NOTICE OF SEMINAR

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Ferromagnetism in 5f-band metamagnet UCoAl induced by Os doping

Date & Time: 10:00-12:00, Nov. 10th (Tue.)
Place: 3F Seminar Room, 4th Build., IMR

The work shows results of recent collaboration between Prague and Sendai groups.

UCoAl (hexagonal crystal structure) exhibits a metamagnetic transition from the paramagnetic ground state to the forced ferromagnetic (F) state in a uniquely low transition field H_{cr} of 0.7 T applied along the *c* axis. The magnetic moment is induced on U, the Co magnetic moment is negligible. UCoAl demonstrates several unusual features. Dilution of the magnetic U sublattice by few % of non-magnetic Y or Lu paradoxically induces ferromagnetism. Then, whereas hydrostatic pressure suppresses F state by increasing Hcr, uniaxial pressure applied along the c axis, opposite, reduces Hcr to zero and thus induces spontaneous ferromagnetism. The state of the 5*f* electrons depends drastically on the interaction with ligands, especially with d-metals. When Co is substituted by *T* = Fe, Ru, Rh and Ir in the $UCo_{1-x}T_xAl$ systems, H_{cr} rapidly decreases and already few % doping stabilizes spontaneous F state. It looks understandable for Rh and Ir because URhAl and UIrAl are ferromagnets. But in the cases of Fe and Ru the terminal compounds UFeAl and URuAl are paramagnets. Opposite, for *T* = Ni, Pd and Pt, Hcr increases and paramagnetism is stabilized despite the fact that terminal compounds UNiAl, UPdAl and UPtAl are magnetically ordered.

Influence of all possible substitutions within the Co sublattice by 3*d*, 4*d* and 5*d* metals was studied systematically except *T* = Os. It was due to very high melting temperature of Os and therefore complicated metallurgy in presence of Al with low melting point. Moreover, it is known that Os does not form UOsAl compound with ZrNiAl structure, so solubility of Os in UCoAl should be limited. In the present work we succeeded to solve the metallurgical problem by using precursors and can therefore finalize the study of the influence of a late d-metal on the magnetism of UCoAl by investigation of the $UCo_{1-x}Os_xAl$ system.

It was found that the homogeneity range in the $UCo_{1-x}Os_xAl$ system is limited to $x = 0.2$ with a small lattice expansion in the basal plane. Magnetization measurements performed on single crystals show that compounds with $x = 0.02, 0.05, 0.10$ are ferromagnets with easy c axis. The spontaneous magnetic moment M_s increases from 0.40 μB per formula unit at $x = 0.02$ to 0.53 μB at $x = 0.10$, which is almost twice larger than the magnetic moment induced at the metamagnetic transition in UCoAl. All the compounds exhibit huge magnetic anisotropy characteristic for UCoAl. Extrapolation of the a-axis magnetization curves to crossing with $M = M_s$ gives anisotropy field H_a as 120-130 T. But this method does not take into account that the easy-axis magnetization is not saturated in the maximum applied field and grows even faster that the hard-axis one. So, the real Ha as a field of crossing of the easy- and hard-axis curves is considerably larger that these already huge values. Similarly to M_s, the Curie temperature increases with x and reaches 48 K for $x = 0.10$. Thus, Os stabilizes ferromagnetism in UCoAl considerably stronger than Rh and Ir and slightly stronger than Fe and Ru.

We also prepared for first time single crystal of UOsAl and found that it has hexagonal Laves phase structure and is almost isotropic paramagnet with almost temperature-independence magnetic susceptibility.

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