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On the 'glassy' transition and fragility of the ferromagnetic plaquette Ising model

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The three dimensional ferromagnetic plaquette Ising model (FPIM) is believed to have a first order phase transition at $T_c \simeq 3.60$ screened by strong metastability leading to a so-called "glassy transition" at $T \simeq 3.40$ when subjected to slow cooling [1,2]. By computing the configurational entropy $S_c \equiv S(\text{liquid}) - \text{S(crystal)}$ in the supercooled temperature range via thermodynamic integration of the internal energy results, we determine the Kauzmann temperature $T_K \simeq 3.18$, defined as that temperature where the extrapolated configurational entropy $S_c(T)$ vanishes. By finding ways to estimate the equilibration time of the supercooled liquid and the nucleation time of the stable crystal droplets, it is shown that $T \simeq 3.4$ is indeed the limit of stability or the effective spinodal temperature T_{sp} at which the two time scales associated with the quasiequilibration of the supercooled liquid, τ_{eq}, and the nucleation of the stable crystal droplets, τ_{nuc}, cross one another, with the former rising above the latter such that the supercooled liquid state becomes physically irrelevant below $T_{\text{sp}} \simeq 3.40$ and the impending entropy crisis at $T_K \simeq 3.18$ ($< T_{\text{sp}}$) is thus avoided [3]. Hence, what is sometimes called "glassy temperature," is really a kinetic spinodal temperature below which fast nucleation of the mismatched crystal droplets is followed by a glacially slow crystal growth [4]. The Adam-Gibbs relation for the structural relaxation time $\tau = \tau_0 \exp(C/TS_c)$, is found to be valid in the supercooled temperature regime. Fragility is measured, and the rapidity with which the liquid's dynamic properties (such as the viscosity) change as the polycrystalline state is approached is compared between FPIM and another homogeneous glassy model known as the Coupled two-level system (CTLS). The results reveal that FPIM is more fragile than the other.

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