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Jamming Mechanisms and Density Dependence of Dynamic Heterogeneities in a Kinetically-Constrained Model

YAIR SHOKEF, Weizmann Institute of Science

Experiments on granular [1] and colloidal [2] systems show steady growth in dynamic heterogeneities as the relaxation time increases with increasing density. In glass-forming liquids, however, the scale of heterogeneities remains modest even as the relaxation time increases by more than ten orders of magnitude with decreasing temperature [3]. This difference may be attributed to the far greater dynamic range measurable in glass-forming liquids [2]. We introduce a simple lattice model [4] which suggests that this difference signals a fundamental distinction between jamming due to an increase in particle density as opposed to jamming by lowering the temperature, or the strength of external driving forces. The recently proposed spiral model [5] has a kinetic constraint that breaks its ergodicity at a critical density smaller than 1. We add to it relaxation mechanisms that mimic the effect of temperature and non-equilibrium driving. This enables us to explore its jamming phase-diagram and study unjamming by temperature or driving above the critical density, which we relate to the random close packing density in particulate systems. We separate the effects of density, temperature and driving and show that jamming resulting from increasing density gives rise to dynamic heterogeneity that grows unboundedly. Whereas decreasing temperature or driving eventually leads to a saturation of the dynamic correlation length even though the relaxation time diverges.

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