Yielding and flow of colloidal glasses

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We have studied some of the rheological properties of suspensions of hard-sphere colloids with particular reference to behaviour near the concentration of the glass transition. With reducing rate of strain under steady shear, suspensions in their fluid and metastable fluid states exhibit a stress σ that falls linearly with strain rate $\dot{\gamma}$ as $\dot{\gamma} \to 0$, corresponding to a Newtonian viscosity $\eta = \frac{\sigma}{\dot{\gamma}}$. By contrast, suspensions which are glassy at rest show a stress which becomes independent of $\dot{\gamma}$ as $\dot{\gamma} \to 0$ (corresponding to a viscosity that diverges as $\dot{\gamma}^{-1}$). This limiting stress can be interpreted as the yield stress of the glass. These findings are in accord with the predictions of a recent mode coupling treatment of sheared suspensions [1].

Creep and recovery measurements during and after a transient step stress also illuminate the problem [2]. We find that, at all values of applied step stress, colloidal glasses show a rapid, apparently elastic, recovery of strain after the stress is removed. With increasing stress, the magnitude of this recovered strain saturates at a surprisingly large value of 10 to 20 %. This recovery is found even in samples which have flowed significantly during stressing, accumulating strains of many times 100 %. We attribute this behaviour to “cage elasticity”, the recovery of the stress-induced distorted environment of any particle to a more isotropic state when the stress is removed.

The behaviour under both steady shearing and transient step stress support the idea that colloidal glasses have a defined yield stress. We note however that the samples do exhibit a slow accumulation of strain due to creep at stresses below the yield stress.

[1] M. Fuchs and M. E. Cates, *Faraday Discussions* **123**, 267 (2003)

[2] G. Petekidis, D. Vlassopoulos and P.N. Pusey, *Faraday Discussions* **123**, 287 (2003)