Incommensurate magnetic structure in $Y_{1-x}Tb_xMn_6Sn_6$.

Yu. O. Chetverikov$^1$, S.V. Grigoriev$^1$, A.I. Okorokov$^1$, A.N. Pirogov$^2$, S.G. Bogdanov$^2$, H. Eckerlebe$^3$, K. Pranzas$^3$

1 Petersburg Nuclear Physics Institute, Gatchina, St. Petersburg 188300, Russia
2 Institute of metal physics UD RAS 620219, Russia
3 GKSS Forschungszentrum, 21502 Geesthacht, Germany

We have investigated the magnetic structure in the intermetallic compounds $Tb_xY_{1-x}Mn_6Sn_6$ ($0 \leq x \leq 0.25$) by means of small angle neutron scattering (SANS). In such intermetallic materials the competition between different exchange interactions results in a variety of the magnetic structures and properties. Thus, giant magnetoresistance was recently found in this type of materials [1].

The $YMn_6Sn_6$ is a compound crystallized in hexagonal HfFe$_6$Ge$_6$-type structure (space group P6/mmm) [2]. The lattice has an intrinsically layered structure, where Mn atoms are organized in a so-called “kagome” lattice within the ab planes, which are stacked along the c axis with Y and Sn$_3$ atomic planes between them. The Mn-Mn interplane distance through Sn$_3$ atomic plane is slightly larger than that through Y atomic plane. Below the Neel temperature $T_N = 333K$ the $YMn_6Sn_6$ compound has an incommensurate periodic structure [3]. It is believed that spins are ordered in the helix along the c axis similar to a simple planar helimagnet [4].

To make clear a role of different exchange interactions we studied samples where Y is partially substituted by Tb. The substitution of magnetic Tb for Y in the $Tb_xY_{1-x}Mn_6Sn_6$ compounds changes the magnetic ordering type from incommensurate antiferromagnetic to ferrimagnetic at the concentration $x = 0.2$. The ferrimagnets at $x > 0.2$ show a change of the magnetocrystalline anisotropy with increase of temperature from an easy-axis type to an easy-plane type through a conical phase [5].

The use of SANS allows one to observe large-scale magnetic ordering modes. Two scattering contributions are well distinguished. The first one is a diffraction peak, which originates from the scattering on the magnetic long periodic structure. The second one is a small angle scattering attributed to the magnetic inhomogeneities such as domains or critical spin fluctuations. The period of the magnetic structure calculated from diffraction peak position for $T=175K$ is $d_{Tb0}=3.76$ nm for $YMn_6Sn_6$ and is $d_{Tb2}=7.06$ nm for $Tb_2Y_{0.8}Mn_6Sn_6$. Coherent lengths of magnetic structure are $\lambda_{Tb0}=17$ nm and $\lambda_{Tb2}=28$ nm. Experimental data suggest that the temperature behavior of the magnetic structure for $YMn_6Sn_6$ is very different from that for the simple planar helimagnet of Ho or Dy- type [4]. The temperature evolution of the magnetic structure for samples with Tb- substitution is even more complex. The c-T phase diagram is obtained on the basis of SANS measurements.

References