Framework for non-Brownian suspension flows

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Title
A unified framework for non-Brownian suspension flows and soft amorphous solids

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Simulations Done Using NYU HPC Cluster
Figure 1. (A) Snapshot of a configuration visited under flow from simulations in two dimensions (see Methods for details). Small and large particles are represented different colors. The width of the black segments connecting particles is proportional to the contact force. The arrows indicate the shear direction. (B) Example of the evolution of the stress with time. Instantaneous jumps upward correspond to the creation of new contacts. Stress relaxes smoothly, however, within periods where contacts do not change. Interestingly, this situation is opposite to the plasticity of amorphous elastic solids, where stress loads continuously before relaxing by sudden plastic events, as illustrated in (C) for compressed soft elastic particles under quasistatic shear.

Figure 2. The relation $\zeta(p)$ within ASM is computed by averaging the normalized pressure $p$ at different packing fractions.

Figure 3. The coordination displays scaling near jamming $dz = z_c - z \sim 1/p_d$ in (A) two and (B) three dimensions. Particles barely connected to the contact network (making less than two contacts with their surroundings), the so-called rattlers, are removed from the analysis. Colors (and symbols) label different packing fractions (see Methods), growing with increasing pressure, and each data point pertains to a single configuration.

Figure 4. Scaling of the lowest frequency $\zeta_{\text{min}}$ vs. normalized pressure $p$ in (A) two and (B) three dimensions. This mode dominates the rheology near jamming, as can be seen by plotting the relative contribution $(s - s_0)/s$ of all the other modes to the stress, that vanishes as $p-0.65$. The relative contribution is found to be independent of $N$.

Figure 5. Spectral analysis of the operator $N$ governing flow as jamming is approached. The density of states $D(\omega)$ averaged over 500 configurations for each pressure indicated in the legend, in (A) two and (B) three dimensions. The amplitude of the peak at low-frequency was rescaled to make it visible. Since it consists of one mode only, this amplitude vanishes in the thermodynamic limit. If the frequency axis is rescaled by the excess coordination $p_d - dz$, as in (C, D), the emergence of a plateau $D(0)\sim p_d$ collapses, indicating that the frequency at which this plateau appears follows $\omega^* \sim dz$. 
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