Spatio-temporal correlations between plastic events in the flow of athermal amorphous solids

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In spite of their extreme diversity, amorphous solids, ranging from foams and jammed emulsions to molecular glasses, display a similar phenomenology when they are forced to flow: on top of a basic elastic response, the material features localised regions where particles rearrange rapidly; these local shear transformations, also known as plastic events, induce a well-characterised long-range elastic deformation field. Although several popular models for the rheology of these materials assume a homogeneous, mean-field-like distribution of such plastic events, spatial correlations in the non-affine deformation field have recently been evidenced at low shear rates [1].

Here, we go one step further in this study by investigating the spatio-temporal correlations between the plastic events themselves, in situations where thermal fluctuations are negligible. The correlations are first studied with the help of atomistic simulations, where they are found to be very anisotropic and to depend on the shear rate. The intensity of the correlations first grows rapidly after the onset of the plastic event, and then decays with absolute time, rather than strain.

Does the simple rheological scenario sketched above suffice to account for the observed correlations? To answer this question, we have developed, and simulated, a simple coarse-grained model based on this scenario. We find that, besides reproducing "macroscopic" properties of the flow, such as the flow curve and the stress autocorrelation function, the model also captures the qualitative picture of the spatio-temporal correlations between plastic events.

[1] Chikkadi, V., et al., EPL, 100, no. 5 (2012): 56001;
Mandal, S. et al., arXiv preprint arXiv:1305.3047 (2013).