Synthetization, Stability and Magnetization of the Quasicrystal, 2/1 and 1/1 Approximants in Cd-Mg-RE (RE = Tm, Er, Ho, Dy, Tb, Gd, Sm, Y) Systems

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The present study was designed to first, determine the effect of Mg and RE elements as well as temperature on stability of the icosahedral quasicrystal (i-QC), 2/1 and 1/1 approximants (APPs) in Cd-Mg-RE (RE = Y, Sm, Gd, Tb, Dy, Ho, Er, Tm) systems. Based on the obtained results, the i-QC compositional region in ternary phase diagrams shrinks gradually as the constituent RE element becomes smaller in atomic size. This phenomenon is argued by considering geometric stability of the rhombic tricontahedral (RTH) cluster. Single i-QC, 2/1 and 1/1 APP grains with, respectively, rhombic triacontahedron, octahedron and rhombic dodecahedron morphologies, in the scale of ≈1.5-2 mm were further synthesized, applying self flux method. The obtained single 2/1 and 1/1 APP grains were then analyzed by single-crystal x-ray diffraction. The initial structure refinement of the 1/1 APP revealed eight Cd_8 cavities along three-fold directions of the RTH cluster unit, which is usually filled by Cd atoms in the ternary Cd-Mg-Yb-1/1 APP system. As a consequence of lacking Cd atoms in Cd_8 cavities, 1/1 APP in these systems deviates from the ideal Cd_6RE stoichiometries. Moreover, magnetic susceptibility of the obtained i-QC, 2/1 and 1/1 APP in Cd-Mg-RE (RE = Tm, Tb, Gd) systems were measured under H = 100 Oe. The preliminery results showed spin-glass-like behavior for all the investigated samples. A rough agreement between the de Gennes scaling and the experimental Curie-Weiss temperatures ($|\Theta|$) was observed (see Fig. 1a). Note that all Θ values are negative indicating that major interaction between spins is antiferromagnetic in the paramagnetic state. Moreover, as a general trend, i-QC shows higher $|\Theta|$ and lower T_{max}, at which the maximum of ZFC dc magnetization occurs, compared to 2/1 and 1/1 APPs, respectively. In the plot of the $T_{max}/|\Theta|$ in Fig. 1b, clearly, i-QC has lower T_{max} for a given $|\Theta|$ values compared to 2/1 and 1/1 APP. Similarly, inside each category, i.e., i-QC, 2/1 and 1/1 APP, which are highlighted in different colors in Fig. 1b, Gd has a lower T_{max} for a given $|\Theta|$ compared to Tb. This phenomena was associated with the difference between Heisenberg-like ion (Gd^{3+}) and non-Heisenberg-like ion (Tb^{3+},Tm^{3+}).

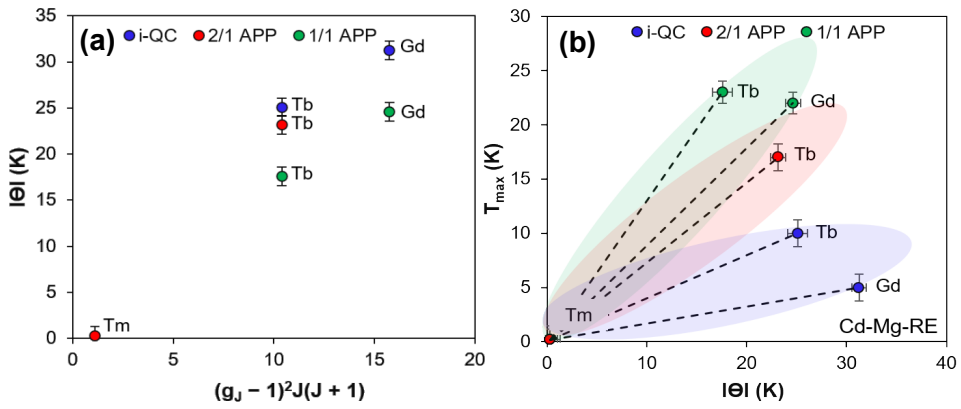

Fig. 1. Variation of (a) Curie temperatures $|\Theta|$ as a function of the de Gennes factor: $(g_J - 1)^2J(J + 1)$ and (b) T_{max} as a function of Θ for i-QC, 2/1 and 1/1 APP in the Cd-Mg-RE (RE=Gd, Tb and Tm) systems.