Flow in soft glassy materials : a cooperative process

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Soft glassy materials such as polymers, colloids and granular assemblies are ubiquitous in nature, but also of great importance in industrial applications. All these materials share a common behaviour. They may loose their ability to flow on lowering the temperature, increasing the volume fraction or releasing some external stress The response of such systems to an external shear stress is characterized by two regimes : for stresses below the yield stress, they remain jammed and respond elastically, whereas for stresses above the yield stress they flow as liquids.

Using local velocity measurements in confined and wide geometry, we have achieved recently a clear picture of the rheological behaviour of these systems. In these materials, flow occurs via a succession of reversible elastic deformations and local irreversible plastic rearrangements associated with a microscopic yield stress. It has been shown that the number of plastic rearrangements per unit time, f is inversely proportional to the local viscosity. This parameter that is usually named fluidity, controls the flow and relaxation of the material : a higher rate is associated with a more fluid system. The link between the macroscopic forcing and the fluidity has been established both experimentally and by using numerical simulations. The value of the fluidity in a given zone of a material increases as a function of the local applied shear stress. More strikingly, it also depends upon the behaviour of the neighbourhood of this zone. This cooperative behaviour is due to the elastic relaxation of the stress after a plastic event. The probability of rearrangements in the neighbourhood of an active zone is higher than close to a quite one. In other words, a single event of rearrangement works as a seed for subsequent rearrangements in the neighbourhood and this cascades on as flow progresses.

Références

1. J. Goyon, A. Colin, G. Ovarlez, A. Ajdari L. Bocquet, Spatial cooperativity in soft glassy flows, *Nature* **454**, 84–87 (2008)