Yielding and liquid-like response

Yield stress and strain

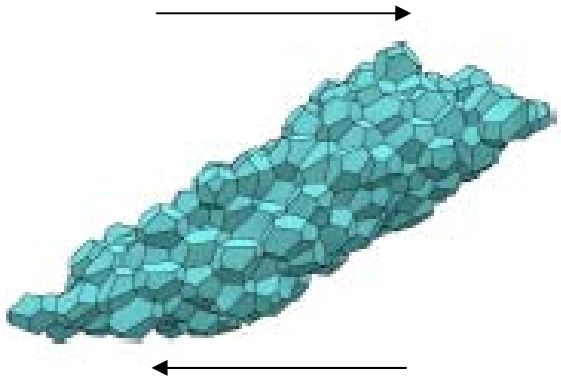
Memory effects

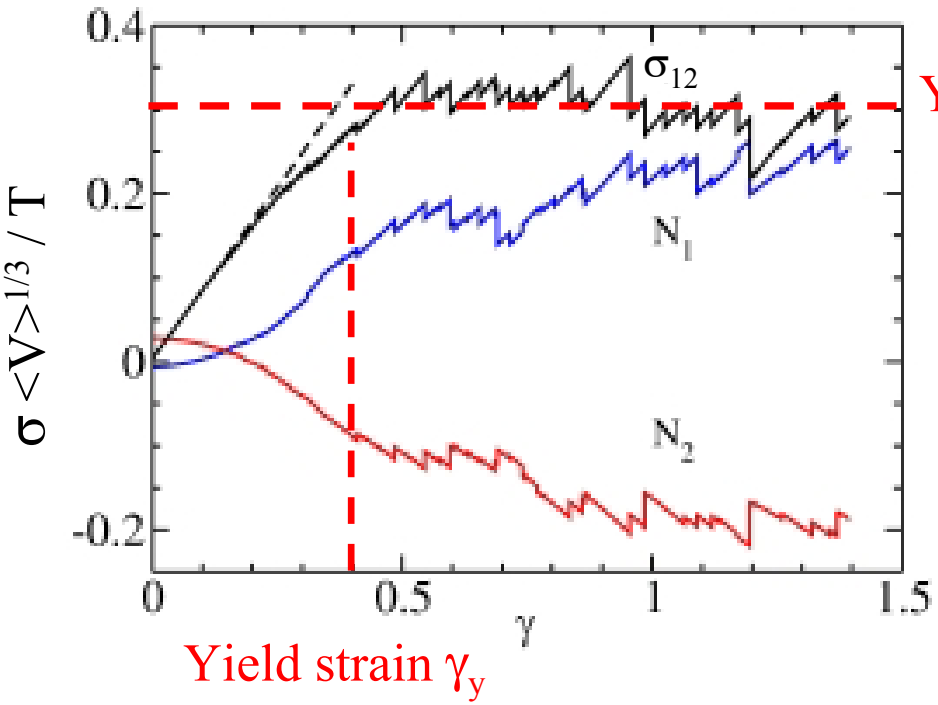
Liquid-like response

Passage from solid-like to liquid-like behavior

Surface Evolver simulations

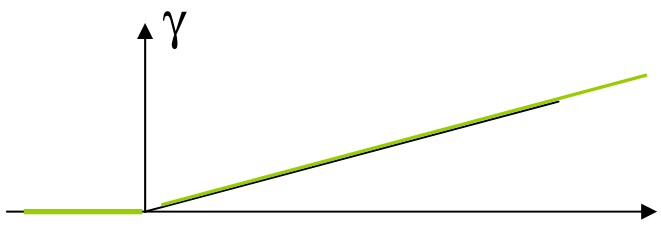
Kraynik, Reinelt 2004



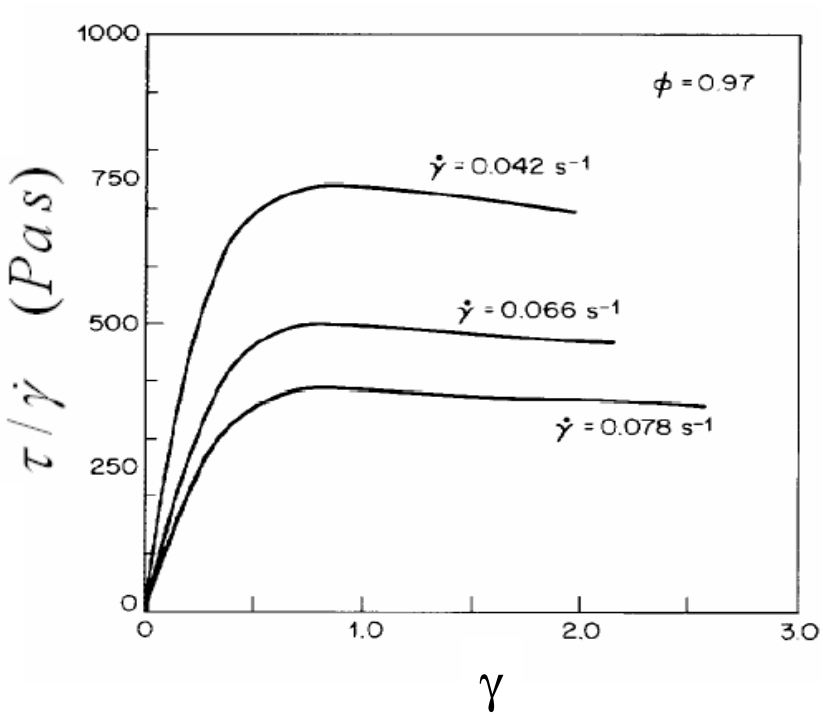


$$\sigma_y \cong 0.3 \frac{T}{< V >^{1/3}}$$

Shear start up

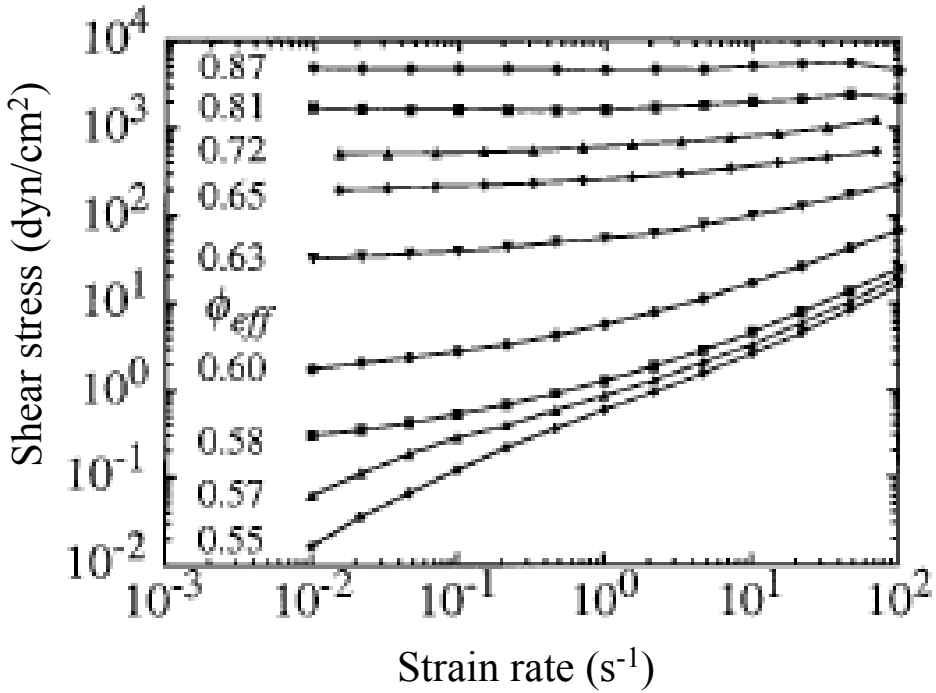


$$\dot{\gamma} = Const.$$



Khan, Schnepper 1988

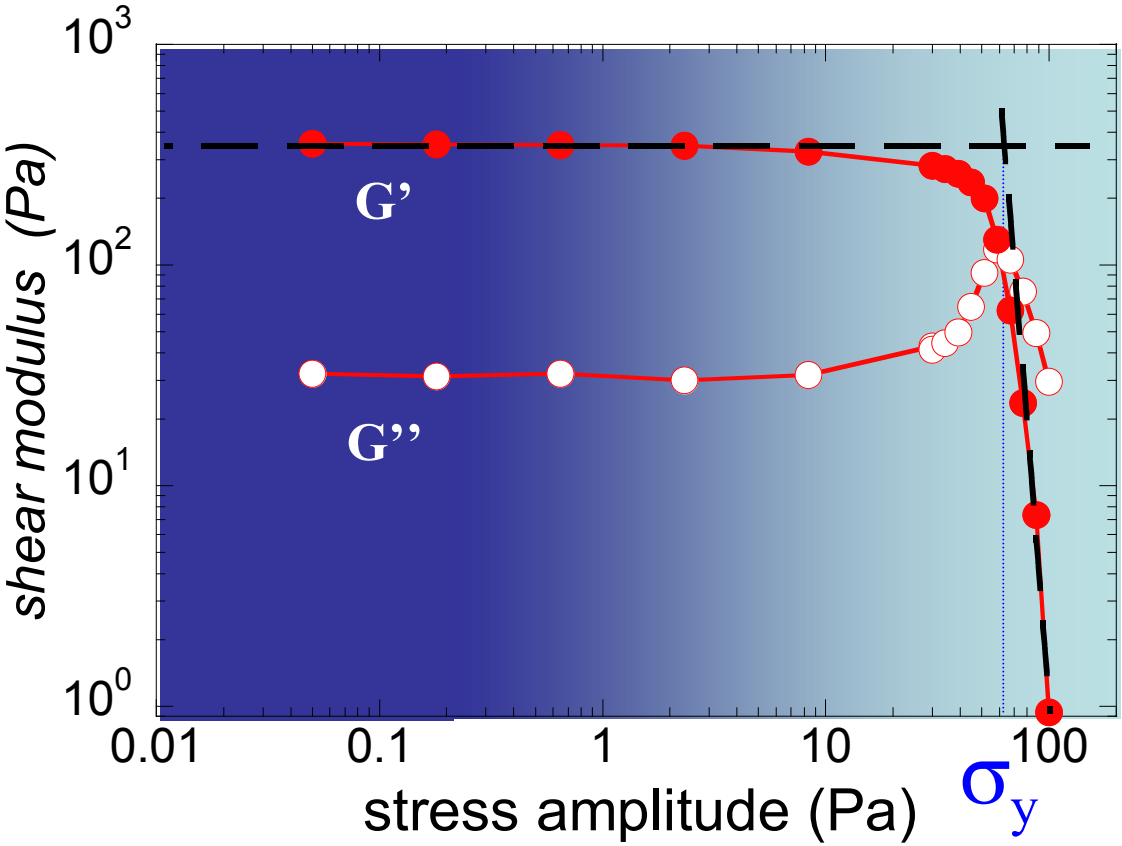
Steady shear stress vs strain rate



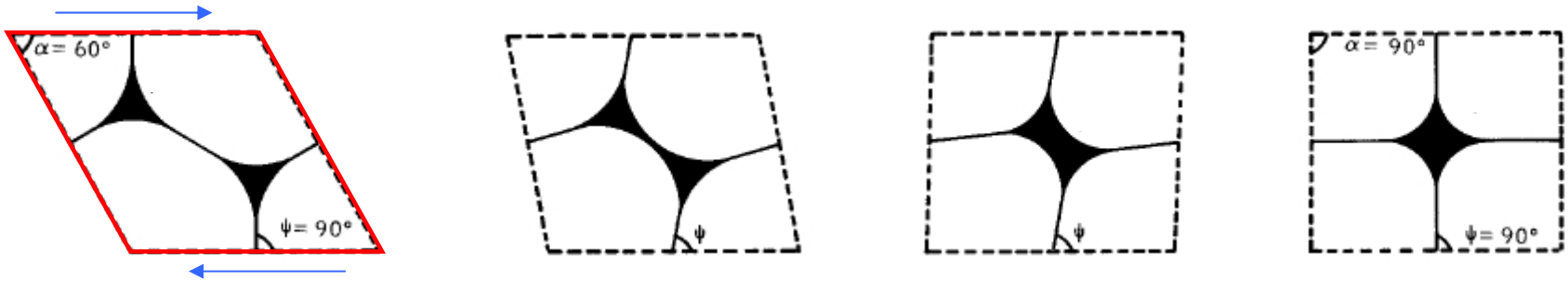
Emulsion

Mason, Bibette, Weitz 1996

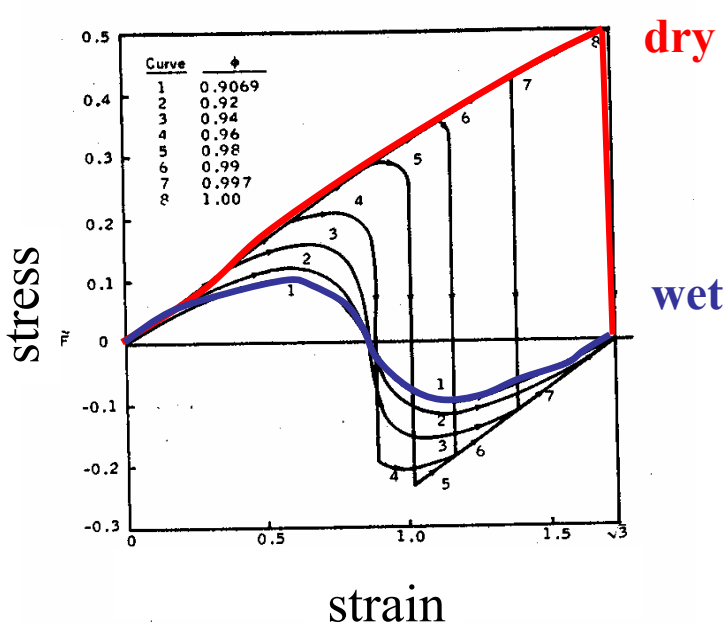
Oscillatory measurements

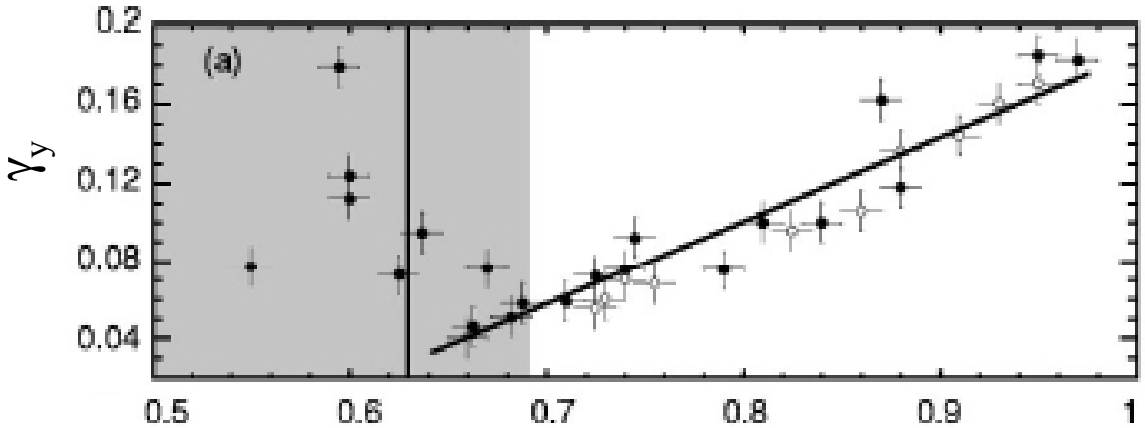


Effect of liquid content



Princen 1983

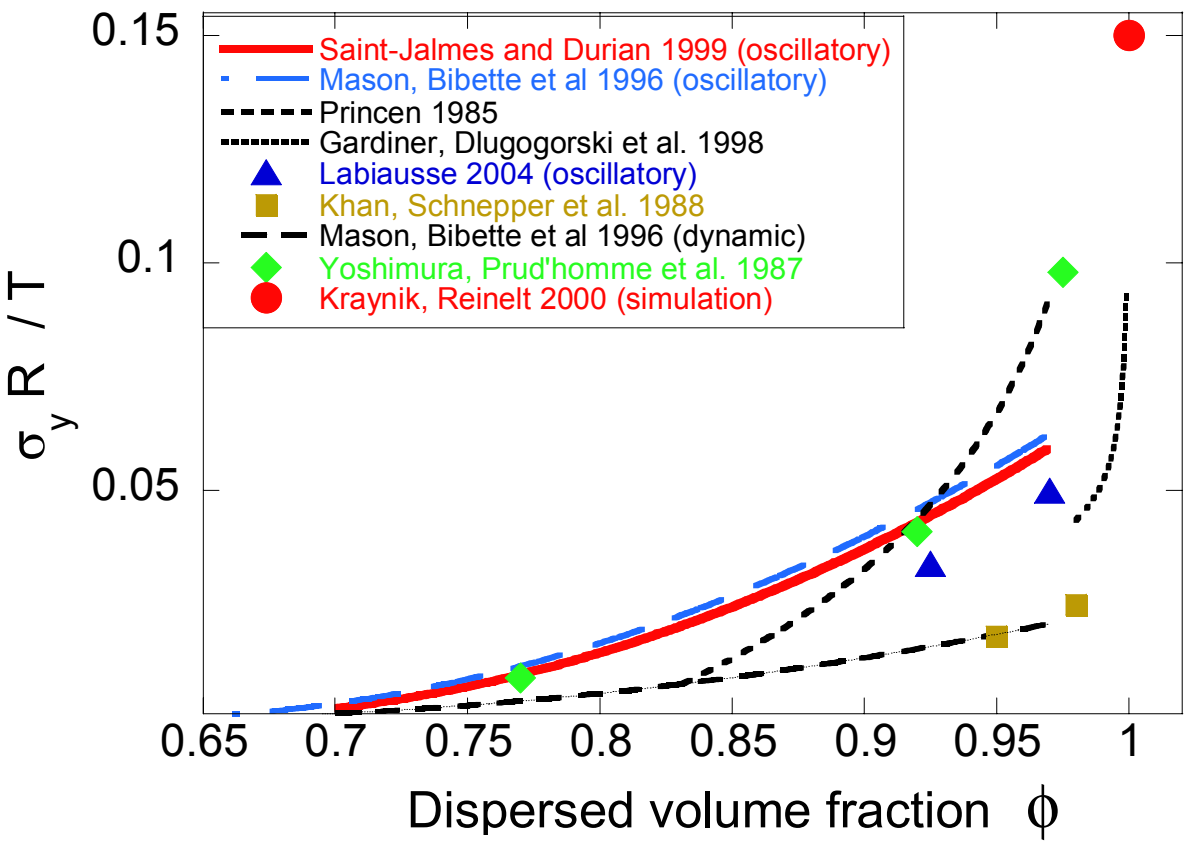




Saint-Jalmes, Durian 1999

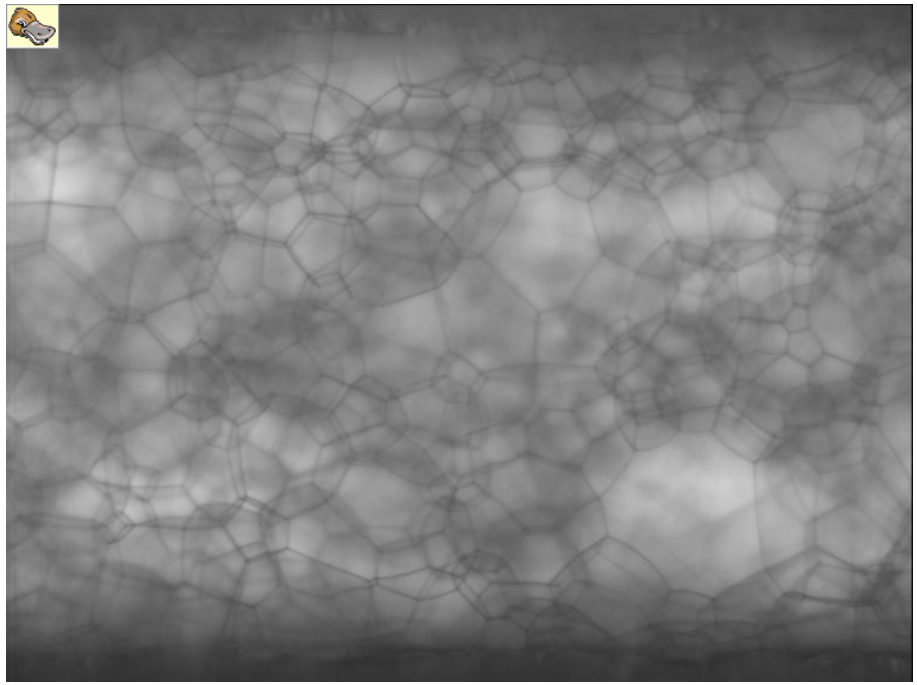
$$\gamma_y \cong 0.5\left(\phi - \phi_c\right)$$

$$\phi_c \cong 0.64$$



$$\sigma_y \cong 0.5\frac{T}{R}\left(\phi - \phi_c\right)^2$$

Onset of rearrangements

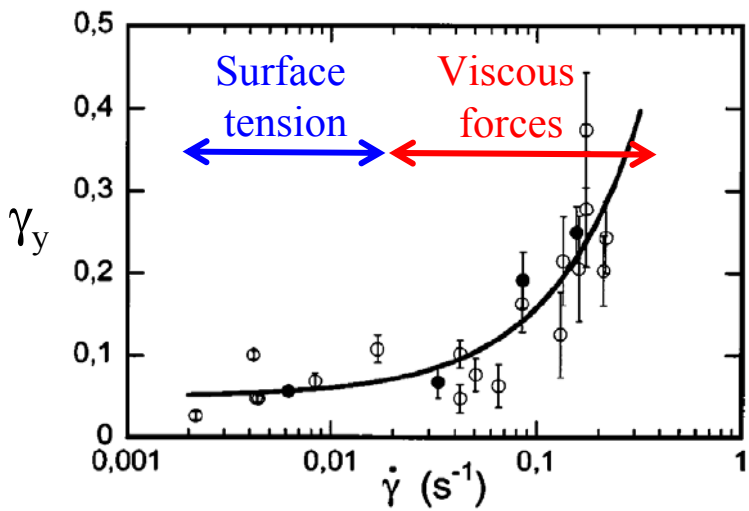


11 mm

F. Rouyer

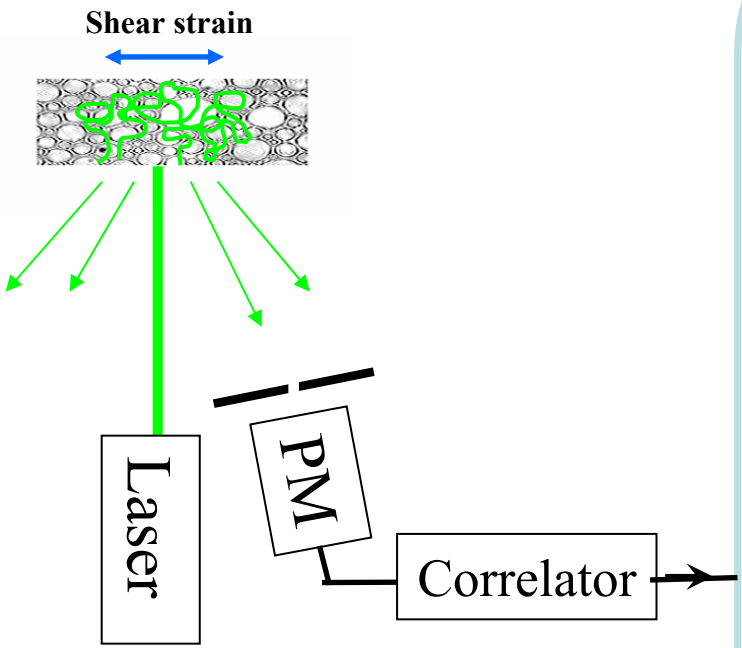
$\dot{\gamma} = 2.2 10^{-2}\ s^{-1}$

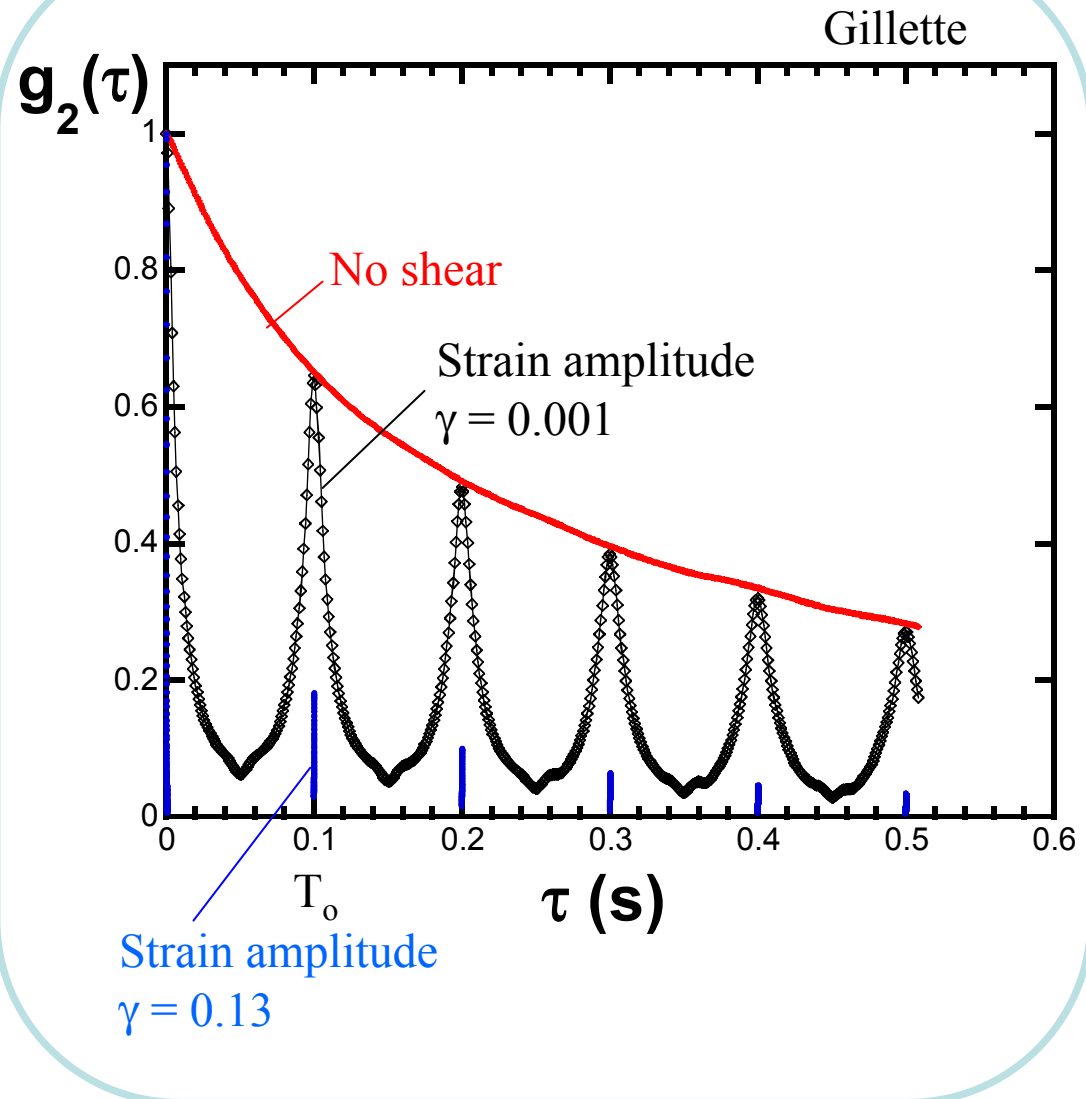
$\gamma_{max} = 1$



Rouyer et al. 2003

Yielding probed by DWS echoes

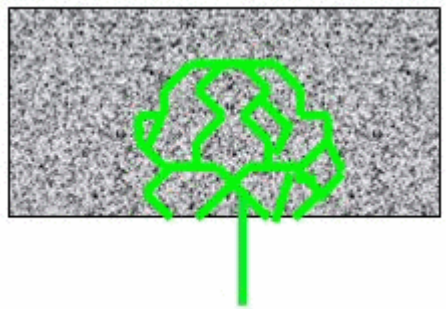




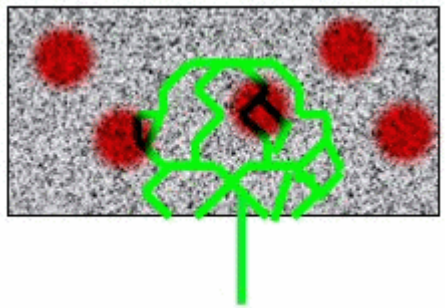
Hébraud, Lequeux 1997
Höhler, C-A, Hoballah 1997

Dynamics of shear induced rearrangements

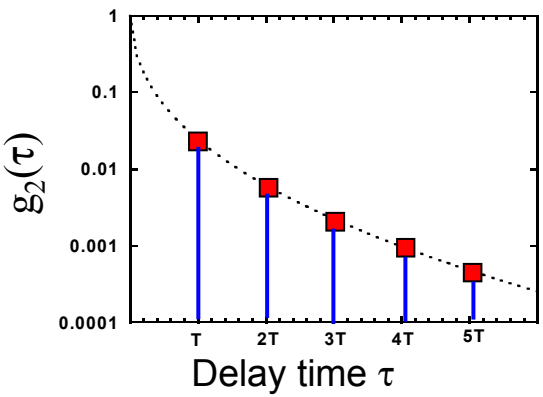
Random



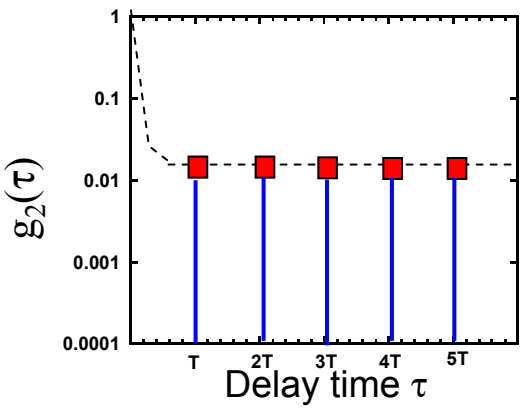
Highly correlated



$$g_1(nT_o) = \int_0^\infty P(s)\; g_1^s(nT_o)\; ds$$

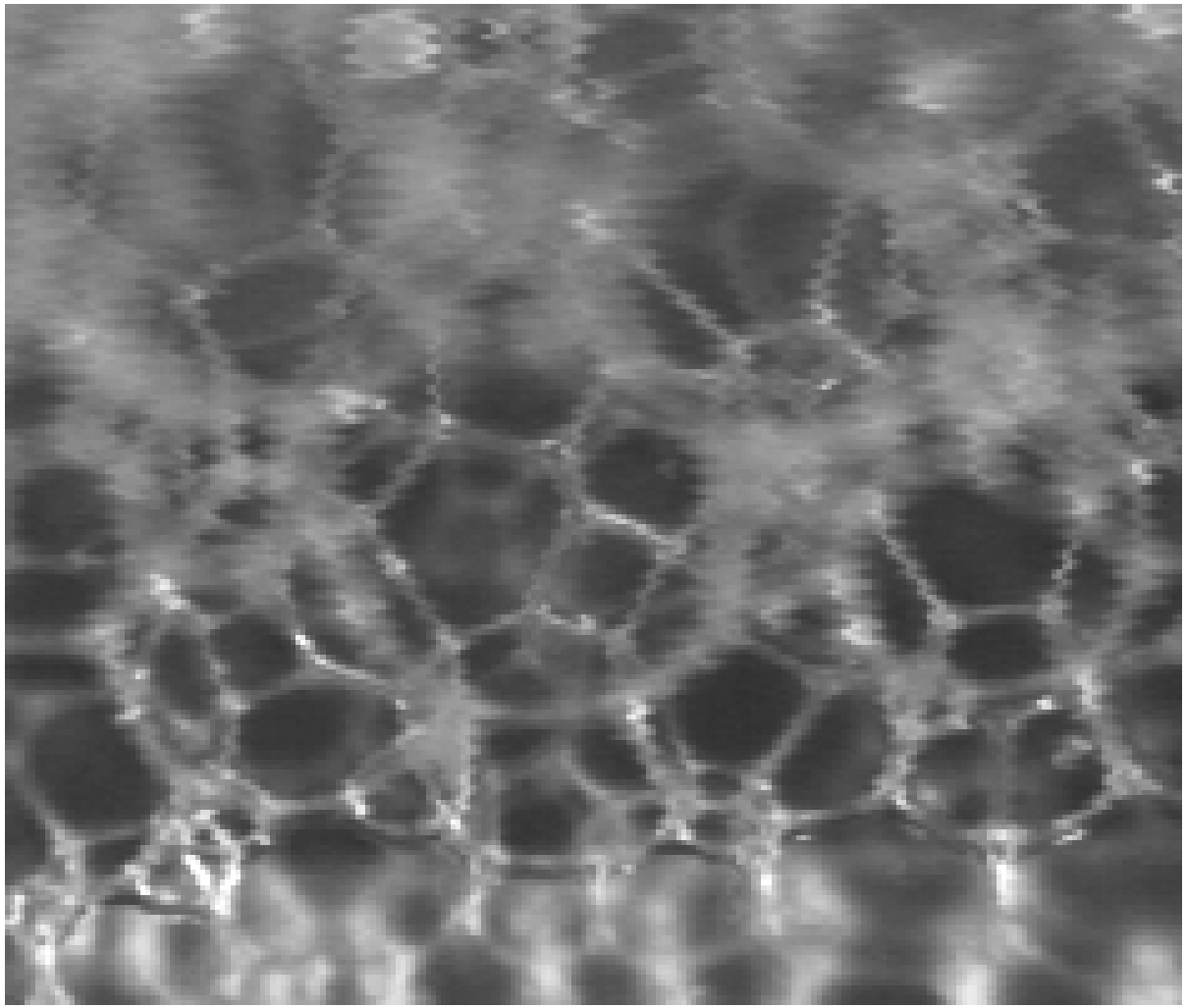


$\gamma << \gamma_y$



γ d γ_y

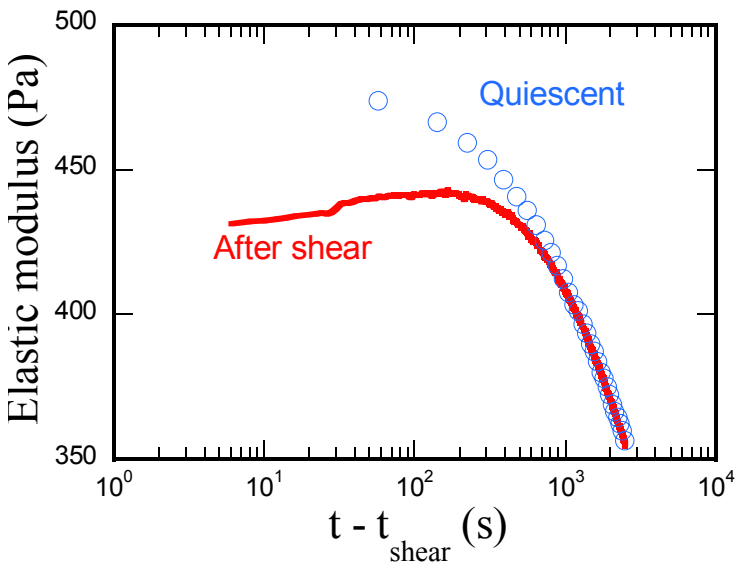
Precursors of shear band ?



V. Labiausse

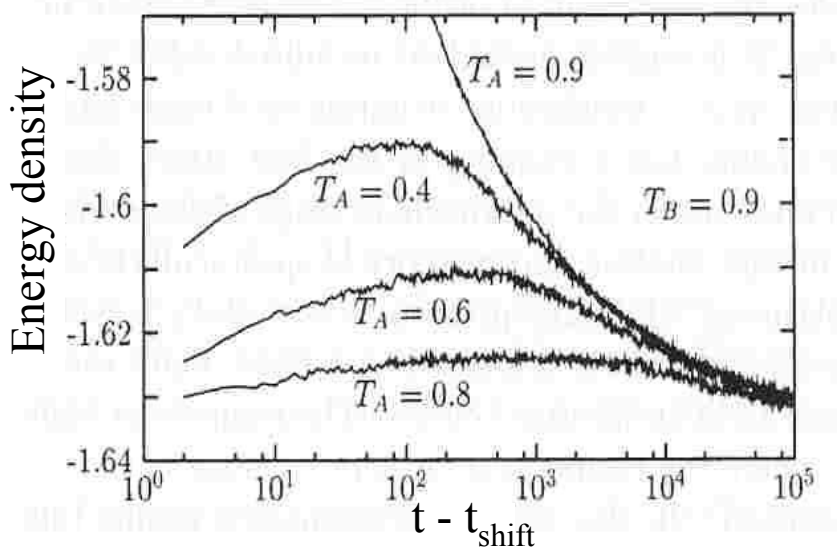
Mechanical memory effects

Foam



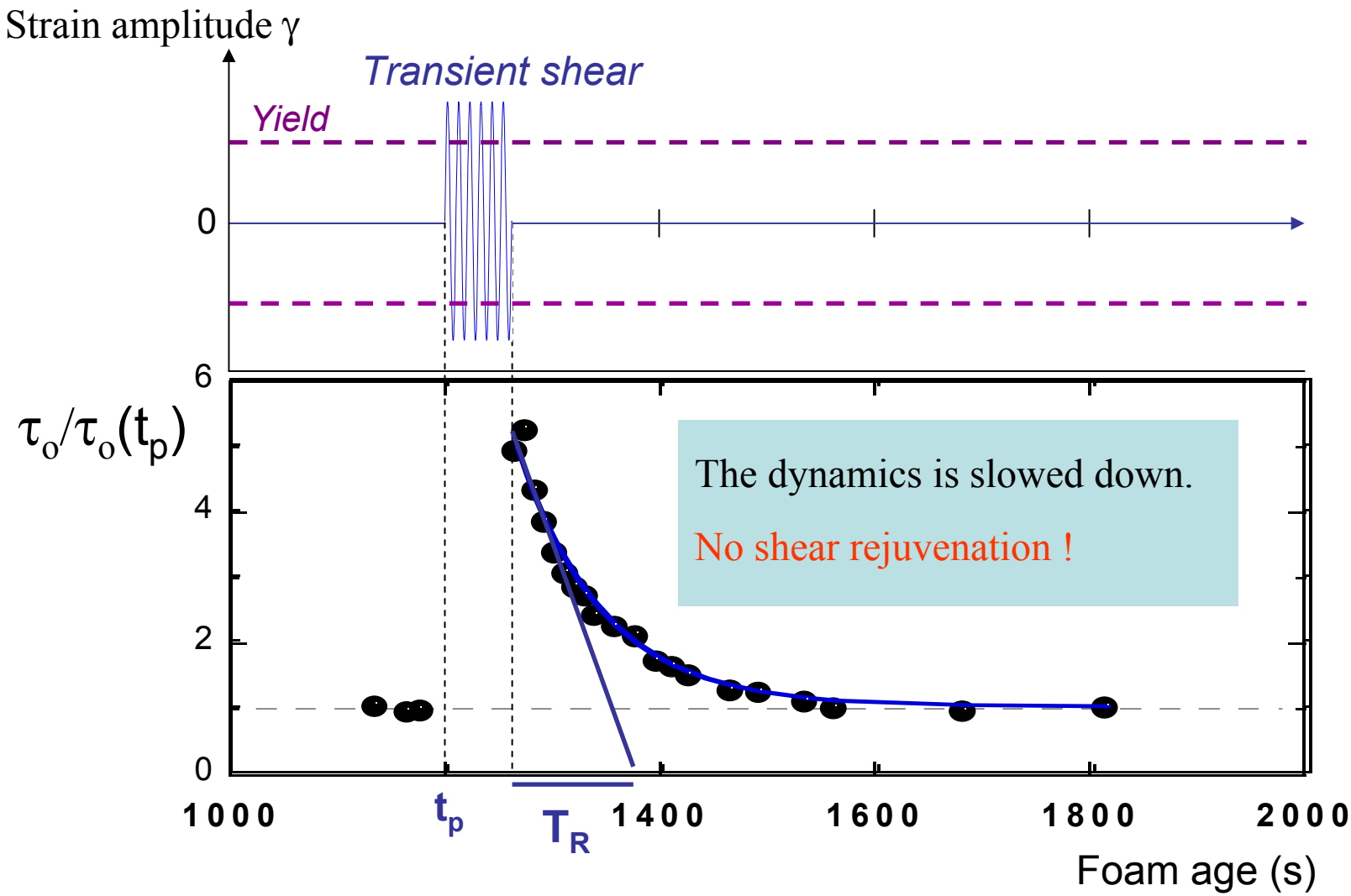
Höhler, C-A, Asnacios 1999

Kovacs effect
polymer, colloidal paste, spin glass



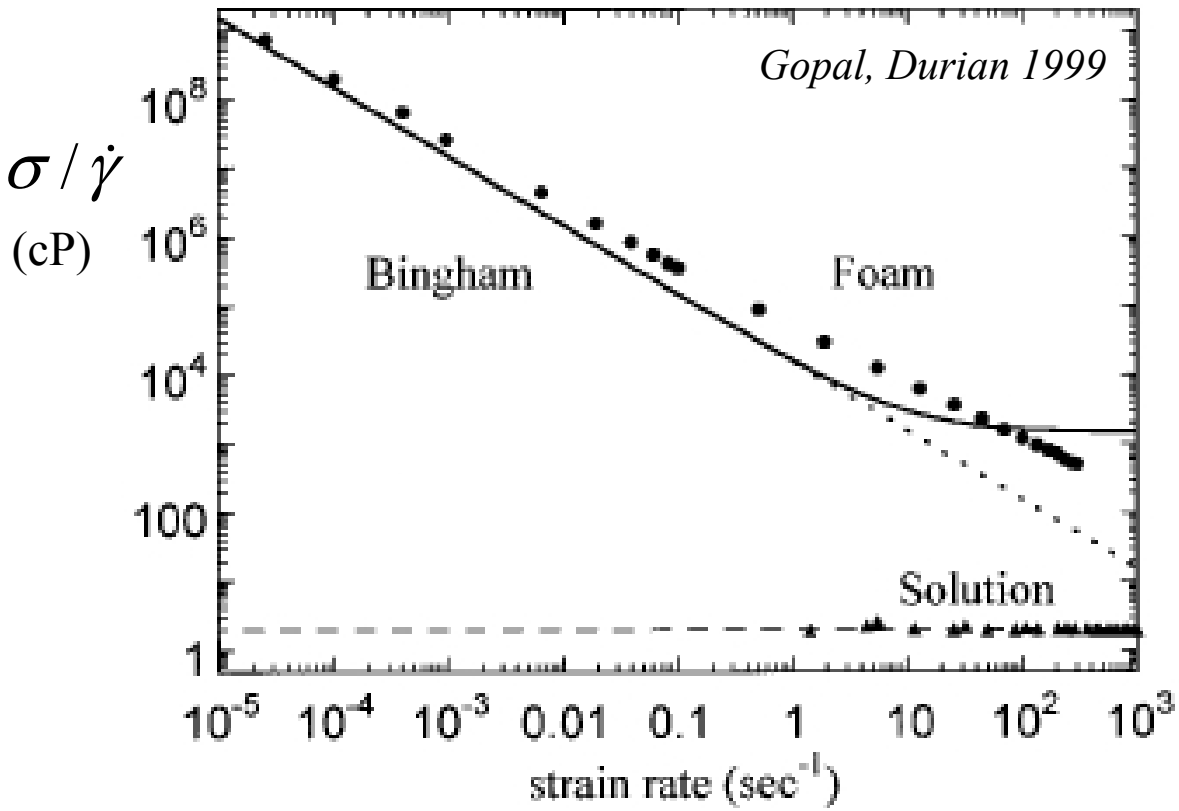
Kovacs 1963
Berthier, Bouchaud 2002
Cloitre, Borrega, Leibler 2000
Derec et al 2003
Ozon et al 2003

Dynamics relaxation during foam "solidification" probed by multispeckle DWS



C-A, Höhler 2001

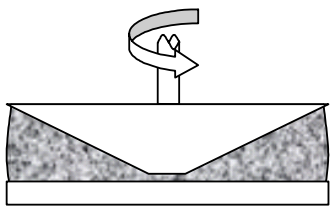
Effective viscosity

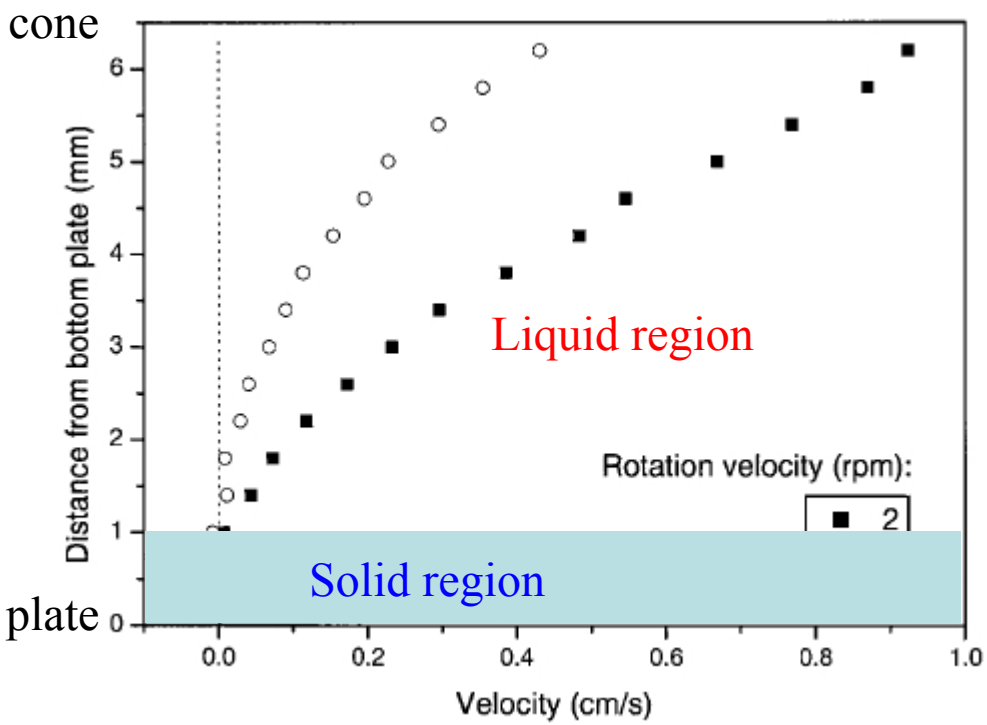


Khan, Schnepper 1988
Princen, Kiss 1989
Denkov et al 2005
Herzhaft et al 2005

Herschel-Bulkley $\sigma = \sigma_y + k\,\dot{\gamma}^{\,n}$ $0.25 < n < 1$

Coexistence of solid-like and liquid-like regions





Mayonnaise emulsion

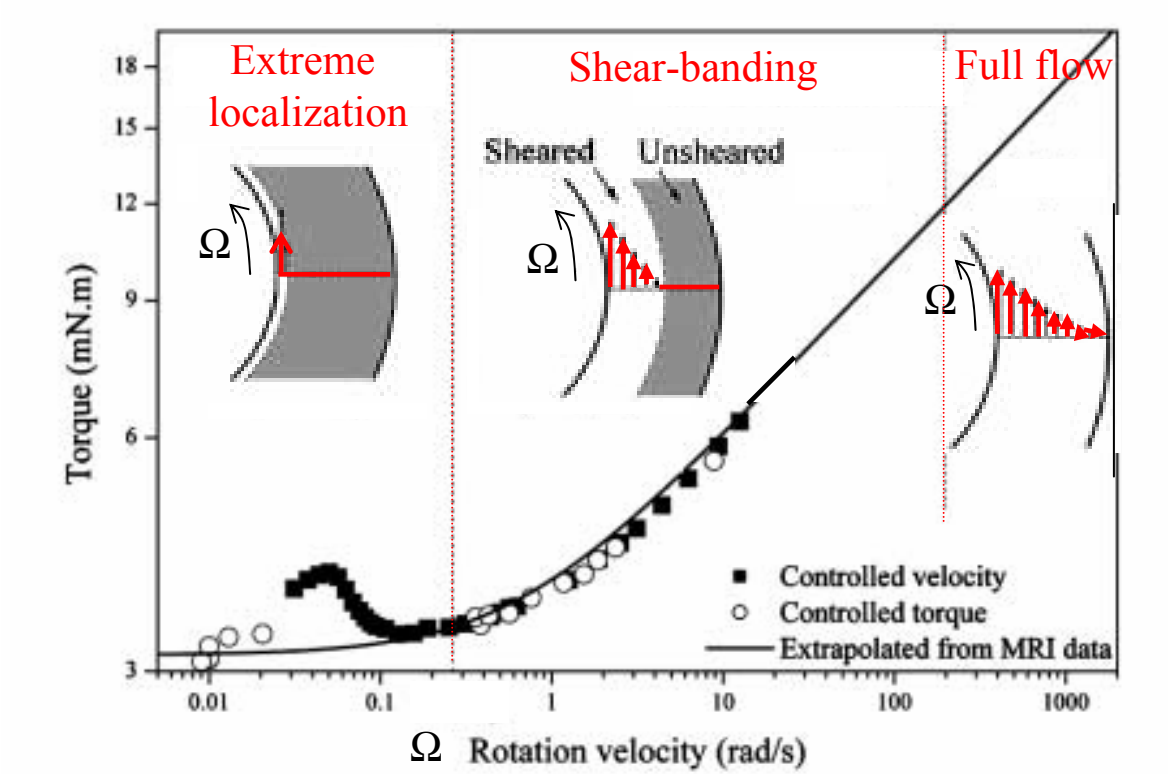
MRI study

Coussot et al 2002

3D cylindrical Couette geometry

Constitutive equation

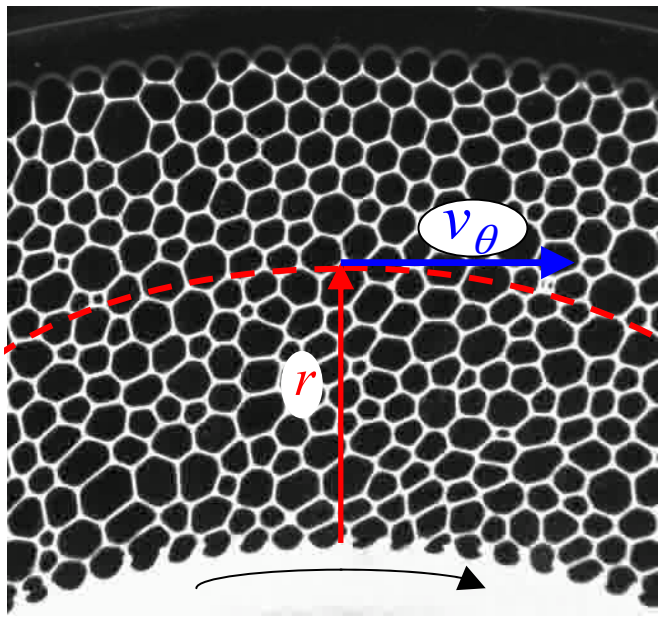
$$\begin{cases} \dot{\gamma}_{local} = 0 & for \quad \sigma < \sigma_c \quad \text{solid region} \\ \sigma = \sigma_c \left(\dfrac{\dot{\gamma}_{local}}{\dot{\gamma}_c} \right)^m & for \quad \sigma > \sigma_c \quad \text{sheared region} \end{cases}$$



Rodts, Baudez, Coussot 2005

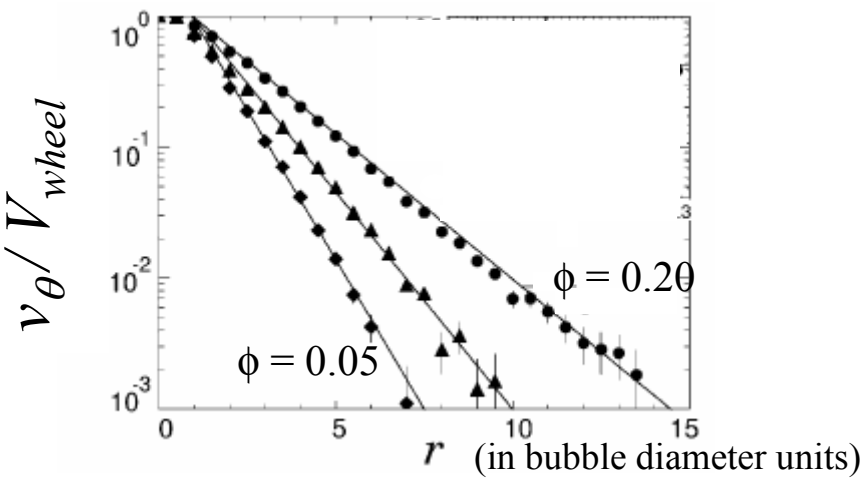
2D cylindrical Couette geometry

Quasistatic flow of bubbles in a Hele-Shaw cell



~ 2 mm

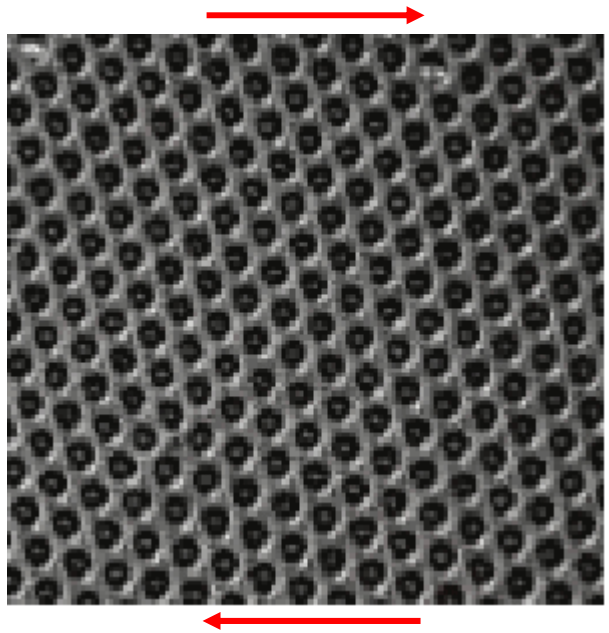
Debregeas



Debregeas, Tabuteau, di Meglio 2001

Bubble rafts

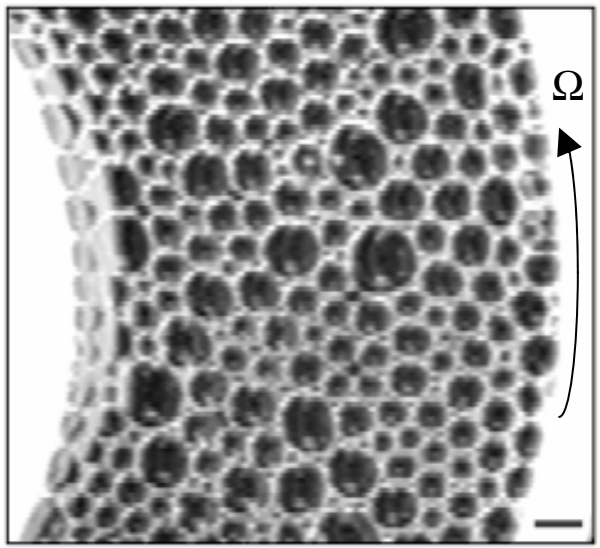
Bragg ~1950
Lauridsen, Twardos, Dennin 2002



www.doitpoms.ac.uk

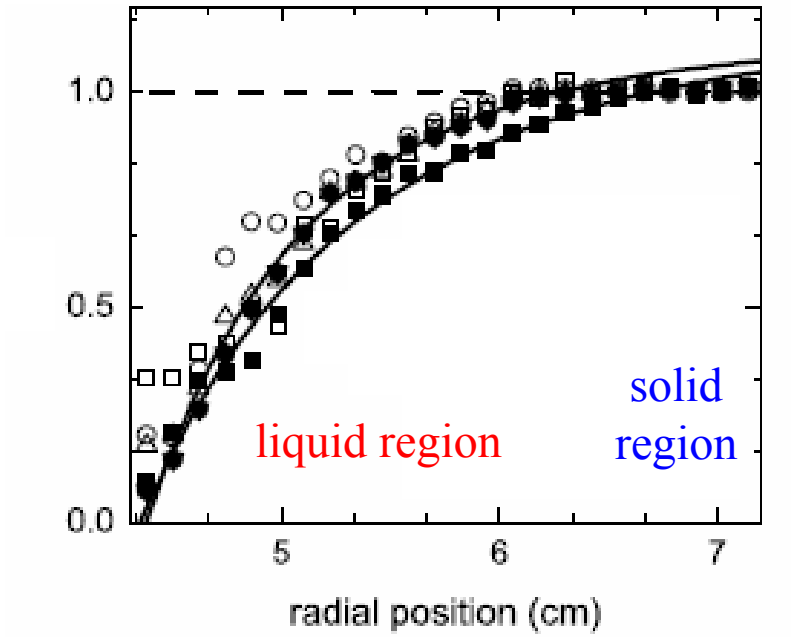
2D cylindrical Couette geometry

raft



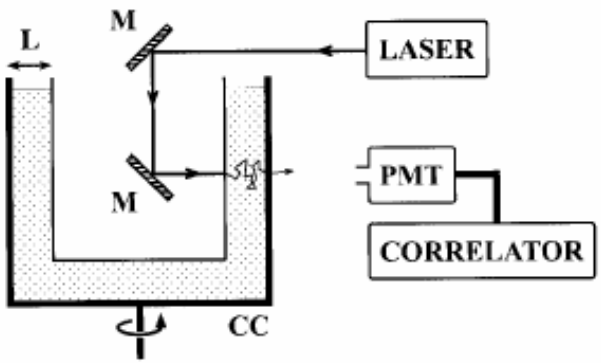
3.6 mm

$v(r) = v_\theta / (r\,\Omega)$

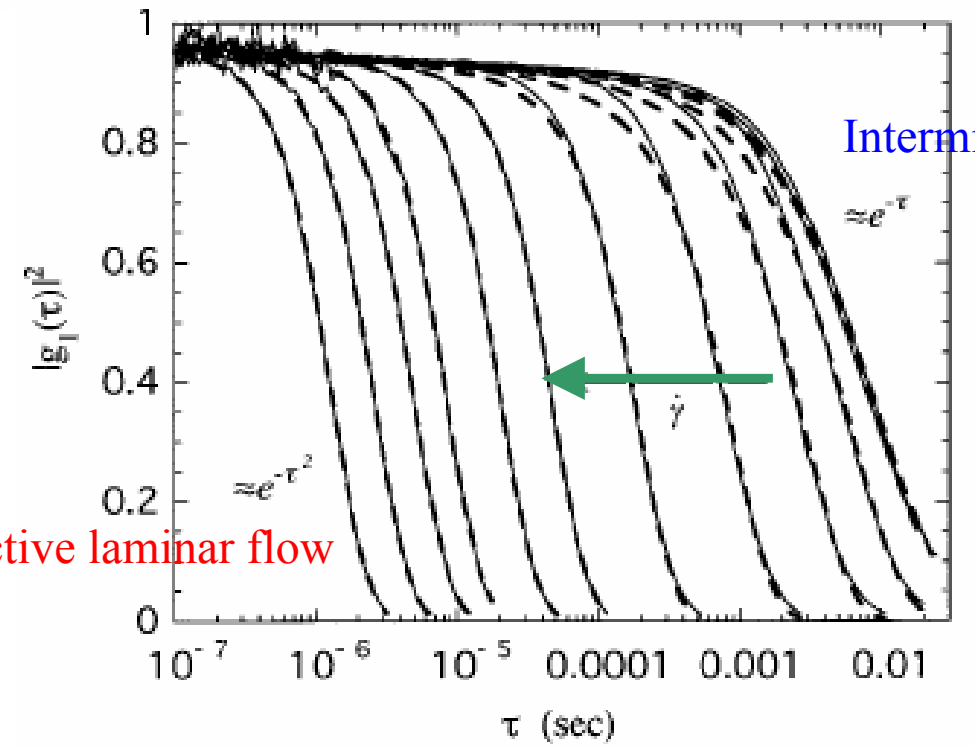


Lauridsen, Chanan, Dennin 2004

Flow dynamics on the bubble scale



$$g_{1T}(\tau) \cong \exp\left(-\frac{1}{6}\left(\frac{L}{\ell *}\right)^2 k^2 < \Delta r^2(\tau) > \right)$$



Intermittent dynamics

Convective laminar flow

Gopal, Durian 1999

Many references in

Rheology of liquid foam

Höhler, C-A, J. Phys.: Condens. Matter (2005)