

Magnetic properties of the $\text{Dy}_x\text{Y}_{1-x}(\text{PO}_3)_3$ glasses

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The magnetic behavior of rare-earth ions is most often explored in periodic crystalline lattices, where the crystal electric field (CEF) which influenced magnetic ion is uniform. In contrast, we investigated magnetic glasses of composition $\text{Dy}_x\text{Y}_{1-x}(\text{PO}_3)_3$ with Dy^{3+} concentrations of $x = 0, 0.0001, 0.001, 0.01, 0.1,$ and 1 . For the non-magnetic sample ($x = 0$), the specific heat displays a boson peak at $T_{\text{BP}} \approx 12$ K, a typical feature of amorphous solids [1]. In magnetic samples ($x \neq 0$), an additional contribution emerges, producing a Schottky-like anomaly in the concentrated Dy^{3+} sample ($x = 1$) whose intensity systematically decreases with dilution. Application of an external magnetic field shifts this anomaly to higher temperatures while reducing its amplitude. Magnetization measurements at 1.8 K yield saturation moments below the theoretical value $\mu_{\text{eff}} = 10.65 \mu_{\text{B}}$, consistent with the pronounced anisotropy of Dy^{3+} ions. The magnetic susceptibility between 1.8 and 300 K shows no difference between zero-field-cooled and field-cooled regimes, confirming the absence of magnetic ordering. A Curie–Weiss analysis indicates weak antiferromagnetic interactions that become progressively weaker with decreasing Dy^{3+} content, while the effective magnetic moment at 300 K remains close to $\mu_{\text{eff}} = 10.65 \mu_{\text{B}}$. AC susceptibility data reveal slow magnetic relaxation in zero field, dominated by a single relaxation mechanism. The characteristic relaxation frequency decreases with Dy^{3+} dilution, starting from above 10 kHz for $x = 1$, to 3 kHz for $x = 0.1$, 730 Hz for $x = 0.01$, 20 Hz for $x = 0.001$, and below 0.1 Hz for $x = 0.0001$ reflecting progressively weaker Dy^{3+} – Dy^{3+} interactions.

References:

[1] P. Baloh et al., Thermodynamic properties of the phosphate glass $\text{Dy}_x\text{Y}_{1-x}(\text{PO}_3)_3$ – Potential influence of boson peak on spin relaxation, *J. Magn. Magn. Mater.* 588 (2023) 171415.

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