Contribution ID : **97** Type : **Poster**

Crystal field interactions in the chiral compounds RNi_3Ga_9 (R = Tb, Dy, Ho and Er) studied by inelastic neutron scattering

Thursday, 12 November 2020 17:45 (1)

In recent years, compounds with chiral structures have attracted much attention mainly because of non-collinear and non-coplanar spin textures, which have an important application in spintronics. In chiral compounds, the lack of inversion symmetry can give rise to an asymmetric spin interaction, the so-called Dzyaloshinskii-Moriya interaction, which contributes to the symmetric exchange interaction and anisotropy effects from the crystal field. These interactions' coexistence can result in unusual magnetic properties and exotic magnetic structures with potential for many applications and novel phenomena. In this work, we study the magnetic properties of the chiral compounds RNi_3Ga_9 (R = Tb, Dy, Ho and Er), which crystalize in a trigonal ErNi3Al9-type structure with non-centrosymmetric space group R32 [1]. For this purpose, we analyzed the inelastic neutron scattering (INS) spectra in powder samples at several temperatures (T) to study the crystal electric field (CEF) excitations and ground-state. The INS experiments were performed at the SIKA beamline using the cold triple-axis spectrometer. The spectrum was analyzed at four temperatures for $ErNi_3Ga_9$ (T = 8, 20, 50 and 100K) and two temperatures for $TbNi_3Ga_9$ (T = 50 and 100K), $HoNi_3Ga_9$ (T = 30 and 100K) and $DyNi_3Ga_9$ (T = 50 and 100K). Moreover, transverse and longitudinal magnetic susceptibility was measured in single-crystalline samples to fit the CEF parameters better.
We developed a code based on the magnetic susceptibility and differential cross-section for magnetic scattering at low Q (dipole approximation) to process and analyze the experimental data. The effective CEF hamiltonian for the system follows the C_3 point symmetry, which results in 9 CEF parameters overall. The least-square fitting procedure uses a machine-learning algorithm based on particle swarm optimization. We report the energy levels scheme due to the crystal field and the CEF ground state's eigenfunctions. In particular, the INS spectra for the ErNi3Ga9 compound showed peaks associated with the so-called hot transitions, which take place between excited energy levels. We only observed peaks associated with transitions between the ground-state and the first excited levels for R = Ho, Tb, and Dy. The calculated INS spectra and magnetic susceptibility were in good agreement with the experimental data. In particular, the calculated magnetic susceptibility showed that the direction of easy magnetization occurs along the c-axis for the ErNi3Ga9 compound and along the basal plane for the other compounds. It evidences the oblate and prolate nature of the rare-earth ions charge distributions. In summary, we used inelastic neutron scattering data to establish the CEF parameters for all compounds according to the C_3 point symmetry. The obtained parameters describe the CEF energy levels' configuration and the relative intensity of the peaks observed in the INS spectrum, besides the transverse and longitudinal magnetic susceptibility in the paramagnetic region.

[1] L. S. Silva, S. G. Mercena, D. J. Garcia et al. Phys. Rev. B, 95, 134434 (2017).

Speakers Gender

Male

Level of Expertise

Student

Do you wish to take part in the poster slam

Yes

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Session Classification : Poster Session

Track Classification : Magnetism & Condensed Matter