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Anomalous specific heat and magnetic properties of $Tm_xDy_{1-x}Al_2$ ($0 \leq x \leq 1$)

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Abstract:

We study crystal structure, phase transitions and magnetism of pseudo-binary $Tm_xDy_{1-x}Al_2$ ($0 \leq x \leq 1$) compounds using temperature dependent X-ray powder diffraction, specific heat and magnetization measurements, first principles, and model calculations. In low external magnetic fields, Dy-rich compounds undergo continuous, second-order phase transitions at the respective Curie temperatures, T_C. In contrast, the Tm-rich compounds exhibit discontinuous, first-order anomalies in the magnetically ordered states. These sharp transitions correlate with a substantial energy difference between the room temperature cubic and ground state rhombohedral structures of $TmAl_2$. A clear anomaly in the lattice parameter is observed at ~30 K for x = 0.5, which nearly coincides with T_C = 31.2 K. The effective quadrupolar moment of the lanthanides changes sign around x = 0.5, which leads to a nearly zero anisotropy constant and approximately spherical effective 4*f* charge densities, providing an explanation for the lack of structural distortions below T_C for x = 0.5. The calculations confirm [001] as the easy magnetization axis in the ground state tetragonal structure of $DyAl_2$, and reveal collapse of the orbital magnetic

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