PROBING MAGNETIC MOMENTS BY OPTICAL SPECTROSCOPY OF *f-f* TRANSITIONS

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Possibilities of modeling physical properties of rare-earth (RE) containing crystals on the basis of the optical spectroscopy of *f-f* transitions are discussed. In particular, peculiarities in magnetic and thermodynamic properties can be well described using optical data on the splitting of the ground doublet of the RE ion. The results on several crystals, studied by the author, with magnetic system formed by two competitive subsystems of *d*- and *f*-ions are presented. Among them, there are compounds from the families of Haldane chain nickelates RE_2BaNiO_5 [1], of classical multiferroics REMnO$_3$ [2], of new magnetically two-dimensional frustrated francisites Cu$RE_3(SeO_3)_2$OCl [3,4].

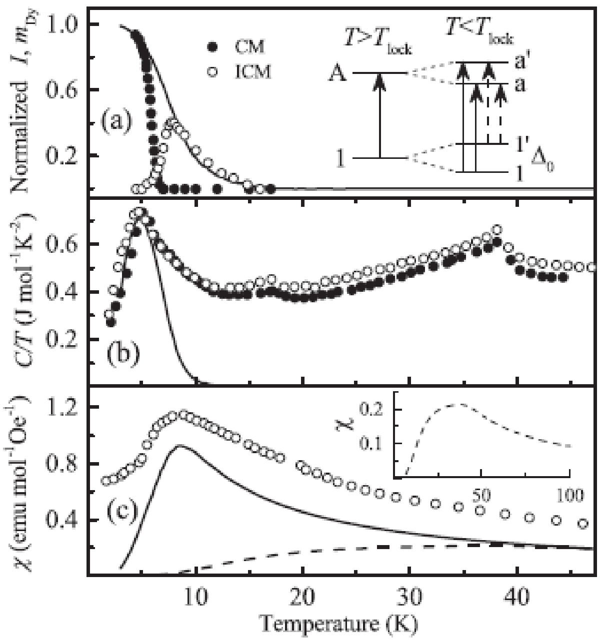

Fig.1. Dysprosium contribution (solid line) into the (a) magnetic moment, (b) specific heat, and (c) magnetic susceptibility of DyMnO$_3$, calculated from the experimentally found ground-state splitting of Dy^{3+} and compared with (a) x-ray resonant magnetic scattering, (b) specific heat, and (c) magnetic susceptibility (H||b) measurements. Symbols represent the literature experimental data. Inset in (a) illustrates Dy line splitting in a magnetically ordered state. Inset and the dashed line in (c) display a hypothetical Dy contribution in the case of $\Delta_0(0)$ = 30 cm^{-1}.

Temperature-dependent (4-300 K) transmittance spectra of the representatives of the mentioned families of compounds were measured with the use of a BRUKER IFS125HR Fourier-spectrometer and an optical pulse-tube cryostat CRYOMECH PT403. As a result, energies of the crystal-field *f*-states, their temperature dependences including energy splittings in a staggered magnetic field were obtained.

To describe magnetic and thermodynamic properties of the compounds studied a model of the ground-state doublet developed in our laboratory was applied together with the mean-field theory. This model allows deriving formulae similar to the phenomenological equations, but some parameters, meaningless in the last case, get physical relevance –in the former. As an example, Fig.1 demonstrates how the modeling using optical experimental data can explain the behavior of the magnetic moment of the Dy^{3+} ion in orthorhombic DyMnO$_3$ and describe the anomalies in the temperature dependences of the specific heat and the magnetic susceptibility of the crystal.

The author acknowledges a scientific contribution of his colleagues [1-4].

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