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Onset of flow in soft glasses: linking percolation to flow heterogeneities

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Understanding the rheological response of soft amorphous materials, from a microscopic point of view, remains a challenging problem. A characteristic feature of such materials is the existence of a yield stress, only exceeding which steady flow is obtained. An important question, in this context, is how an amorphous solid, starting from a quiescent state, yields under external shear. Using extensive numerical simulations, we have studied the onset of flow in model soft glasses, using different forcing protocols.

We observe that inhomogeneous flow patterns characterize the transient regime from the quiescent state to steady flow. The lifetime of such dynamical heterogeneities, which often take the shape of shearbands, becomes longer as one decreases the applied shear. In the case of yielding under an applied stress, these heterogeneities become persistent as the material creeps in the vicinity of the yield stress.

However, even before the formation of these dynamical flow heterogeneities, we see the occurrence of a percolation transition involving mobile regions, for all forcing amplitudes, and this belongs to the universality class of directed percolation. Only at low shear rates or stresses near the yielding threshold, the percolating cluster evolves into the transient (but long-lived) shear band which then grows diffusively to fluidize the entire system.