Physical Review B 2017 vol.95 N12

Spectroscopy of f-f transitions, crystal-field calculations, and magnetic and quadrupole helix chirality in DyF e3(B O3)4

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Abstract

© 2017 American Physical Society. We present the results of temperature- and polarization-dependent high-resolution optical spectroscopy studies of DyFe3(BO3)4 performed in spectral ranges 40-300cm-1 and 3000-23000cm-1. The crystal-field (CF) parameters for the Dy3+ ions in the P3121 (P3221) phase of DyFe3(BO3)4 are obtained from calculations based on the analysis of the measured f-f transitions. Recently, quadrupole helix chirality and its domain structure was observed in resonant x-ray diffraction experiments on DyFe3(BO3)4 using circularly polarized x rays [T. Usui, Y. Tanaka, H. Nakajima, M. Taguchi, A. Chainani, M. Oura, S. Shin, N. Katayama, H. Sawa, Y. Wakabayashi, and T. Kimura, Nat. Mater. 13, 611 (2014)10.1038/nmat3942]. Using the obtained set of the CF parameters, we calculate temperature dependencies of the electronic quadrupole moments of the Dy3+ ions induced by the low-symmetry (C2) CF component and show that the quadrupole helix chirality can be explained quantitatively. We also consider the temperature dependencies of the bulk magnetic dc-susceptibility and the helix chirality of the single-site magnetic susceptibility tensors of the Dy3+ ions in the paramagnetic P3121 (P3221) phase and suggest the neutron and resonant x-ray diffraction experiments in a magnetic field to reveal the helix chirality of field-induced magnetic moments.

http://dx.doi.org/10.1103/PhysRevB.95.125131

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