MAR12-2011-005731

Abstract for an Invited Paper
for the MAR12 Meeting of
the American Physical Society

Geometrical analysis of suspension flows near jamming[1]

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The viscosity of suspensions was computed early on by Einstein and Batchelor in the dilute regime. At high density however, their rheology remains mystifying. As the packing fraction increases, steric hindrance becomes dominant and particles move under stress in a more and more coordinated way. Eventually, the viscosity diverges as the suspension jams into an amorphous solid. Such a jamming transition is reminiscent of critical points: the rheology displays scaling and a diverging length scale. Jamming bear similarities with the glass transition where steric hindrance is enhanced under cooling, and where the dynamics is also observed to become more and more collective as it slows down. In all these examples, understanding the nature of the collective dynamics and the associated rheology remains a challenge. Recent progress has been made however on a related problem, the unjamming transition where a solid made of repulsive soft particles is isotropically decompressed toward vanishing pressure. In this situation various properties of the amorphous solid, such as elasticity, transport or force propagation, display scaling with the distance to threshold. Theoretically these observations can be shown to stem from the presence of soft modes in the vibrational spectrum, a result that can be extended to thermal colloidal glasses as well. Here we focus on particles driven by shear at zero temperature. We show that if hydrodynamical interactions are neglected an analogy can be made between the rheology of such a suspension and the elasticity of simple networks, building a link between the jamming and the unjamming transition. This analogy enables us to unify in a common framework key aspects of the elasticity of amorphous solids with the rheology of dense suspensions, and to relate features of the latter to the geometry of configurations visited under flow.

[1]Supported by NSF (DMR-1105387), the Petroleum Research Fund (52031-DNI9) and the Sloan Fellowship