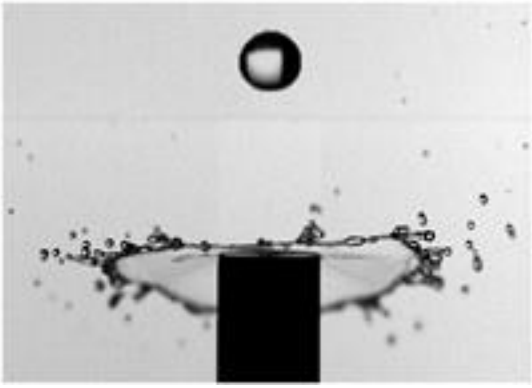
SOFT MATTER TEAM



The research program of the Soft Matter team encompasses a broad variety of systems such as liquid crystals, surfactants, polymers, colloids and biomimetic systems.
Research themes are:

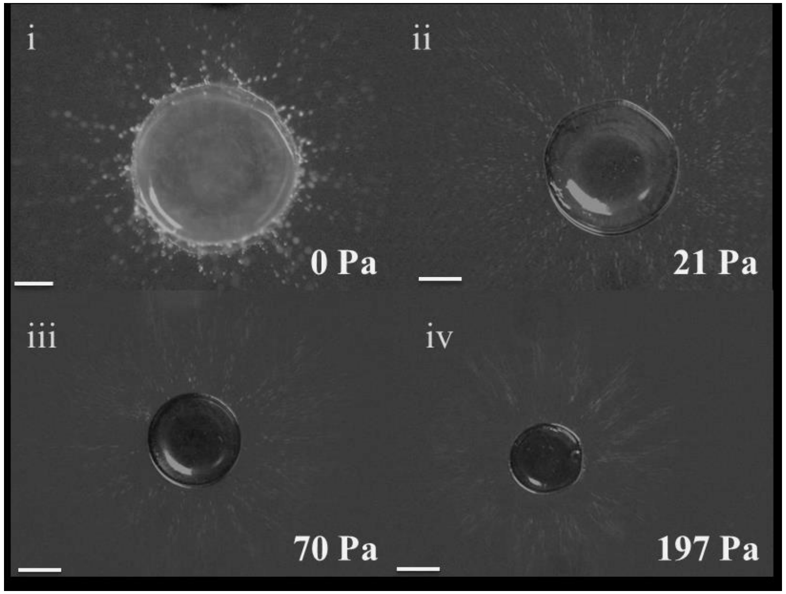
- PHYSICS OF BIOLOGICAL AND BIOMIMETIC SYSTEMS
- - COMPLEX INTERFACES
- **- JAMMING, PLASTICITY AND MATERIAL FAILURE**

  - SOFT MATTER FOR AGRONOMY AND ENVIRONMENT
- - SOFT COMPOSITES

The Soft Condensed Matter Team is currently composed of about 35 scientists (including 17 research fellows and faculty members)

JAMMING, PLASTICITY AND MATERIAL FAILURE

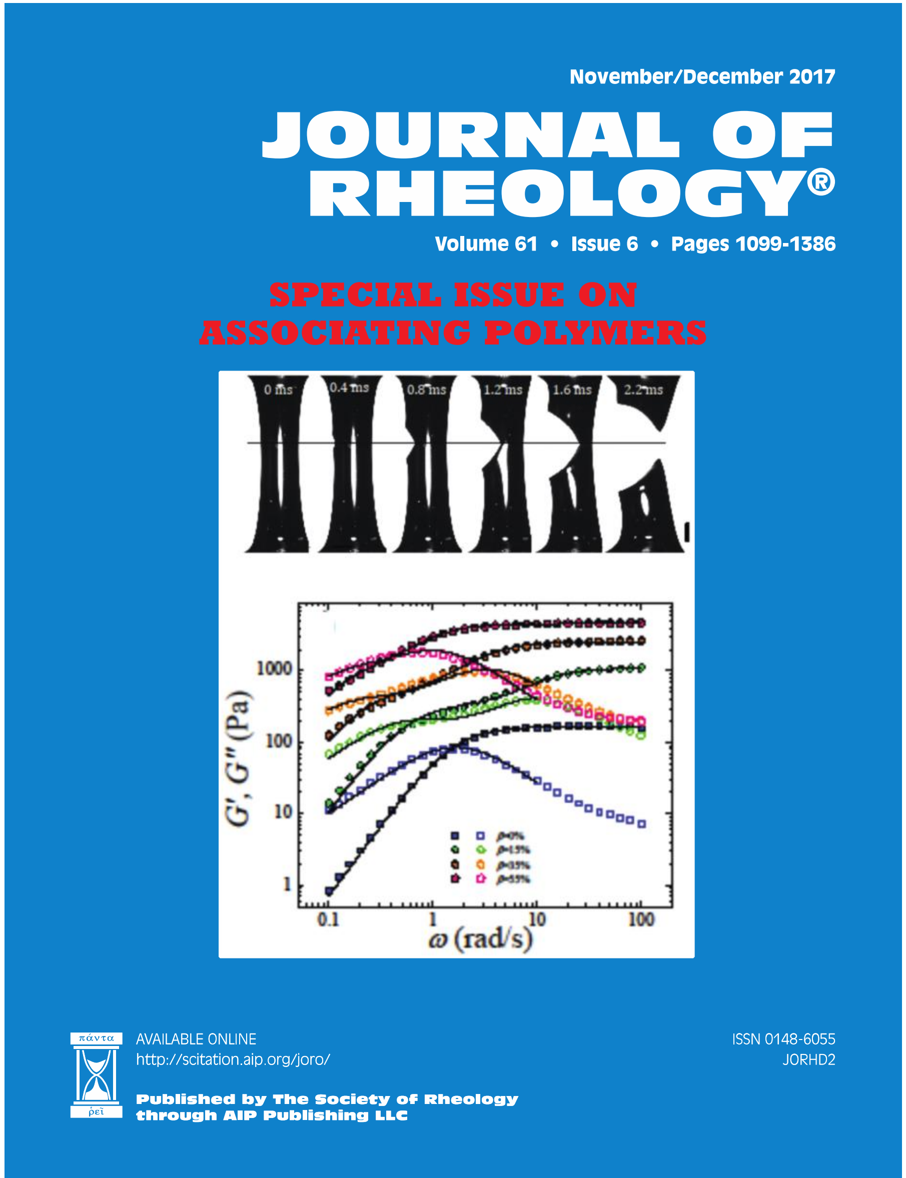
- MATERIAL FAILURE
- THE GLASS TRANSITION OF SOFT COLLOIDS
- **VISCOUS, VISCOELASTIC, AND ELASTIC SHEETS**



Maximal extension of sheets resulting from the impact of (i) a viscous drop and (((i), (ii), (iii)) soft elastic balls with various elastic moduli, on a solid surface covered by a thin layer of N2 to limit viscous dissipation *(S. Arora et al)*

Example:

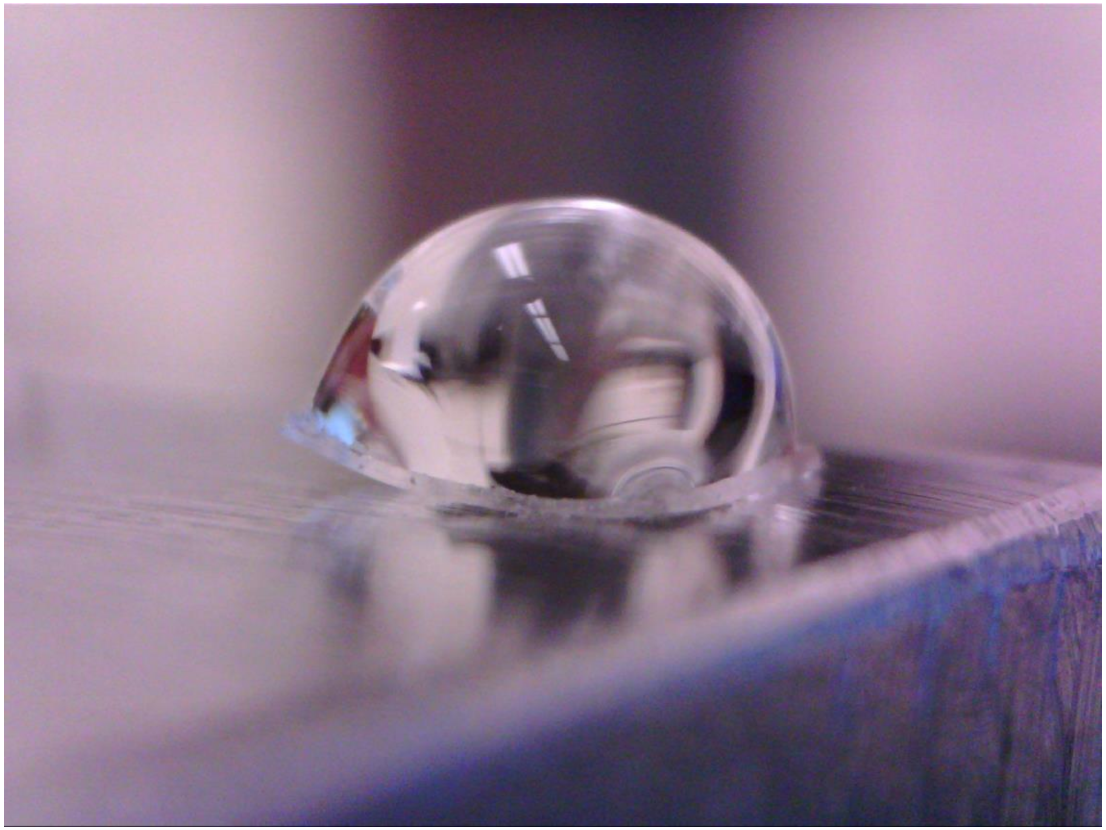
Brittle fracture of polymer transient networks ,Arora S, Shabbir A., Hassager O. Ligoure C. , Ramos L. *Journal Of Rheology* vol. **61** p.1267-1275 (2017)



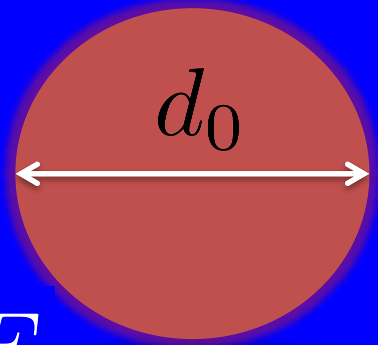
PROJECT for DODYNET
Transient elastocapillarity effects

Elasto-capillarity:

Ability of capillary forces to deform an elastic material.



Deformation of a thin PDMS sheet by a water droplet



Young modulus E

Surface tension γ

$$E_{bulk} \sim d_0^3 E$$
$$E_{surf} \sim d_0^2 \gamma$$

$$E_{surf} \gtrsim E_{bulk} \Leftrightarrow d_0 \lesssim \frac{\gamma}{E}$$

Bulk elasto-capillary length $\boxed{l_{ec} = \frac{\gamma}{E}}$

$d_0 < l_{ec}$ Surface energy dominates

$d_0 > l_{ec}$ Bulk elastic energy dominates

$$E = 50\mathrm{kPa} \Rightarrow l_{ec} \simeq 1\mu\mathrm{m}$$

$$E = 50\mathrm{Pa} \Rightarrow l_{ec} \simeq 1\mathrm{mm}$$

Transient elastocapillarity effects for a double dynamic network

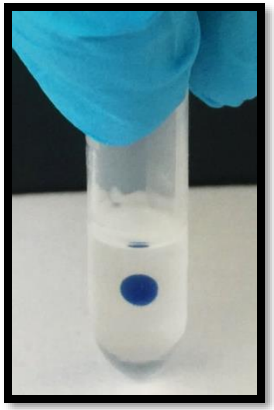
$$l_{ec} = \frac{\gamma}{G(De_1, De_2)}$$

$$De_i = \frac{\tau_i}{t_{exp}}$$

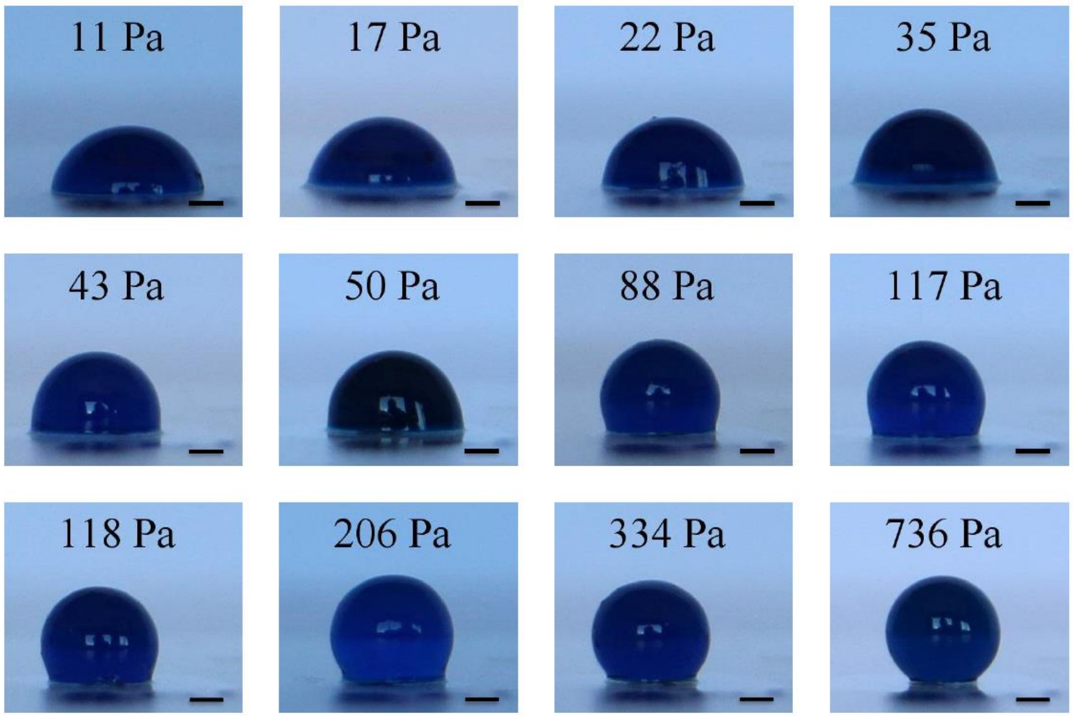
How l_{ec} will compare to d_0

A question of time….

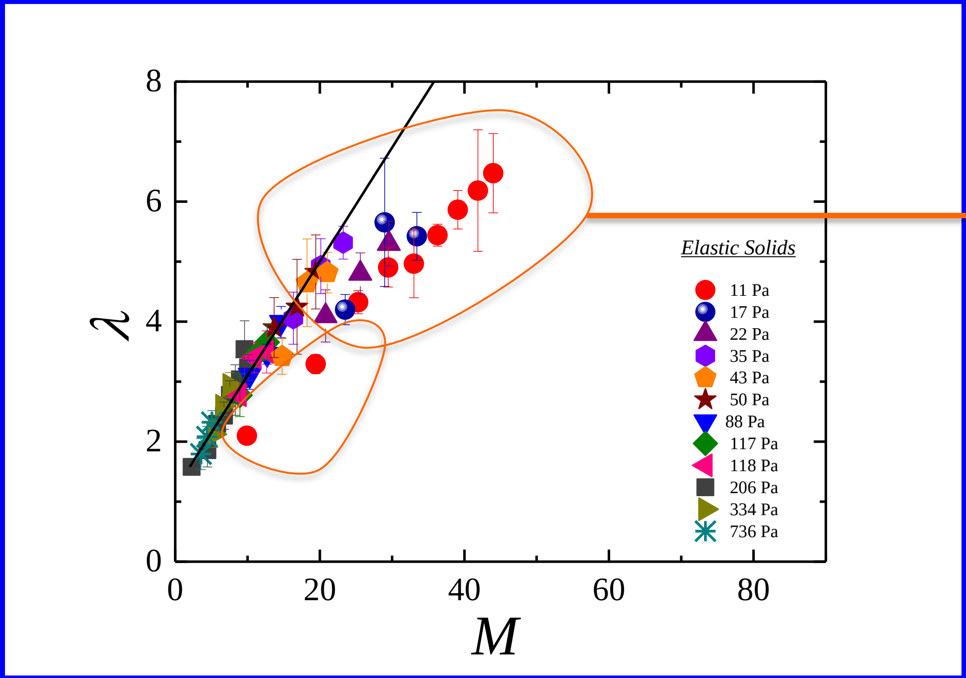
SAMPLES 1. solids



Ultrasoft elastic beads (waterswollen)polyacrylamide gel
Diameter d_0=*3.7mm*
Shear modulus 10Pa$\leq G_0 \leq$800 Pa



Maximum spread factor



Deviation from at low G_0 $\quad \lambda \approx \frac{v_0}{U_S}$

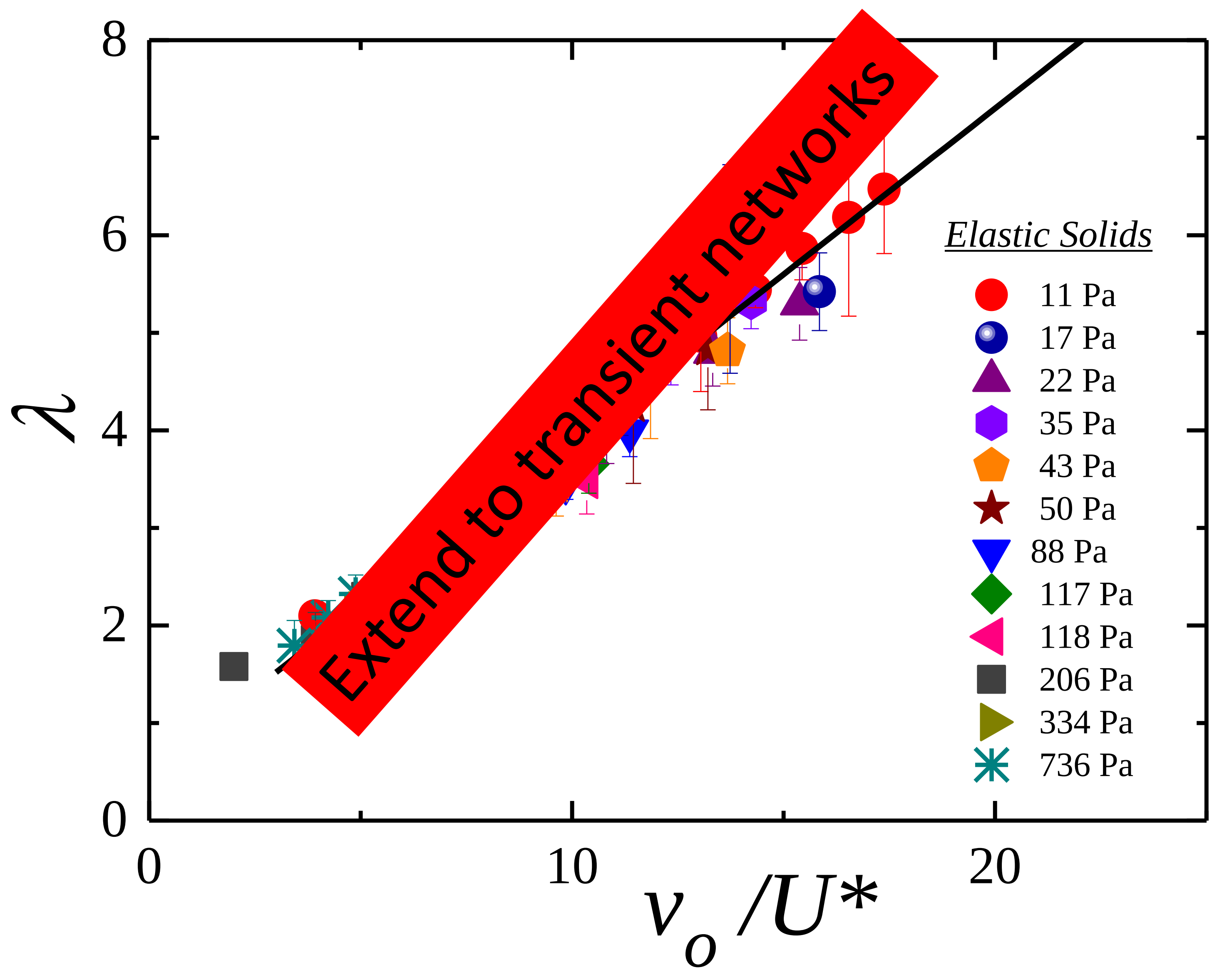
Interpretation: elasto-capillarity

$$E_\gamma \gtrsim E_{bulk} \quad \text{if} \quad l_{ec} = \frac{3\gamma}{G_0} \lesssim d_0 \Leftrightarrow G_0 \lesssim 60\mathrm{Pa}$$

Energy Balance $\quad E_k = E_\gamma + E_{bulk} \Rightarrow \boxed{\lambda \approx \frac{u_0}{U^\star}}$

$$U^\star = \sqrt{U_S^2 + U_L^2} \qquad U_L = \sqrt{\frac{3\gamma}{\rho d_0}} \qquad U_s = \sqrt{\frac{G_0}{\rho}}$$

Characteristic velocity of generalized elastic deformations



Extend to transient networks
Elastic Solids
11 Pa
17 Pa
22 Pa
35 Pa
43 Pa
50 Pa
88 Pa
117 Pa
118 Pa
206 Pa
334 Pa
736 Pa
λ
v_o / U^*
0
2
4
6
8
0
10
20

Stiffening solids with liquid inclusions

Robert W. Et al , Nature Physics 2015

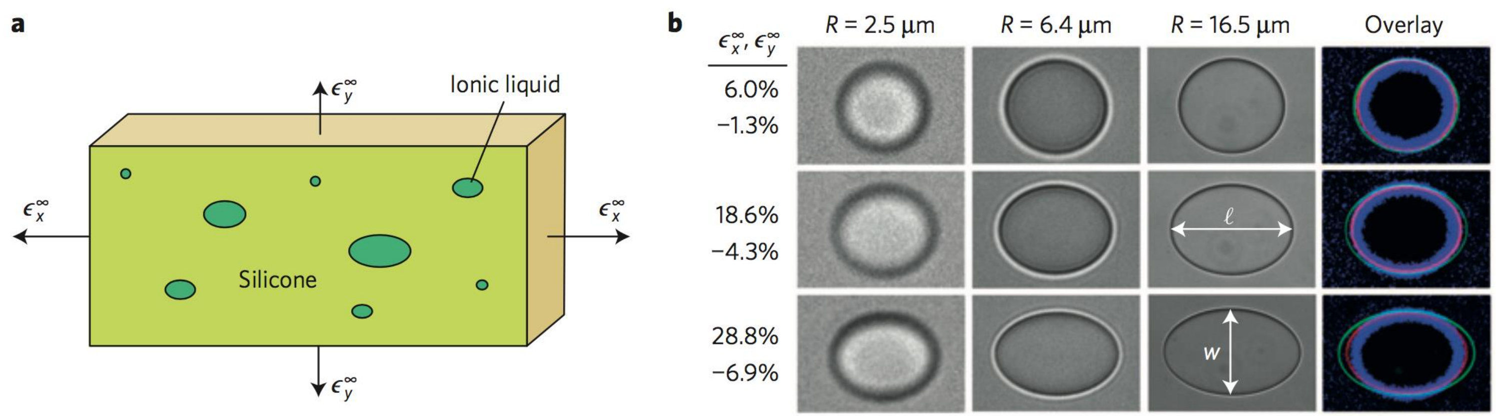


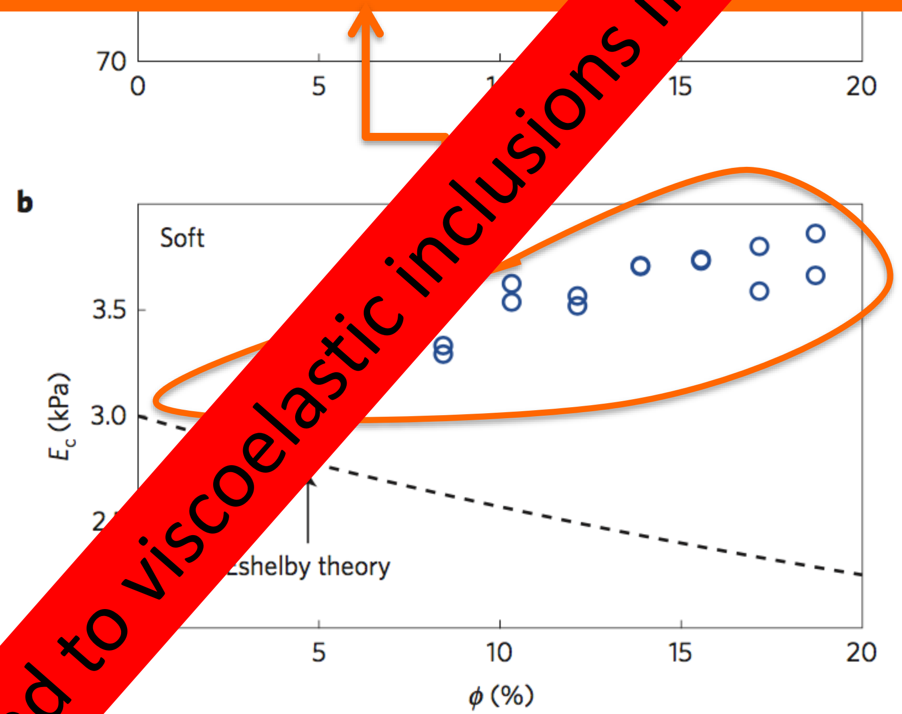
Figure 1 | Stretching droplets embedded in soft solids. a, The sample is clamped and stretched in the *x*-direction. **b**, Example images of ionic-liquid droplets in a soft, silicone solid $E = 1.7$ kPa. Larger droplets deform more at the same applied strain. Overlay shows small (blue), medium (red) and large (green) droplet images combined together for shape comparison.

- Foundational theory of solid composites, due to Eshelby, describes how isolated inclusions in a composite behave in response to applied stresses. Eshelby applied this result to predict the stiffness of dilute solid composites

- According to Eshelby’s theory of , liquid inclusions, which have zero Young’s modulus, should reduce the stiffness of a solid composite.

Small liquid Inclusions enhance the Young modulus of soft composites

$$E_\gamma \gtrsim E_{bulk} \Leftrightarrow d \lesssim l_{ec}$$



3 | Young's modulus of soft composites as a function of liquid ...ent. Glycerol droplets embedded in $E \sim 100$ kPa (**a**) and $E \sim 3$ kPa (**b**) ...icone gels. Dashed curves show Eshelby's predictions for incompressible liquid droplets in an incompressible solid with Young's modulus E.

Extend to viscoelastic inclusions in a soft matrix

An also

- Frequency dependant modes of vibration of hemi-spherical caps of transient gels on omnophobic surfaces : a tool to measure transient elastocpillary effects (see Aditi Chakrabarti and Manoj K. Chaudhury , Langmuir 2013)

- suction ,identation of transient gels
- Etc…