Ferromagnetic phase transition modified by domain effects in strongly anisotropic $DyAl_3(BO_3)_4$, at sub-kelvin temperatures.

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A detailed investigation of low-temperature magnetic properties of the rare-earth aluminoborate $DyAl_3(BO_3)_4$ is presented, based on specific heat, dc and ac magnetization, and magnetic susceptibility measurements carried out at temperatures below 1 K, in magnetic field up to 9 T applied parallel and perpendicular to the crystallographic $\boldsymbol{c}$ axis. A sharp λ-type anomaly in the specific heat at $T_c \approx 0.52$ K provides clear evidence for a second-order magnetic phase transition associated with the onset of long-range magnetic ordering of Dy^{3+} moments. The magnetization and susceptibility data reveal strong uniaxial magnetic anisotropy with the easy magnetization axis aligned along $\boldsymbol{c}$ axis, consistently with an Ising-like character of the Dy^{3+} ground-state Kramers doublet reported in literature.

The temperature–magnetic field phase diagram exhibits, surprisingly, an unusual non-monotonic dependence of the temperature of appearance of the specific heat anomaly on the applied magnetic field. In weak magnetic fields applied along the easy axis, the temperature of appearance of the specific heat maximum is initially suppressed and then increases in higher fields, in contrast to the monotonic increase of the transition temperature expected for conventional ferromagnets. At the same time, the magnetic contribution to the specific heat below T_c remains only weakly dependent on the external magnetic field. This combination of features provides strong evidence that temperature dependence of the specific heat within the low-temperature ordered phase is governed by magnetic domain structure, which effectively diminishes the intensity of the internal magnetic field.

We analyzed the obtained results in frames of the molecular field approximation by adopting the model elaborated for the dipolar magnets [1,2] to the case of $DyAl_3(BO_3)_4$. A satisfactory agreement between the experimental data and the theoretical curves was achieved.

References:

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[2] G. Mennenga, L. J. de Jongh, and W. J. Huiskamp, J. Magn. Magn. Mater. 44, (1984) 59.