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# Jamming and clogging transitions for systems with quenched disorder

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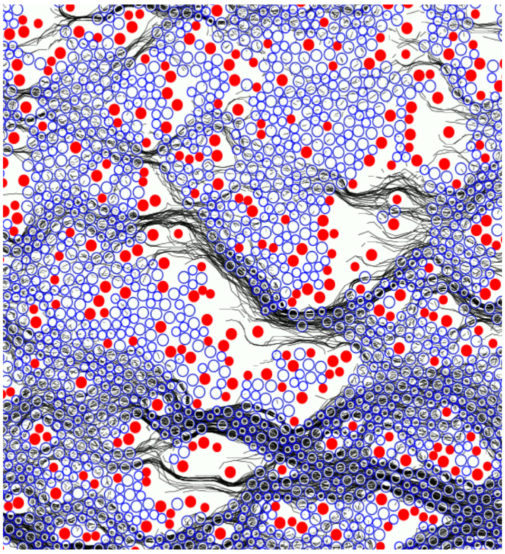

Jamming can occur in systems consisting of collections of particles when the response of the system changes from a fluid like state that can easily flow to a state that acts like a solid. For a loose collection of grains or colloids, jamming can occur as a function of density, where at low densities the grains readily flow but as the density increases there is a transition to a jammed state at point J. Liu and Nagel have proposed that there may be a universal jamming phase diagram as a function of density, load, or temperature [1] which may also include the glass transition. Here we propose that the density of fixed obstacles or quenched disorder can be considered a new axis for the jamming phase diagram, since the disorder causes the system to jam at densities below the density of point J. For a small number of obstacles, the system exhibits jamming behavior; however, for higher disorder density there is a crossover to a behavior which we term clogging rather than jamming since the stuck states are highly heterogeneous, are fragile, and exhibit memory effects. Our results imply that clogging is a distinct phenomenon from jamming with very different behaviors. These results are of relevance for particle flow in porous media, depinning transitions, and jamming in crowded environments. I will also briefly cover other systems beyond granular matter that we have been studying in the presence of quenched disorder that exhibit jamming or clogging behaviors, including vortices in type-II superconductors, active matter such as swarming bacteria, and dislocation pileup formation in materials.

[1] A.J. Liu and S.R. Nagel, Nature 396, 21 (1998).