Tata Institute of Fundamental Research

Survey No. 36/P, Gopanpally Village, Serilingampally, Ranga Reddy Dist., Hyderabad – 500 046

Webinar

Study of Dynamical and Mechanical Properties of Glassy Materials using Rod-like Inclusions

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Probing dynamic and static correlations in glass-forming supercooled liquids has been challenging, despite decades of extensive research. Dynamic correlations manifest themselves as Dynamic Heterogeneity (DH) and are ubiquitous in many systems, from dense colloids to collections of cells. On the other hand, the growing static correlation is required to explain the massive growth in the viscosity of supercooled liquids on cooling. Experimental studies to obtain these correlations are scarce. The most common experiments in the glass community are single-molecule (SM) investigations. They correctly point toward the existence of DH, but the length-scale calculation has yet to be attempted. The probes of different lengths would provide an averaged response of the system over different length scales, making them the ultimate sub-ensemble experiments. Utilising the same, we developed an experimentally realisable technique to extract the length scales using rods as a probe. We used deviation from the rotational Brownian motion to extract the dynamic correlations, while the anomalies in the rotational first-passage-time distribution gave us static correlations. The translational dynamics of rods, the Stokes-Einstein and Stokes-Einstein-Debye violations also gave us the same results. This method was further extended to active glassy systems, with the ambition of its subsequent use in ubiquitous out-of-equilibrium experimental situations. In active systems, the length scales were found to increase five times more than in the usual supercooled system, thus serving as an excellent test ground. Finally, to complete the subensemble picture in an active system, we also studied the wavevector dependence of SE breakdown to show that the dynamic length scale plays a crucial role in the violation.

Lastly, we have studied the mechanical behaviour of amorphous solids with increasing concentrations of the rod. We found that the dopant’s (rod's) rotational degrees of freedom significantly impact the mechanical properties of amorphous solids. Systems with rotationally free dopants tend to sustain more load, while in contrast, the absence of the same makes the system highly brittle. Thus our study reveals more insights into the microscopics of microalloying.

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11:30 Hrs