Phase diagram of $URu_{2-x}Fe_xSi_2$ in high magnetic fields

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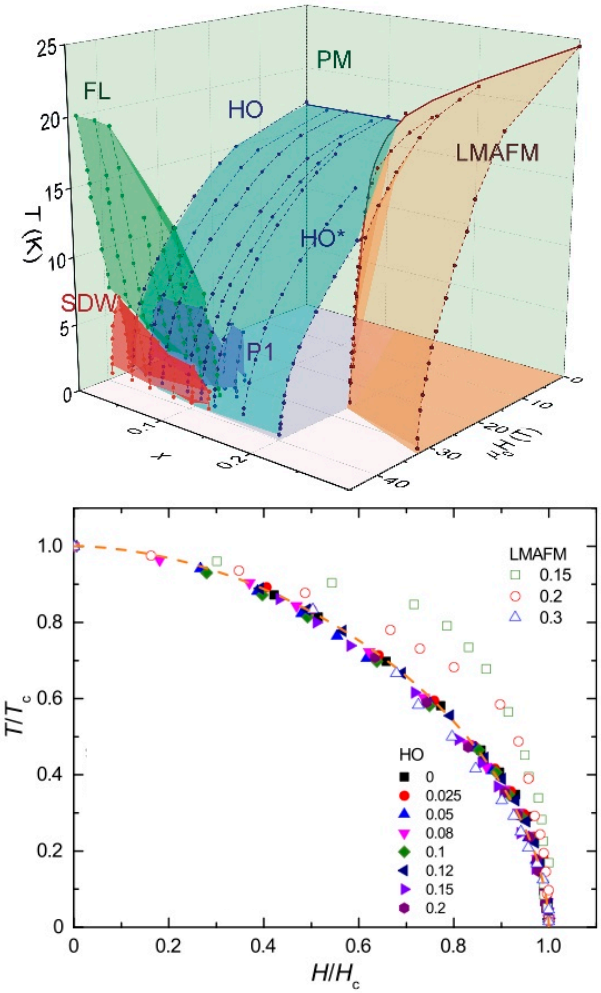
The renowned and mysterious hidden-order (HO) phase in URu_2Si_2 is intimately related to the large-moment antiferromagnetic (LMAFM) phase that is induced under pressure or upon iron (Fe) substitution. MagLab users performed electrical resistivity measurements on single crystals of $URu_{2-x}Fe_xSi_2$ in magnetic fields of up to 45T (Hybrid Magnet) and 65T (Pulsed Magnets). Various phases including HO, LMAFM, HO* (reentrant HO phase), SDW (spin density wave), FL (ordinary Fermi-Liquid metallic phase, recovered at high field), and PM (paramagnetic phase at high temperature) were mapped, along with P1 (a possible new intermediate-field phase), to establish a three-dimensional (3D) field – composition - temperature (*H, x, T*) phase diagram for this complex material.

The 3D phase diagram establishes a "universal" relationship between the normalized transition temperature T/T_0 and the normalized critical magnetic field H/H_0 for the HO phase: the H/H_0 versus T/T_0 data in the lower figure collapses onto a single curve. This curve provides tight constraints on potential models for the order parameter of the HO phase.

Within a certain range of x values, x~0.17, the HO phase reenters when magnetic fields suppress the LMAFM phase. This is similar to the behavior observed for pure URu_2Si_2 crystals within a certain range of pressures.



Upper: Three-dimensional phase diagram for $URu_{2-x}Fe_xSi_2$ single crystals, with temperature *T*, magnetic field (parallel to **c**) *H*, and Fe concentration *x* as the three axes. The labels for the phases are defined in the text.

Lower: Normalized critical-field H/H_0 as a function of normalized critical temperature T/T_0 for $URu_{2-x}Fe_xSi_2$ single crystals, with x=0, 0.025, 0.05, 0.08, 0.1, 0.12, 0.15, 0.2, and 0.3. The solid and open symbols represent data for the Hidden Order(HO) and Large Moment Antiferromagnetic (LMAFM) phases, respectively. The dashed line represents the best fit of the equation $(T/T_0)^n + (H/H_0)^n = 1$ to the data, which yields $n = 1.8$. The inset shows $(T/T_0)^{1.8}$ as a function of $(H/H_0)^{1.8}$ for the crystals.

Facilities and instrumentation used: 65 Tesla capacitor-driven magnet at the MagLab's Pulsed Field Facility, Los Alamos; 45 T Hybrid Magnet at the MagLab' DC Magnet Facility, Florida State University;

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