Crystal field excitations of $Tb_3Ga_5O_{12}$ in a magnetic field

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We will discuss crystal field excitation (CFE) and phonon of a nonmagnetic insulator $Tb_3Ga_5O_{12}$ (TbGG) in a magnetic field observed by the inelastic neutron scattering. In addition to the acoustic phonon, several CFEs with large intensity around 6 meV and with weak intensity at low energies are observed. The latter one (approximately 2 meV at 4 T magnetic field) is thought to be related to the phonon Hall effect (PHE), which is a Hall effect with respect to a heat flow carried by a phonon. When a magnetic field is applied perpendicularly to a heat flow, a temperature difference occurs in a direction perpendicular to both of the heat flow and the magnetic field. It has been observed in TbGG [1,2]. Since phonons have neither charge nor spin, its mechanism is not obvious. We theoretically proposed that the origin is resonant scattering of phonons by Tb-CFE [4]. The Tb ion is located in the center of a twisted tetrahedron (D_2) composed of oxygen, and there are six different sites within a unit cell under a magnetic field [5,6]. Using the crystal field parameters given in these previous studies, the CFE is calculated in accordance with our experimental configuration, and the wave function of the crystal field depending on the magnetic field in the low energy region is obtained. It becomes possible to determine the elementary process of resonance scattering that contributes to the phonon Hall effect.

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