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Critical Jamming and gel rheology of droplet suspensions in living cells

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Cytoplasm wo metabolism undergoes dynamic arrest similar to glass or jamming at the physiologically-relevant concentration whereas the affinity interactions tend to induce phase separation. Without metabolism, phase separation of the concentrated cytoplasm only slowly proceeds, indicating that the phase separation and jamming/gelation compete.

In this study, we aim to investigate the mechanics of living cytoplasm. The viscoelastic properties predicted for critically-jammed materials, *i.e.*, $G(\omega) \propto (i\omega)^{0.5}$ were generally observed in living cells whereas the elastic plateau arises at low frequencies as $G(\omega) = G_0 + A(i\omega)^{0.5}$ for ATP-depleted cells and cell extracts wo metabolism. The living cytoplasm is fluidized towards the critical jamming situation, but not any further. Regardless of the fluidization in living cells, phase separation does not proceed to create macroscopic droplets unless artificial biochemical control is applied. The metabolic activities not only fluidize the cytoplasm, but may also suppress the growth of phase-separated droplets; microphase-separated structures may be crowding in living cells. Indeed, the length scale of the dynamic heterogeneity in cells (20 ~ 70 nm) is consistent to the view and various aspects of microrehology in living cells.

Finally, we investigate the mechanical properties of macroscopically grown droplets in living cells. The fluctuation-dissipation theorem was satisfied in the droplets. The fast dynamics in the droplets are fluidic (close to water), but the slow fluctuation was suppressed more than the ordinary living cytoplasm. We also report that the slow dynamics are further suppressed by aging.