# Surprises in the Familiar: Delayed Collapse in Colloidal Gels

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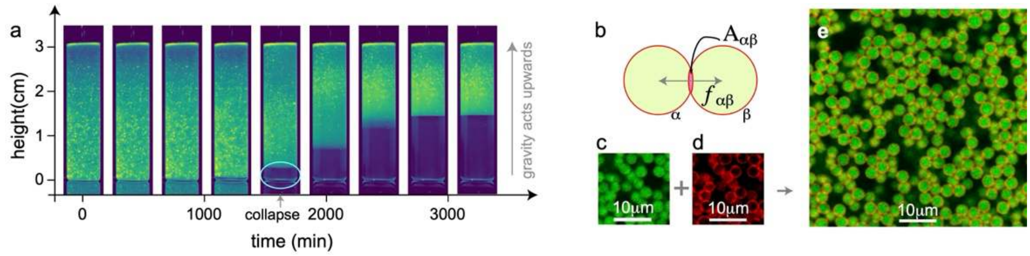


***Figure: Macroscopic collapse and microscopic stress in gels.*** *(a) Delayed collapse. After a period of no visible change, colloidal gels can collapse catastrophically. Here the particles are light so the gel creams (sediments upwards). (b-e) Identifying the forces between particles $\alpha$ and $\beta$. (c) Particle channel. (d) Contact (force) channel. (e) Combined two channel image showing contacts in a gel.*

Colloidal suspensions are prized as model condensed matter systems with simple interactions. Colloids exhibit phase behaviour akin to molecular systems, such as crystals and glasses whose processes can be followed at the microscopic level by tracking the particle coordinates with confocal microscopy. [1]. They are also very important both industrially and in a biological context. The equilibrium behaviour of colloidal "sticky spheres" is well understood [2]. Yet out of equilibrium, mysteries remain. Far-from equilibrium, sticky spheres can form a gel, whose solidity is due to rigid minimum energy clusters [3]. As gels age, they stiffen due to coarsening of the gel network [4]. Remarkably, after a period of increasing strength, with no visible macroscopic change, gels undergo catastrophic gravitational collapse.

We can study the microscopic mechanisms of yielding using computer simulation [5]. We have also developed an experimental system to determine forces between particles in addition to their coordinates. This reveals the local stress tensor [6]. However, such microscopic measures of yielding cannot address the challenge of why macroscopic samples suddenly collapse after a period where nothing seems to happen for up to weeks or even years.

We have developed a new technique to address this needle-in-haystack problem: multiscale confocal microscopy. Here we image an entire bulk sample with microscopic resolution. We reveal the nature of precursors to the sudden catastrophic collapse, so-called streamers. These are channels of solvent which start at the top of the gel and make their way through the bulk of the sample. This leads ultimately to a runaway increase in flow rate and gel collapse.

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[3] Royall CP, Williams SR, Ohtsuka, T and Tanaka H, "Direct observation of a local structural mechanism for dynamic arrest", *Nature Materials* **7**, 556-561, (2008).

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