Field-induced glassiness in disordered cluster antiferromagnets

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Cluster magnets are systems in which the intrinsic magnetic moments are assembled in small groups that weakly interact with their environment. In these systems, a richness of physical properties is observed, which is ruled mostly by the cluster structure and intracluster interactions. In the present work, we present a study of cluster antiferromagnets in which a disordered coupling between clusters is considered. We adopt the Sherrington-Kirkpatrick [1] type of coupling, which was evaluated within a replica-symmetry approach. Our model considers triangular and square plaquette clusters of Ising spins. We evaluate the temperature \( T \) versus longitudinal external magnetic field \( H \) phase diagrams - by computing the de Almeida-Thouless stability line - and the magnetocaloric properties of these systems. As a result, we found field-induced freezing of magnetic cluster moments for the square plaquette. Moreover, when geometrical frustration is present, a field-induced revival of cluster glassiness is observed. We also notice that the magnetocaloric properties can be used to identify whether a weak disorder is manifested in cluster antiferromagnets. In particular, we found that the convergence of the adiabatic curves in the \( T - H \) plane towards the critical fields when \( T \to 0 \), which is observed in the clean limit, is smeared out by a weak disorder. More important, this effect can be identified even above the freezing temperature. Our results reinforce that weakly disordered cluster antiferromagnets are prototypes for field-induced glassiness, as suggested in a recent investigation of a van Hemmen cluster model [2]. We also propose that the present theoretical framework can help to identify disorder effects in cluster antiferromagnets.
