Magnetic Hyperfine Field at ^{119}Sn and ^{111}Cd probes in Gd_5Ge_4 Studied by Mössbauer and PAC Spectroscopy

V. I. Krylov[1,2], B. Bosch-Santos[1], G. A. Cabrera-Pasca[1], A. W. Carbonari[1], R. N. Saxena[1], and O. F. S. Leite Neto[1]

[1]*Instituto de Pesquisas Energéticas e Nucleares, IPEN, São Paulo, SP, Brazil*
[2]*Skobeltsyn Institute of Nuclear Physics, Moscow State University, 119992 Moscow, Russia*

E-mail: rnsaxena@ipen.br

The magnetic structure of Gd_5Ge_4 belonging to the family of giant magnetocaloric $Gd_5(Si_{1-x}Ge_x)_4$ alloys [1] has been examined by magnetization measurements in single crystal [2, 3], X-ray resonant magnetic scattering (XRMS) [4], and neutron powder diffraction (NPD [5]. Gd_5Ge_4 crystallizes in the orthorhombic structure (space group *Pnma*) having three non-equivalent Ge-sites. At low temperatures, the Gd magnetic moments are ferromagnetically (FM) aligned within the slabs along the c-direction, while their stacking in the *b*-direction is antiferromagnetic (AFM) below 127 K [2, 4].

In this work, the temperature dependence of the magnetic hyperfine field (HF) and electric quadrupole interaction on ^{119}Sn and ^{111}Cd probe nuclei in Gd_5Ge_4 compound have been investigated by Mössbauer and perturbed angular correlation (PAC) spectroscopy. At the saturation, the HF magnitudes reach of B_{hf} =28.0(5) T and B_{hf}= 12.6(5) T for ^{119}Sn and ^{111}Cd, respectively, which correspond to the FM local magnetic environment for these probes. It was found that ^{119}Sn probes are placed in two Ge positions, whereas ^{111}Cd probes are located in only one of the three Ge positions in Gd_5Ge_4. Temperature dependence of B_{hf} for both ^{119}Sn and ^{111}Cd probes in Gd_5Ge_4 present anomalous behavior. In the range from 20 K to 120K, the HF decreases almost linearly when temperature increases.

These anomalous behavior of B_{hf}(T) for ^{119}Sn and ^{111}Cd probes are in agreement with the temperature variation of the magnetic (070) and (010) peak intensities that have been found in XRMS [3] and NPD [4] studies. The AFM ordering temperature of Gd_5Ge_4, T_N=129(1) K, found from the B_{hf} (T) is in agreement with previous results of [2 - 5].

Changes of the values and sign of the quadrupole shift of Mössbauer spectra for ^{119}Sn atoms with the increase of temperature from 30 to 50 K confirm the spin-flop transition in Gd_5Ge_4 [2, 4].

[1] V. K. Pecharsky and K. A. Gschneidner, Jr., Phys. Rev. Lett., **1997**, *78*, 4494.
[2] E. M. Levin *et al.* Phys. Rev. B, **2004**, *69*, 114428.
[3] Z. W. Ouyang et al. Phys. Rev. B, **2007**, *76*, 134415.
[4] L. Tan *et al.*, Phys. Rev. B, **2005**, *71*, 214408.
[5] D. H. Ryan *et al.*, Phys. Rev. B, **2010**, *82*, 224405.