第 528 回 物性セミナー・創発的物性物理研究拠点セミナー

High-field transitions in Er-Co and Tm-Co intermetallics with high Co content

講 師：Alexander V. Andreev
（Institute of Physics, Academy of Sciences, Prague, Czech Republic）
日 時：2018 年 9 月 28 日（金） 15:00-
場 所：先端物質科学研究科　402N

Intermetallic compounds RCo_5 (R is a rare-earth metal) have hexagonal crystal structure of the $CaCu_5$ type. Due to lanthanide contraction, the stability of this structure decreases along the R series. The compounds with R = Er and Tm can be obtained only in very fast-cooled samples, moreover, only as a second off-stoichiometric phase in ingots with R_2Co_{17} as a main phase. A partial replacement of Co by Al with a larger atomic radius compensates the effect of lanthanide contraction, and compounds RCo_4Al with the $CaCu_5$ crystal structure exist for all rare-earth elements including R = Er and Tm. Therefore, a systematic study of the whole RCo_4Al series can be performed.

We studied high-field magnetization (up to 60 T) on single crystals of $ErCo_4Al$ and $TmCo_4Al$ which can be considered as Al solid solutions in the non-existing compounds $ErCo_5$ and $TmCo_5$. Single crystals were prepared by a modified Czochralski method in triarc furnace in Prague. High-field magnetization was measured in Dresden-Rossendorf High-Field Laboratory.

$ErCo_4Al$ is a ferrimagnet with T_C = 503 K and M_s = 3.6 μ_B/f.u. (at 2 K) directed along the *c* axis. Magnetic moment of the Co sublattice can be found as 5.4 μ_B from the difference between moment of the Er^{3+} ion and total M_s. The Er sublattice dominates at low temperatures but weakens with temperature faster than the Co sublattice, so above the compensation point T_{comp} = 127 K the total moment is along the Co sublattice.

$ErCo_4Al$ exhibits two metamagnetic transitions in field applied along the *c* axis, at 45 and 52 T (at 2 K). Magnetic moment above transitions, 9 μ_B, is equal to M_{Er}, so the transitions can be attributed to demagnetization of the Co sublattice. Therefore, the state is on halfway to the forced ferromagnet and next transitions should occur above 60 T. Ratio between magnetization changes at the transitions, 3:1, shows that at the first transition the Co atoms in the 3g positions are demagnetized and at the second transition - in the 2c positions where one of Co atom is substituted by Al. Critical field of the first transition decreases with increasing temperature and is extrapolated to zero at T_{comp}, no transition is observed above this temperature. Second transition is not visible above 40 K. The transitions are accompanied by pronounced magnetostrictive and magnetoelastic effects. No field-induced transitions are observed in the basal plane of the crystal.

$TmCo_4Al$ is a ferrimagnet with T_C = 490 K and M_s = 2.1 μ_B/f.u. (2 K) with, as the Er analogue, uniaxial anisotropy. Below compensation point T_{comp} = 87 K the total moment is along the Tm sublattice, above T_{comp} along Co. Magnetic moment of the Co sublattice in assumption of collinear antiparallel arrangement of the Tm and Co sublattices can be determined as 5 μ_B. Therefore, the observed magnetic moment 12 μ_B after the metamagnetic transition corresponds to the forced ferromagnetic arrangement of the sublattices ($M = M_{Tm}+M_{Co}$) and no more transitions should be expected in higher fields (in difference with Er analogue).

Due to high coercivity at low temperatures (in particular, at T_{comp}), a phenomenon of “negative magnetization” is observed in both compounds when the magnetization of the sample, passing through T_{comp}, becomes oriented against the applied field. At heating, the magnetization becomes “normal” when the coercive field decreases below value of applied field.

The high-field behavior of $ErCo_4Al$ and $TmCo_4Al$ is discussed in comparison with results on other R-Co intermetallics recently studied on the single crystals (Er_2Co_{17} and Tm_2Co_{17}). In these compounds, the total moment in the ground state is along the Co sublattice, not along the R sublattice as in $ErCo_4Al$.

5 研究科共同セミナーの認定科目です
担当：石井　勲（先端物質科学研究科）・内線 7042