behavior with T and H. No ferromagnetic wings were observed up to the highest fields. This is consistent with the expectation from BKV theory that disorder suppresses the field induced wings below zero temperature. Further measurements are still needed to investigate whether the wings appear at high fields for lower concentrations.

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