Huge negative magnetic hyperfine fields for ^{111}Cd probe nuclei in the Fe_3X (X=C, Ge, and Ga) compounds with specific properties

Vasily I. Krylov[1,2], Brianna Bosch-Santos[1], Gabriel Adolfo Cabrera-Pasca[1], Artur Wilson Carbonari[1]

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

In recent years, Fe_3X (X = C, Ga, and Ge) alloys are actively investigated experimental and theoretical methods due to their potential practical use as invar, magnetostrictive materials, and multi-layered ferromagnetic film [1-3]. The Fe_3C alloy was studied by nuclear resonant scattering on ^{57}Fe and by x-ray emission spectroscopy at high pressure up to 50 GPa because this substance could be the major Earth's inner core component [4, 5].

In this work we found huge negative HFs reaching a magnitude of B_{hf} = -46T on ^{111}Cd probe nuclei in ferromagnetic Fe_3X (X = C, Ga, and Ge) alloys by perturbed γ-γ angular correlation (PAC) spectroscopy. These values are the highest known HFs on ^{111}Cd nuclei in metallic magnets. It was established that in Fe_3C crystallizing in the orthorhombic DO11 structure (Pnma space group) ^{111}Cd probes are placed in Feg sites with 11Fe atoms as nearest neighbours (n.n.). For Feg positions, the n.n. arrangement is similar to normal hexagonal close packing. The HF value for ^{111}Cd atoms in Fe3C is equal to B_{hf} = -38.0(1) T at 77K. In tetragonal DO3 crystal structure of Fe3Ga 111Cd probes are placed in both Ga sites (12 n.n. Fe) and in FeII (8n.n.Fe). The HFs for ^{111}Cd atoms in Fe_3Ga are equal to B_{hf} = -39.8(1) T and B_{hf} = -24.2(3) T at 77K for Ga and FeII sites of ^{111}Cd localization. In hexagonal DO19 crystal structure of Fe_3Ge ^{111}Cd probes are placed in Ge sites (12 n.n.). The HF value for ^{111}Cd probes in Fe_3Ge is equal to B_{hf} = -46.0(1) T at 40K. There are no any anomalies of the B_{hf} (T) on ^{111}Cd nuclei in the spin reorientation region of Fe_3Ge. The results of this work are analyzed with the previously obtained HF's values on ^{111}Cd nuclei in 3d metals and their alloys including Heusler alloys.

[1] I. G. Wood et al., J. Appl. Cryst. 37, 82 (2004)
[2] R. Wu, J. Appl. Phys. 91, 7358 (2002)
[3] F. Albertini et al., J Appl Phys. 96 2110 (2004)
[4] L. Gao et al., Geophys. Res. Lett. 35, L17306 (2008)
[5] J. F. Lin et al., Phys, Rev. B 70, 212405 (2004)