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The Gardner Transition: A new approach for understanding low-temperature glasses

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Recent theoretical advances in the mean-field theory of glasses predict the existence deep in the glass phase of a novel phase transition, a so-called Gardner transition. This transition signals the emergence of a complex free energy landscape composed of a marginally stable hierarchy of sub-basins within a broad glass metabasin. It is thus the onset of marked changes in thermal and transport properties of glasses, and ultimately leads to the unusual critical behavior at jamming. The Gardner transition itself is immediately related to a diverging (i) characteristic relaxation time, (ii) caging susceptibility and (iii) correlation length of the caging heterogeneity as well as aging, even in well-thermalized glasses. We have detected some of these signatures both in a mean-field model and in standard hard-sphere glass formers. We find the results to quantitatively agree with theory in the former and qualitatively so in the latter, which suggest that the transition should be detectable in a wide array of numerical and experimental systems. Interestingly, although the Gardner transitions is primarily associated with structural glass formers, we also find features of the transition in crystals of polydisperse particles once the landscape becomes rough.