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2004 J. Phys.: Condens. Matter 16 4273

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Magnetic structures and phase transitions in the pseudobinary $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ system

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Received 19 December 2003

Published 4 June 2004

Online at stacks.iop.org/JPhysCM/16/4273

doi:10.1088/0953-8984/16/24/009

Abstract

X-ray and neutron diffraction studies as well as magnetization and electrical resistivity measurements of $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ compounds were performed. In the Er-rich compounds, $0 \leq x \leq 0.2$, a temperature-induced metamagnetic transition takes place between weak and strong Co magnetic states. In the intermediate concentration region, $0.1 \leq x \leq 0.7$, below 40 K a spin reorientation was observed. The magnetic structure below the spin-reorientation transition is non-collinear. The Er moments on the ‘cubic’ sites (6c) are tilted from the c -axis by an angle of about 55° , while those on the uniaxial 3a positions compose a smaller angle, of about 15° . The spin-reorientation transition is accompanied by a large orthorhombic distortion of the hexagonal PuNi_3 -type crystal structure, which is accounted for by a large anisotropic magnetostriction of the Er sublattice. The distortion parameter $(a\sqrt{3} - b)/b$ varies linearly with x . Its extrapolated value for ErCo_3 is about 2×10^{-3} . The concentration dependence of both types of magnetic instabilities is depicted in a magnetic phase diagram of the pseudobinary $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ system for the low-temperature region.

1. Introduction

The current interest in the RCO_3 intermetallic compounds (rhombohedral PuNi_3 -type structure) is to a considerable extent determined by the magnetic instability found in YCo_3 . This

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compound, a very weak itinerant electron ferromagnet with $T_C = 301$ K and $M_S = 1.35 \mu_B/\text{fu}$, exhibits at low temperatures two successive field-induced metamagnetic transitions (MTs) at $B_{m1} = 60$ T and $B_{m2} = 82$ T [1]. With a magnetic rare earth, if the intersublattice $f-d$ molecular field exceeds at low temperatures one or both critical fields (B_{m1} and B_{m2}), a temperature-induced MT can occur in RCo_3 compounds at a certain critical temperature T_M . This phenomenon was observed in ErCo_3 , HoCo_3 and some diluted $\text{R}_{1-x}\text{Y}_x\text{Co}_3$ systems [2–4]. It has been observed that single-phase compounds of RCo_3 can be synthesized with a wide range of stoichiometry, this being obviously the reason why in ErCo_3 the critical temperature T_M varies from 65 K in $\text{ErCo}_{2.88}$ up to 100 K in $\text{ErCo}_{3.00}$.

In the PuNi_3 -type structure the Co atoms occupy three non-equivalent crystallographic positions, 3b, 6c and 18h. The NMR data obtained for the $(\text{Gd}, \text{Y})\text{Co}_3$ and the $(\text{Nd}, \text{Y})\text{Co}_3$ systems at 4.2 K [5] have shown that all three Co sites are involved in the MT. Neutron diffraction data of the ErCo_3 compound [6], however, revealed that the contribution from the 18h sites dominates for the MT at about 100 K. As it follows from the magnetization measurements on the single crystalline sample [7, 8], the resulting magnetization vector of ErCo_3 rotates from the easy axis toward the basal plane in fields as low as 3 T. This was referred to the different local anisotropy on the two Er sites in this structure. While the local symmetry of the 3a sites (Er_{I}) is uniaxial along the hexagonal c -axis, the local symmetry of the 6c sites (Er_{II}) is pseudo-cubic and the magnetic moments of these Er atoms tend to be perpendicular to the c -axis. As a result of the competition between the local anisotropies of the Er_{I} and Er_{II} atoms and the uniaxial anisotropy of Co atoms (the easy magnetization direction of YCo_3 is the c -axis [9]), the magnetic anisotropy of ErCo_3 is almost completely compensated.

In some substituted $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ compounds an orthorhombic distortion of the hexagonal PuNi_3 -type crystal structure has been observed in the temperature-dependent x-ray diffraction measurements [2]. This has been accounted for a rotation of the spontaneous magnetization away from the c -direction in the substituted compounds. The existence of a spontaneous spin-reorientation transition in this pseudobinary system is not trivial and needs further investigation. The details of the magnetic structure can be provided by neutron diffraction experiments.

The aim of this work was to establish a magnetic phase diagram for the pseudobinary $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ system by applying x-ray and neutron diffraction, magnetoresistance and magnetization measurements.

2. Experimental details

Polycrystalline sample materials of the pseudobinary $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ system with $x = 0.0, 0.05, 0.1, 0.15, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.75, 0.8, 0.9$, and 1.0 were prepared by arc or induction melting. The ingots were annealed at 930 °C in vacuum for 24 h. In order to figure out the role of stoichiometry on the metamagnetic transition, samples with different compositions, $\text{ErCo}_{2.88}$ and RCo_3 , were prepared and studied [2–4, 6]. In this work all the neutron diffraction data, except those for $\text{ErCo}_{3.00}$, were collected with the stoichiometry 1:2.9. The temperature-dependent x-ray diffraction and electrical resistivity measurements were performed on samples with the stoichiometry 1:2.88.

The neutron diffraction data using powdered polycrystalline sample materials were collected on the E6 diffractometer at the BENSC (HMI-Berlin) in the temperature range from 2 to 60 K and magnetic fields up to 5 T. The wavelength used was 1.197 Å. In order to fix the particles in the sample holder when applying the external magnetic field, a mixture of deuterized methanol–ethanol was added to the powders. The magnetic structure and the orientation of the sublattice magnetizations $M_{\text{ErI}}, M_{\text{ErII}}, M_{\text{CoI}}, M_{\text{CoII}}, M_{\text{CoIII}}$ have been solved with the FULLPROF software [10]. Further experimental details concerning the sample preparation, temperature-

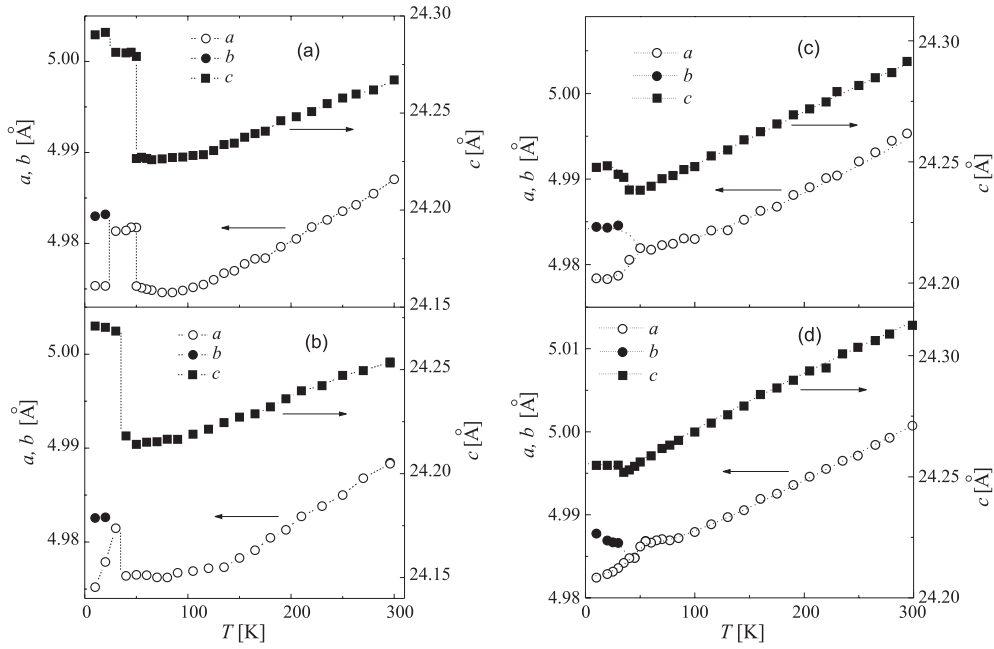


Figure 1. The temperature dependence of the lattice parameters a , b , and c of the $\text{Er}_{0.9}\text{Y}_{0.1}\text{Co}_3$ (a), $\text{Er}_{0.8}\text{Y}_{0.2}\text{Co}_3$ (b), $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$ (c), and $\text{Er}_{0.5}\text{Y}_{0.5}\text{Co}_3$ (d) intermetallic compounds.

dependent x-ray diffraction, magnetization and magnetoresistance techniques can be found in [2–4, 6].

3. Experimental results

3.1. Temperature-dependent x-ray diffraction

The temperature-dependent x-ray diffraction measurements were performed on samples with 1:2.88 stoichiometry. Figures 1(a)–(d) show the temperature dependence of the lattice parameters (in the hexagonal description) of four selected $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ compounds ($x = 0.1, 0.2, 0.3$ and 0.5). In $\text{Er}_{0.9}\text{Y}_{0.1}\text{Co}_3$ (figure 1(a)), a large volume (isotropic) expansion is observed at 50 K; $\Delta V/V$ calculated from this figure is equal to 4.8×10^{-3} , which indicates the temperature-induced MT in the itinerant Co subsystem (as observed in the boundary compound ErCo_3). With further decreasing temperature, an orthorhombic lattice distortion of the hexagonal structure takes place at 25 K. The distortion indicates the appearance of a non-zero projection of the Er magnetization vector on the basal plane. Note that both the transitions are of a first-order type in this compound. $\text{Er}_{0.8}\text{Y}_{0.2}\text{Co}_3$ still shows a large volume effect at T_M , $\Delta V/V = 0.7 \times 10^{-3}$. Simultaneously, an orthorhombic distortion of the lattice occurs (figure 1(b)). In this compound the temperature of the MT is substantially smeared and coincides with the temperature of spin reorientation T_{SR} . $\text{Er}_{0.8}\text{Y}_{0.2}\text{Co}_3$ is the richest Y-containing compound exhibiting a temperature-induced MT ($T_M \approx T_{SR} = 33$ K). The magnetovolume effect in this compound reaches 2×10^{-3} at 8 K.

The results for $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$ ($T_{SR} = 40$ K) and $\text{Er}_{0.5}\text{Y}_{0.5}\text{Co}_3$ ($T_{SR} = 35$ K) are given in figures 1(c) and (d). No volume expansion, which might be associated with a temperature-induced MT, was found in these intermetallics.

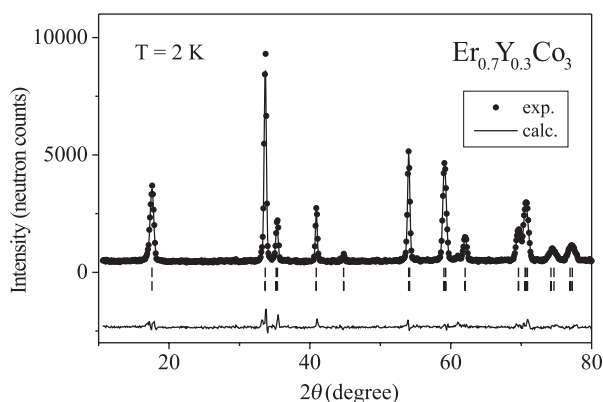


Figure 2. The experimental and calculated neutron diffraction patterns of $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$ at 2 K. The vertical bars correspond to the (hkl) positions (nuclear and magnetic) and the difference curve is given at the bottom of the figure. The Bragg and the magnetic R -factors of the refinement are: $R_B = 4.28\%$, $R_{\text{magn}} = 6.59\%$.

3.2. Neutron diffraction data

For the analysis of the evolution of the magnetic structure in the $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ system, three compounds with $x = 0.1, 0.3$ and 0.5 have been investigated. In figure 2, the neutron diffraction pattern of $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$ refined with the FULLPROF code is shown at 2 K as an example of what has been performed for all the compounds studied at different temperatures. Using these results the magnetic characteristics of $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ compounds were evaluated.

Figure 3 shows the temperature variation of the three Co sublattice (Co_I , Co_{II} , Co_{III}) magnetizations obtained from a FULLPROF fit for $x = 0.1$ and 0.3 and those for ErCo_3 (the dependences for $x = 0.3$ and 0.5 are qualitatively similar). Though the details of the temperature dependence of the Co moments vary from sample to sample, the variation is regular, and the highest magnetization rise at T_M shows the Co_{III} sublattice.

As can be seen from figure 3, the spin reorientation does not affect the value of the Co magnetic moments. The FULLPROF analysis at zero external field B_{ext} shows that the low temperature magnetic phase in the intermediate compounds with $x = 0.1, 0.3$ and 0.5 is non-collinear and the resulting sublattice moments do not lie in the basal plane. For $x \geq 0.3$, the Er_{II} moments form an angle of about $55^\circ \pm 10^\circ$ with the c -axis, while the angle of the Er_I moments is considerably smaller, about $12^\circ \pm 5^\circ$. The three Co sublattice magnetizations also have different orientations, and their resulting magnetization makes an angle of about 55° with the c -axis. The numerical data for $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$ at 2 K are: $\theta_{\text{Er}_I} = 13.9^\circ$, $\theta_{\text{Er}_{II}} = 65.8^\circ$, $\theta_{\text{Co}_I} = 55.7^\circ$, $\theta_{\text{Co}_{II}} = 52.7^\circ$, $\theta_{\text{Co}_{III}} = 50.3^\circ$. Considering that these angles depend weakly on the concentration in the range $0.3 \leq x \leq 0.5$ and are equal to zero for ErCo_3 , it can be concluded that in $\text{Er}_{0.9}\text{Y}_{0.1}\text{Co}_3$, with $\theta_{\text{Er}_I} = 0^\circ$, $\theta_{\text{Er}_{II}} = 10.4^\circ$, $\theta_{\text{Co}_I} = \theta_{\text{Co}_{II}} = \theta_{\text{Co}_{III}} \approx 0^\circ$ at 2 K, the spin reorientation transition is about to start. Owing to a lower line resolution we were not able to detect orthorhombic distortions in the neutron diffraction experiments.

As a representative for the variation of the angles θ_i with the temperature and magnetic field, the (003) neutron peak intensity has been considered. In neutron diffraction this peak has a finite intensity only in the case when some of the Er moments are tilted from the c -direction in the PuNi_3 -type structure and have non-zero projection in the basal plane. Figure 4 shows the evolution of the (003) peak for $\text{Er}_{0.9}\text{Y}_{0.1}\text{Co}_3$ (a), $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$ (b), and $\text{Er}_{0.5}\text{Y}_{0.5}\text{Co}_3$ (c) with temperature. The appearance of a non-collinear spin structure can clearly be seen in these figures. However, it should be noted that the details of the spin reorientation transition

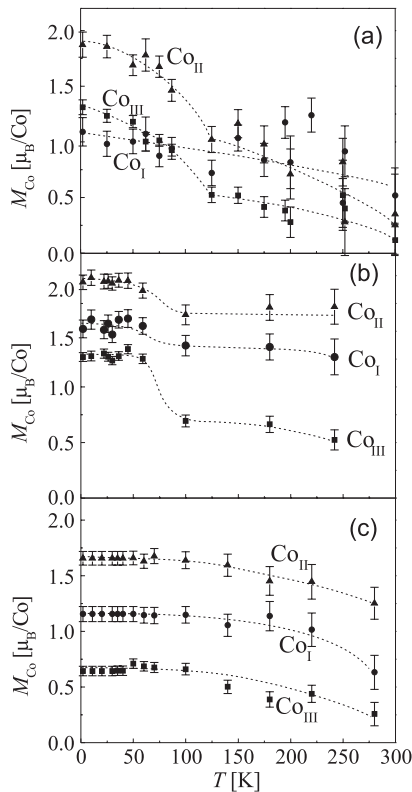


Figure 3. The temperature dependence of the Co sublattice magnetizations M_{CoI} , M_{CoII} and M_{CoIII} for the ErCo_3 (a), $\text{Er}_{0.9}\text{Y}_{0.1}\text{Co}_3$ (b), and $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$ (c) compounds. The dashed curves are guides for the eye.

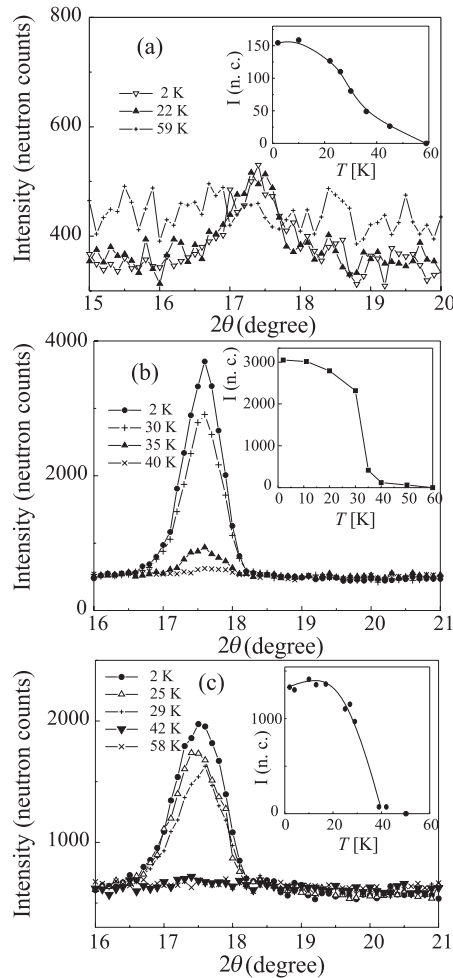


Figure 4. Evolution of the (003) neutron diffraction peak of $\text{Er}_{0.9}\text{Y}_{0.1}\text{Co}_3$ (a), $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$ (b), and $\text{Er}_{0.5}\text{Y}_{0.5}\text{Co}_3$ (c) with temperature. The insets give the temperature dependence of the intensity $I_{(003)}$, and the solid curves are guides for the eye.

depend on the stoichiometry. The x-ray data for $\text{Er}_{0.9}\text{Y}_{0.1}\text{Co}_3$ (1:2.88 stoichiometry) show that the spin reorientation is of a first-order type, while the neutron data obtained for the stoichiometry 1:2.9 show a smoother drop of the (003) peak intensity. Figure 5 illustrates the influence of an external magnetic field on the temperature of the spin reorientation transition in $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$. As seen, T_{SR} increases with the field at a rate of 8 K T^{-1} , and broadens simultaneously. The metamagnetic transition is less sensitive to the magnetic field, e.g., for $\text{ErCo}_3 \partial T_{\text{M}}/\partial B = -1.1 \text{ K T}^{-1}$ [3].

3.3. Magnetoresistance and magnetization

Owing to the itinerant character of the Co magnetism, the temperature dependence of the electrical resistivity is expected to be sensitive to the changes of the magnetic state of Co. As seen from figure 6, the temperature dependence of the electrical resistivity of the $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$

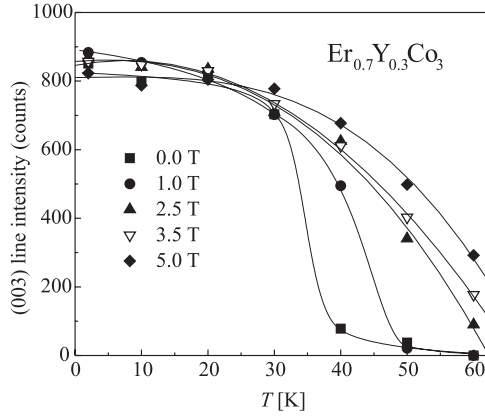


Figure 5. The temperature dependence of the intensity of the (003) reflection of $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$ at different magnetic fields. The curves are guides for the eye.

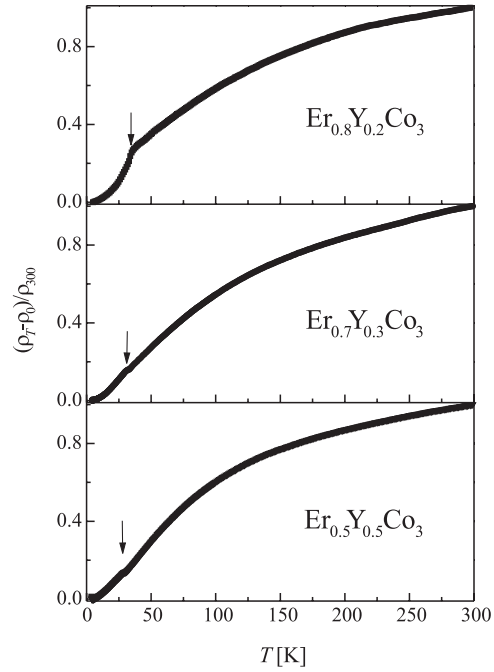


Figure 6. The temperature dependence of the electrical resistivity $\rho_T - \rho_0$ normalized to 300 K for $\text{Er}_{0.8}\text{Y}_{0.2}\text{Co}_3$, $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$, and $\text{Er}_{0.5}\text{Y}_{0.5}\text{Co}_3$. ρ_0 is the value of the resistivity at 2 K. Arrows indicate the position of T_{SR} determined from the thermal expansion data.

compounds shows a noticeable kink at T_M ($x = 0.2$), while T_{SR} is hardly visible on the $\rho(T)$ curves in this scale. The pronounced negative curvature in ρ versus T at elevated temperatures is a clear sign that the spin-fluctuation scattering (within the Co 3d band) dominates the resistivity.

In contrast, the spin reorientation transition is well detected in magnetoresistance measurements $(\Delta\rho/\rho) = (\rho(B) - \rho(0))/\rho(0)$. In figures 7–9 the results for $\text{Er}_{0.5}\text{Y}_{0.5}\text{Co}_3$, $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$ and $\text{Er}_{0.8}\text{Y}_{0.2}\text{Co}_3$ are depicted. In the low temperature region far below the magnetic compensation temperature and above the transition points, the magnetoresistance is small and negative. If there is a spin reorientation only, as for example in $\text{Er}_{0.5}\text{Y}_{0.5}\text{Co}_3$ (see figure 7), $(\Delta\rho/\rho)$ passes over a small maximum at T_{SR} and then again negative values appear in the non-collinear phase. The absolute value of $(\Delta\rho/\rho)$ increases with field and further decreasing temperature, and reaches 5.5% for $B_{\text{ext}} = 8$ T. In the vicinity of the MT, $\text{Er}_{0.8}\text{Y}_{0.2}\text{Co}_3$ (see figure 9), the magnetoresistance changes the sign and $(\Delta\rho/\rho)$ is positive when the Co sublattice is in the strong magnetic state. From the comparison of figures 7 and 9 it follows that the effect of the MT strongly dominates over that of the spin reorientation and $(\Delta\rho/\rho)$ reaches 12% in the low temperature limit for $B_{\text{ext}} = 8$ T.

The $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$ sample shows a borderline behaviour (see figure 8). Down to T_{SR} $(\Delta\rho/\rho)$ versus T resembles that for the sample $\text{Er}_{0.5}\text{Y}_{0.5}\text{Co}_3$. However, below 30 K a strong positive contribution to the magnetoresistance appears, which almost entirely compensates the negative component. In this sample the temperature variation of the magnetoresistance looks qualitatively as a sum of the $(\Delta\rho/\rho)$ versus T dependences of the two others.

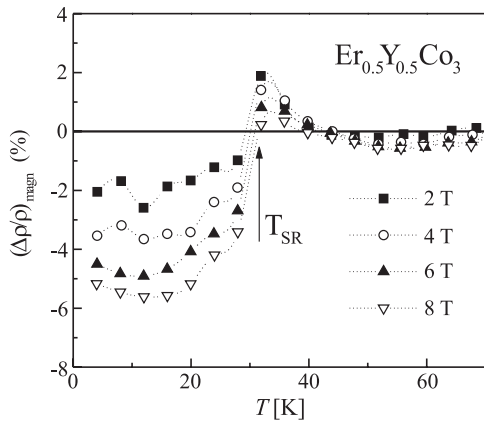


Figure 7. The temperature dependence of the magnetoresistance of $\text{Er}_{0.5}\text{Y}_{0.5}\text{Co}_3$ at different external fields.

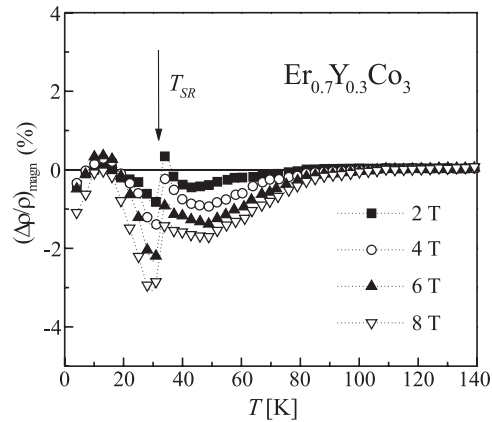


Figure 8. The temperature dependence of the magnetoresistance of $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$ at different external fields.

It was mentioned earlier [4, 6, 11] that, due to the mutual influence of the Co and Er sublattices, the change in the Co magnetic moment induces a corresponding change of the Er magnetization at the temperature-induced MT. As a consequence, the magnetization changes of the resulting Er and Co sublattices substantially compensate each other, and the temperature variation of the magnetization of polycrystalline RCO_3 compounds varies smoothly and shows hardly anomalies at the MT.

The M versus T dependences are, however, sensitive to the spin reorientation. In figure 10 the temperature variation of the magnetization of $\text{Er}_{0.9}\text{Y}_{0.1}\text{Co}_3$ at $B_{\text{ext}} = 1$ and 3 T is shown. The measurements were performed on a textured bulk sample with preferential grain orientation for which the external field was obviously perpendicular to the c -axis. The spin-reorientation transition is clearly visible in the 1 T measurements at 30 K (see figure 1(a)). The minimum in M versus T at 210 K (see figure 10) is due to a compensation of the sublattice magnetizations. The inset in figure 10 shows that at 50 K the magnetization process occurs along the hard direction.

4. Discussion

In figure 11 the concentration dependence of the transition temperatures T_M and T_{SR} is depicted for the $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ system as obtained from x-ray diffraction and resistivity data. The values of T_M and T_{SR} obtained from different measurements are in good agreement.

For a given concentration x , T_M is determined by two temperature-dependent parameters, $M_{\text{Er}}(T_M)$ and $B_M(T_M)$. It can be found from the condition

$$B_M(T_M) = n_{\text{ErCo}}(1-x)M_{\text{Er}}(T_M) \quad (1)$$

(n_{ErCo} is the intersublattice molecular field coefficient averaged over the different Er and Co sublattices). Here the right-hand side of equation (1) is the intersublattice molecular field acting on the Co sublattice. Since B_M is known at low temperatures only, we could not have calculated the T_M -values for different yttrium concentrations. The calculation is possible for low T_M when B_M can be taken 82 T. From figure 11 it follows that the variation of T_M versus x is linear at least up to $x = 0.2$ (a linear dependence is expected when the temperature dependence of M_{Er} and B_M can be neglected). Using a linear extrapolation one would expect

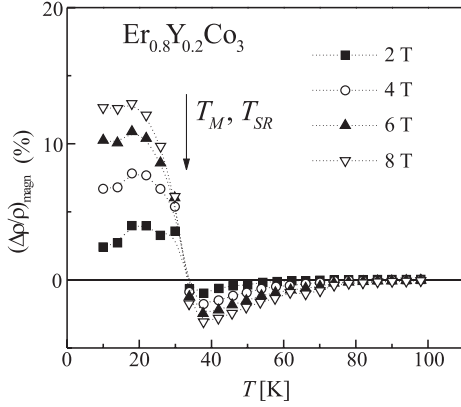


Figure 9. The temperature dependence of the magnetoresistance of $\text{Er}_{0.8}\text{Y}_{0.2}\text{Co}_3$ at different external fields. T_M and T_{SR} coincide for this compound.

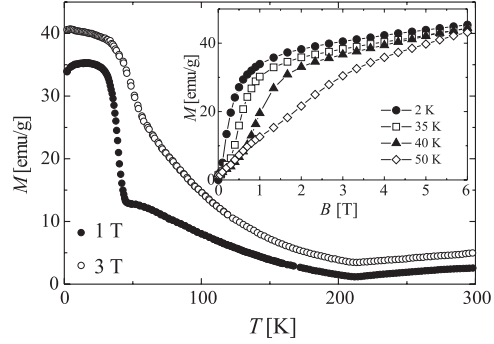


Figure 10. The temperature variation of the magnetization of a textured $\text{Er}_{0.9}\text{Y}_{0.1}\text{Co}_3$ sample. The inset shows the field dependences of the magnetization at different temperatures below and above T_{SR} .

a metamagnetic transition for $\text{Er}_{0.7}\text{Y}_{0.3}\text{Co}_3$ at about 18 K, which however is not observed. A possible reason is obviously the appearance of the non-collinear magnetic structure below T_{SR} , which reduces the total molecular field acting on the Co sublattices and thus no MT exists for $x = 0.3$. This conclusion is also supported by the magnetoresistance. It is easily seen in figure 8 that the spin-reorientation transition prevents the MT in this case, which one would expect near to 20 K.

Taking the critical field B_M of the Co subsystem at 10 K as 82 T in all of the $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ compounds, one can find by linear extrapolation that a temperature-induced MT should occur at about 10 K in $\text{Er}_{0.6}\text{Y}_{0.4}\text{Co}_3$. The coefficient of the intersublattice molecular field n_{ErCo} thus evaluated from equation (1) is $14.8 \text{ T}/\mu_B$, which is close to the value $13.1 \text{ T}/\mu_B$ found in [8] from direct magnetization measurements.

At a first glance, a spin-reorientation transition cannot occur in substituted compounds, as the magnetic anisotropy of the Co sites is uniaxial (note the anisotropy field in YCo_3 is about 10 T at 4.2 K [9]). Since the single ion anisotropy of the Er sites is proportional to the Er concentration, the anisotropy energy of the Er sublattices in substituted compounds can be written as

$$E_A^{(\text{Er})} = \frac{1}{3}(1-x)(E_A^{\text{Er}_I} + 2E_A^{\text{Er}_{II}}), \quad (2)$$

where $E_A^{\text{Er}_I}$ and $E_A^{\text{Er}_{II}}$ have different signs. As seen from equation (2), the total anisotropy energy cannot change its sign with Y substitutions, and the anisotropy field should decrease monotonically with increasing Y concentration. However, it must be taken into account that the absolute values of $E_A^{\text{Er}_I}$ and $E_A^{\text{Er}_{II}}$ are very close in ErCo_3 . Hence, a delicate misbalance due to the Y substitutions is able to change the sign of $E_A^{(\text{Er})}$. In the PuNi_3 -type structure, the coordination polyhedron of the hexagonal Er_I -sites is larger than that of the pseudo-cubic Er_{II} -sites. Therefore it is plausible that Y atoms have some preference to the hexagonal lattice sites. Putting in equation (2) a parameter δ , the difference between the Y content in the two Er sites, one obtains an additional term that can be responsible for the spin reorientation in the substituted compounds:

$$E_A^{(\text{Er})} = \frac{1}{3}(1-x)(E_A^{\text{Er}_I} + 2E_A^{\text{Er}_{II}}) + \delta(E_A^{\text{Er}_I} - 2E_A^{\text{Er}_{II}}). \quad (3)$$

In equation (3), $E_A^{(\text{Er})}$ can change sign if $\delta > 0$.

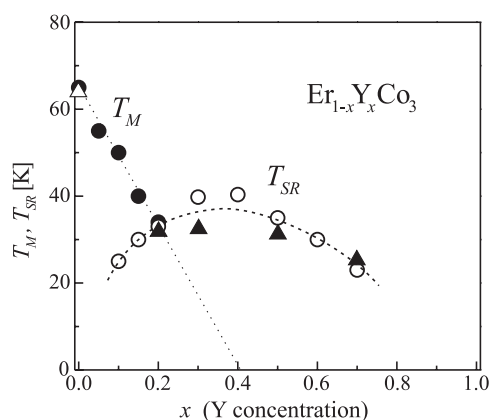


Figure 11. Concentration dependence of the transition temperatures T_M and T_{SR} in the $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ system obtained from x-ray (solid and open circles) and magnetoresistance (open and solid triangles) data. The dashed curves are guides for the eye.

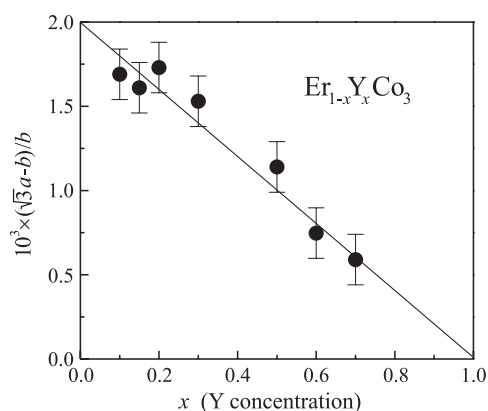


Figure 12. Concentration dependence of the parameter $(a\sqrt{3} - b)/b$ in the $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ system at $T = 8$ K.

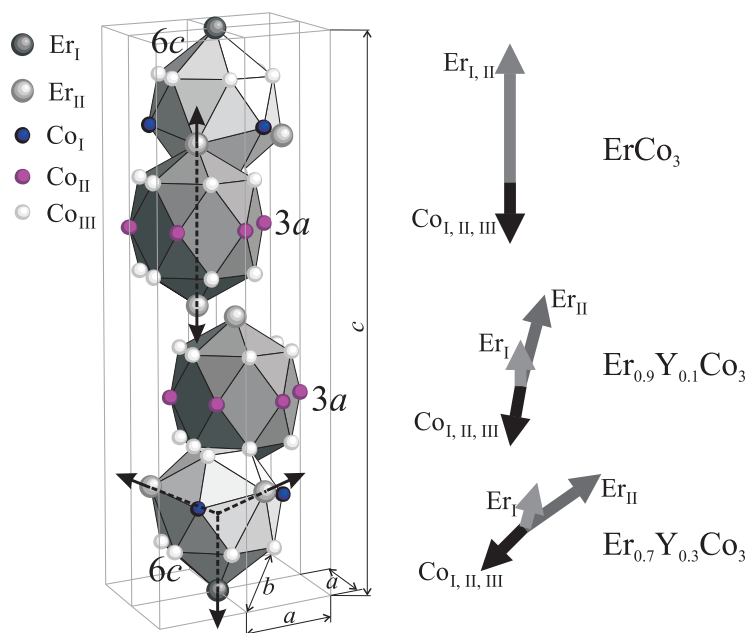


Figure 13. Coordination polyhedra of the Er_I ($3a$) and Er_{II} ($6c$) sites in the rhombohedral PuNi_3 -type crystal structure. The bold arrows indicate the preferable orientations of the Er magnetic moments in polyhedra. The approximate orientation of the Er and Co magnetic moments in $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ compounds at low temperatures is depicted on the right-hand side by thick arrows.

(This figure is in colour only in the electronic version)

Consider now the magnetoelastic distortion and magnetic structure of the $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ compounds. According to the single-ion theory of magnetostriction, the magnetostriction constants must vary linearly as a function of the rare earth concentration (see, for example, [12]).

One can suggest that the anisotropic magnetostriction is determined solely by the Er sublattice. Then, if the Er moments lie in the basal plane, the distortion parameter $\varepsilon = (a\sqrt{3}-b)/b$ is equal to the magnetostriction constant $\lambda^{\gamma,2}$ [12]. When the magnetic structure is canted, the relation between $\lambda^{\gamma,2}$ and ε is more complicated and, since the magnetoelastic constants of different Er sites are different, the variation of ε versus x can deviate from linearity. Figure 12 shows the concentration dependence of ε at low temperature (8 K). Within the frame of experimental accuracy the dependence is linear. This fact can be interpreted as a consequence of a weak concentration dependence of the angles the Er moments form with the basal plane (at least in the range $0.2 \leq x \leq 0.7$); i.e., one can assume that below T_{SR} in the non-collinear phase the low temperature magnetic structure of the $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ compounds is stable. The low temperature value of $\varepsilon = 2 \times 10^{-3}$ evaluated for ErCo_3 is comparable with the values of $\lambda^{\gamma,2}$ found for other R-Co intermetallics, R_2Co_7 and RCo_5 [12].

Taking into account the above arguments, the arrangement of the magnetic moments in the $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ system can qualitatively be depicted as in figure 13. The canting angle for $\text{Er}_{0.9}\text{Y}_{0.1}\text{Co}_3$ is substantially smaller than in compounds with $x \geq 0.3$.

5. Summary

The $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ intermetallics exhibit interesting phenomena related to both the Co magnetic instability and the Er magnetic anisotropy. A non-collinear magnetic structure appears in the intermediate Y-concentration region, which indicates that the Y atoms obviously prefer to occupy the larger 3a sites with cubic symmetry in the PuNi_3 -type structure. The magnetic phase diagram of the $\text{Er}_{1-x}\text{Y}_x\text{Co}_3$ system shows that the temperature-induced MT observed in ErCo_3 is retained up to a substitution of 20 at.% of Y.

Acknowledgments

We are obliged to give proper credit to BENSC staff members and facilities. This work was supported by the EU through the Human Potential Program under HPRI-CT-1999-00020 and HPRI-CT-2001-00138 and by RFBR under Pr. No. 03-02-16482a.

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