Rheology of complex fluids: glasses and mixtures of liquid crystals and magnetic nanoparticles

A talk by Gaurav P. Shrivastav
Institute of Theoretical Physics
Technical University of Berlin

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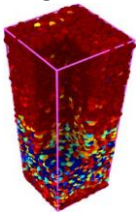
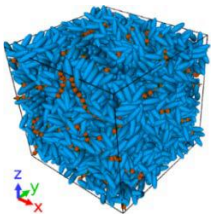
Complex fluids exhibit both elastic and viscous like properties at different time scales in response to an externally applied shear. This response depends on the interplay of the shear-induced and structural relaxation timescales of the material. In this talk, I will present our results on the rheology of glasses and a mixture of liquid crystals and magnetic nanoparticles.



Glasses, which are characterized as simple yield stress fluids, show transient shear banding, the nature of which is not very well understood. Using extensive molecular dynamics (MD) simulations, we first demonstrate that a directed percolation transition occurs near the yielding of the glass. We, then, quantify the effect of temperature, age and shear rate on transient dynamical heterogeneities in thermal glasses.

The composites of liquid crystals (LC) and magnetic nanoparticles (MNP) are interesting hybrid systems in terms of advancing new functionalities. The equilibrium dynamics and rheology of these mixtures are not very well studied as compared to their equilibrium self-assembly. We investigate, using equilibrium and non-equilibrium MD simulations, the equilibrium dynamics and the effect of shear on a LC-MNP mixture where the sizes of both the species are comparable.



We demonstrate that the anisotropic environment provided by the LC matrix strongly affects the equilibrium translational dynamics of the MNPs. This effect is reflected in the form of a subdiffusive regime at intermediate times in the mean square displacement of the MNPs which gets extended as the strength of the dipolar coupling is increased. Also, when the external shear is applied, the mixture shows a transition from Newtonian to non-Newtonian behavior. The extent of the non-Newtonian regime is increased as the strength of the dipolar coupling among the magnetic particles is increased.

References:

1. “Yielding of glass under shear: a directed percolation transition precedes shear-band formation", G. P. Shrivastav, P. Chaudhuri, J. Horbach, Phys. Rev. E 94, 042605 (2016).
2. “Heterogeneous dynamics during yielding of glasses: Effect of aging", G. P. Shrivastav, P. Chaudhuri, J. Horbach, J. Rheol. 60, 835 (2016).
3. “Anomalous transport of magnetic colloids in a mixture of liquid crystals and magnetic colloids", G. P. Shrivastav, Sabine H. L. Klapp, under review in Soft Matter (2018).