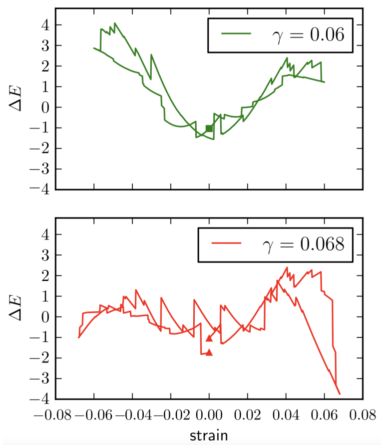
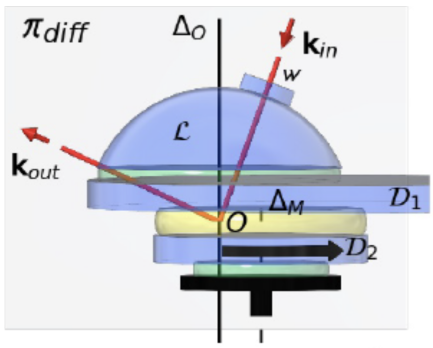
Reversibility and plasticity in a colloidal glass

Pascal Hébraud
INSTITUT DE PHYSIQUE ET CHIMIE DES MATERIAUX DE STRASBOURG
pascal.hebraud@ipcms.unistra.fr
http://biosoft-ipcms.fr

We study the reversibility of particles trajectories, in a concentrated suspension of colloidal particles in a glass phase, close to the elastoplastic transition. The elementary microscopic deformation processes at play in such materials have been understood long ago in amorphous metals, and more recently in concentrated suspensions : they have been identified and described as shear transition zones (STZ), corresponding to localized regions in which local rearrangement of the particles packing changes. Numerical simulations have shown that, if the system is "trained", by the application of a periodic oscillation of amplitude γ, in the plastic regime, then, subsequent deformation of amplitude different from γ leads to irreversible trajectories, while microscopic trajectories under a deformation of amplitude equal to the training amplitude γ are reversible [1]. This means that the microscopic plastic rearrangements may be reversible.
We will perform an experimental study of the reversible of particles trajectories in the plastic regime, after periodic "training". To this goal, we have developed a light scattering under shear setup that allows to probe the trajectories of the particles over length scales ranging from their radius to several particles diameters [2]. We will quantify the reversibility of the particles trajectories as a function of the orientation of the scattering vector relative to the flow and as a function of its magnitude.
This will help to elucidate the fundamental mechanisms at play in the elastoplastic transition in an amorphous system, both close to the glass transition and deep in the glass state.



Particle trajectory under a deformation equal to the training amplitude, $\gamma = 0.06$ **(a)** and under a slightly different amplitude **(b)**. In the first case, the particle comes back to its initial state (square) although it is submitted to a series of rearrangements. In the second case, the particle trajectory is irreversible (from [1]).



Schematic of the experimental setup. The illuminating light, of wave vector $\mathbf{k}_{in}$. Varying the detection direction, allows to vary the probe length scale while translating the shear cell relative to the scattering volume allows to change the orientation of the scattering vector relative to the flow.

References

[1] D. Fiocco, G. Foffi and S.Sastry Encoding of Memory in Sheared Amorphous Solids, *Physical Review Letters*, **112**, 025702, 2014.

[2] D. Kushnir, N. Beyer, E. Bartsch and P. Hébraud Wide-angle static and dynamic light scattering under shear, *Review of Scientific Instruments*, **92**, 025113, 2021.