SPIN-REORIENTATION TRANSITIONS IN RARE-EARTH INTERMETALLIC COMPOUNDS

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The spin-reorientation transitions (SRT's) in magnetic materials have attracted an attention for more than forty years. Over the past decade, the SRT's have been increasing both fundamental and technical interest in context of ultrathin ferromagnetic films. The phenomenon originates from a combined action of an exchange interaction and a magnetic anisotropy. Therefore, a study of the SRT's allows one to obtain information about these interactions and to determine their main characteristics.

We review the results of our investigations of the spontaneous SRT, SRT determined by concentration and SRT induced by a magnetic field in Tm_2Fe_{17}, $Tb_{1-x}Er_xNi_5$ and $TbMn_6Sn_6$ compounds. Neutron diffraction experiments were carried out on diffractometers: D-3 (Zarechny, Russia), E-4 (Berlin, Germany), HRPD (Taejon, Korea) and C-2 (Chalk River, Canada). An inelastic neutron scattering has been measured with the KDSOG spectrometer (Dubna, Russia).

In Tm_2Fe_{17} the spontaneous SRT is accompanied by large magnetization anisotropy of Tm- and Fe-sublattices. The largest value of magnetization anisotropy (about 25 %) is observed in the Tm-sublattice, formed by the ions at the 2*b* positions. Using temperature dependence of the Tm-sublattice magnetization we have determined the parameter of Tm-Fe exchange interaction (~ 230 K/Tm-ion) and anisotropy constants of the Tm ions at 2*b*- and 2*d*- positions (120 and 30 K/Tm-ion, respectively). These values are satisfactory agreed with those obtained from the inelastic neutron scattering data. In the framework of a model of system with strongly quenched orbital magnetic moments the anisotropy constants of each of four Fe-sublattices were estimated. Fe atoms at 4*f* position exhibit the largest magnitude of the anisotropy (~ 15 K/Fe-atom).

The SRT determined by concentration is observed in $Tb_{1-x}Er_xNi_5$ as a rotation of the spontaneous magnetization from the basal plane to the *c*-axis with increase of the concentration *x* at 2 K. At the same time, as it follows from an analysis of concentration dependence for a rare-earth sublattice magnetization, the magnetic moments of the Tb- and Er- ions keep orientations along the own easy axis directions: perpendicular and parallel to the *c*-axis for the Tb- and Tm- moments, respectively. This implies that magnetic anisotropy energies of the Tb- and Tm- ions exceed Tb- Er exchange interaction energy.

The SRT in $TbMn_6Sn_6$ can be induced at room temperature by an application of a relatively low external magnetic field. The Tb- and Mn-sublattice magnetizations rotate from *c*-axis at the angle 40°, when the magnetic field $\mu_0H=4$ kOe is applied. Another feature of the induced SRT in $TbMn_6Sn_6$ is that it becomes apparent as a first order magnetization process.

Three-sublattice model of magnetic anisotropy for compounds of the rare-earth elements and 3d-transition metals are discussed.