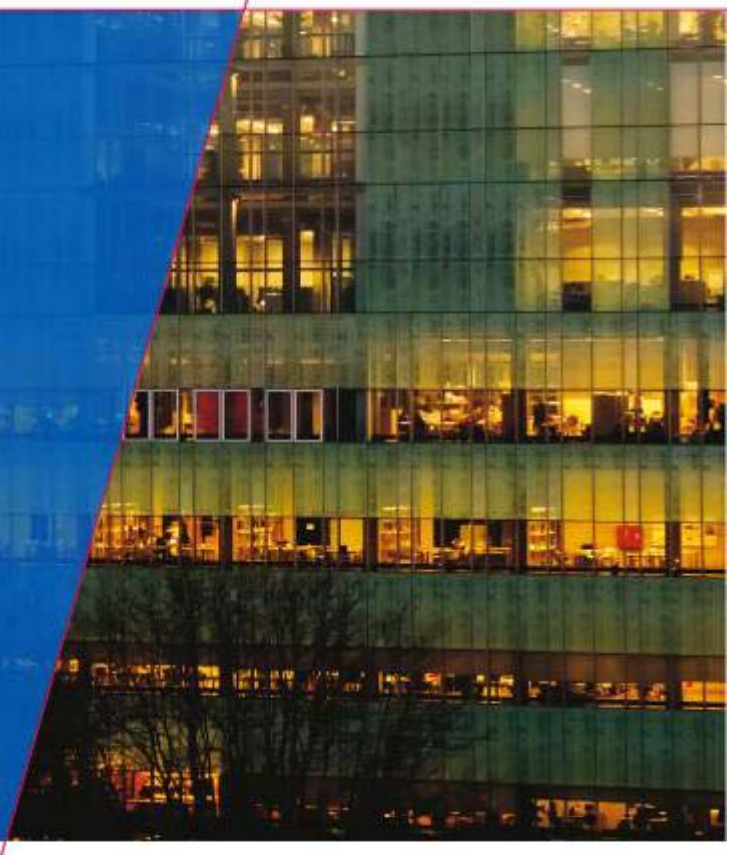
Reologie is overal

(nou ja, bijna overal)

WND Conferentie, Noordwijkerhout
16, 17 december 2011

Gerrit W.M. Peters



TU/e Technische Universiteit Eindhoven University of Technology

Where innovation starts

the silly putty bomb

rheology definition

study of flow and deformation of matter

(description of flow properties of materials
where the time scale plays an important role)

examples of interesting materials:

- polymer melts / solutions
- biological tissues / fluids
- food

lets do some history

deborah number (*De*)

“even the mountains flowed before the lord”

from the song of Deborah after her victory over the Philistines,
Judges 5:5

(translated by M. Reiner, Physics today, Jan. 1964)

Coast of Bretagne, France

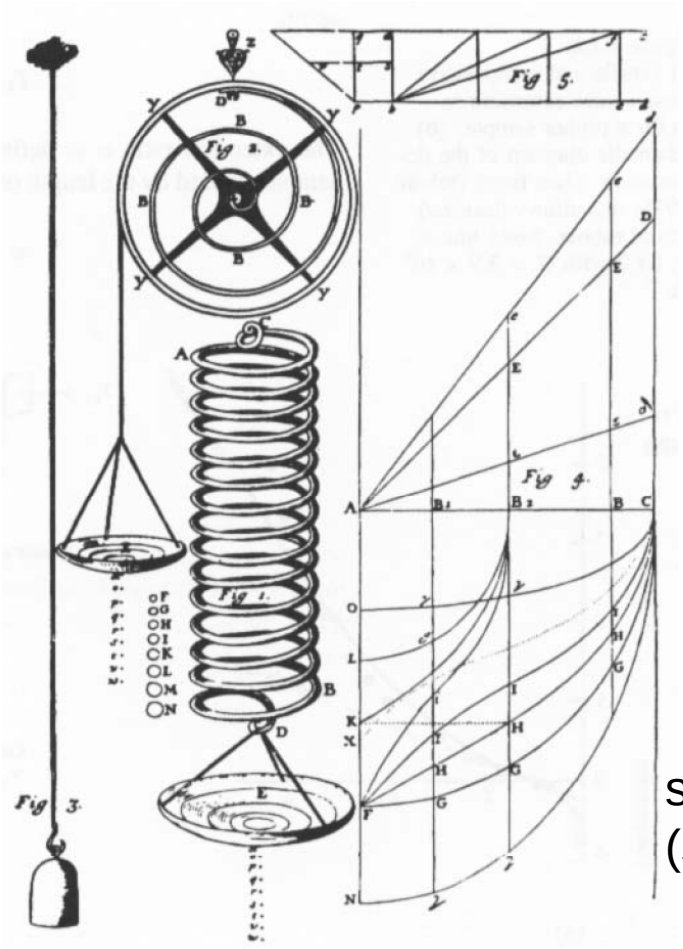
$$De = \lambda / t$$

λ: characteristic material time
t: characteristic process time

Silly putty bomb: $\lambda \sim 10^{3}$, $t \sim 10^{-3}$:$De \sim 10^{6}$

elastic solid: force versus extension

$f \sim \Delta L$

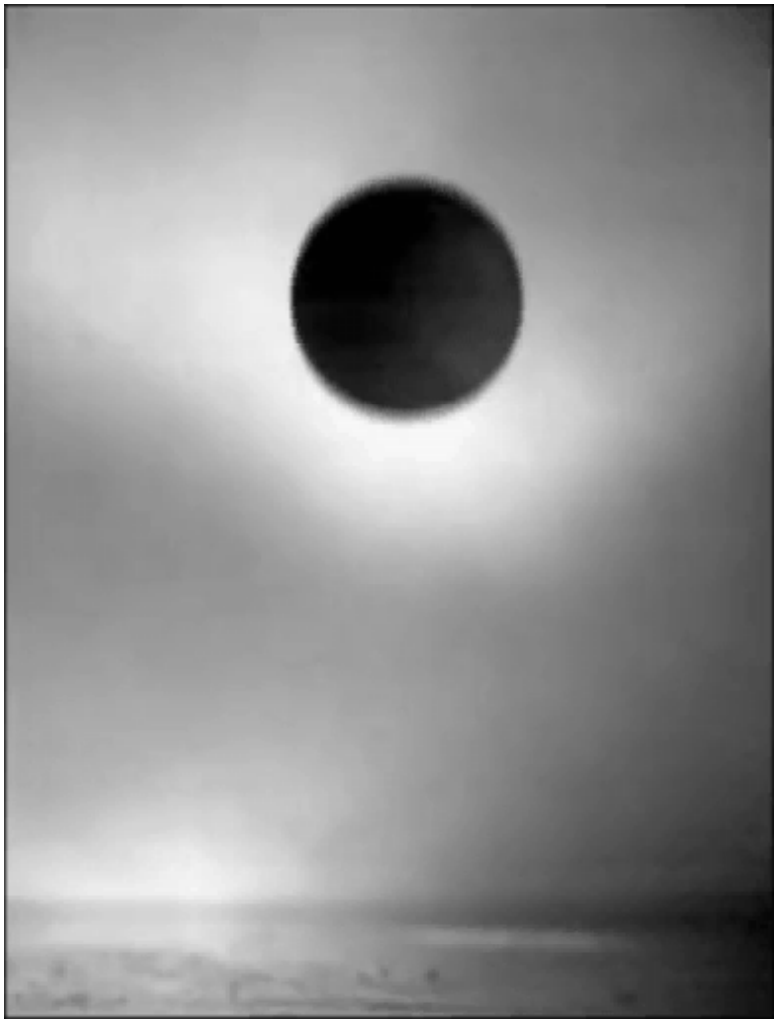


by Rita Greer, from written descriptions, 2009

Hooke, 1678 (??)

stress versus strain: Cauchy:,1820
(small deformations. metals ceramics)

elastic solid: bouncing ball

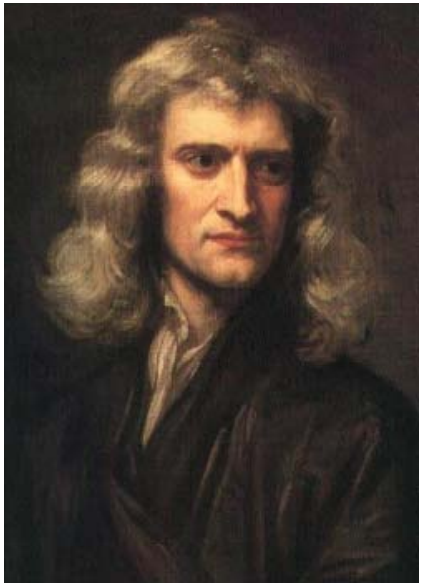


elastic solid: force versus extension

tooth paste; a solid (?)

viscous fluid: force versus velocity

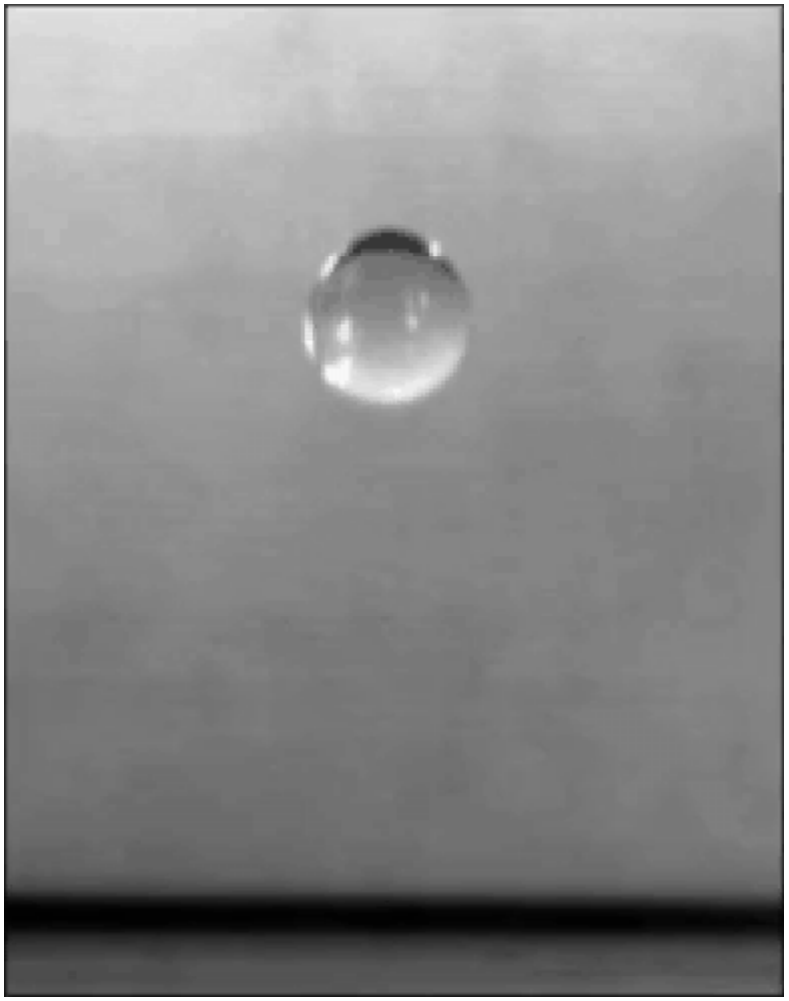
The resistance which arises from the lack of slipperiness originating in a fluid, other things being equal, is proportional to the velocity by which the parts of the fluid are being separated from each other (Newton, Principia Mathematica, 1678)



one dimensional case: $\tau_{yx} = \eta \frac{dv_x}{dy}$

Three dimensional formulation: Stokes 1856

viscous fluid: water drop



viscous fluid: pitch drop experiment

Pitch has a viscosity of approximately 230 billion (2.3×10^{11}) times that of water.

viscous fluid: pitch drop experiment

Timeline

Date	Event	Duration (Months)	Duration (Years)
1927	Experiment set up		
1930	The stem was cut		
December 1938	1st drop fell	96–107	8.0–8.9
February 1947	2nd drop fell	99	8.3
April 1954	3rd drop fell	86	7.2
May 1962	4th drop fell	97	8.1
August 1970	5th drop fell	99	8.3
April 1979	6th drop fell	104	8.7
July 1988	7th drop fell	111	9.3
28 November 2000	8th drop fell	148	12.3

viscous fluid: pitch drop experiment

Timeline

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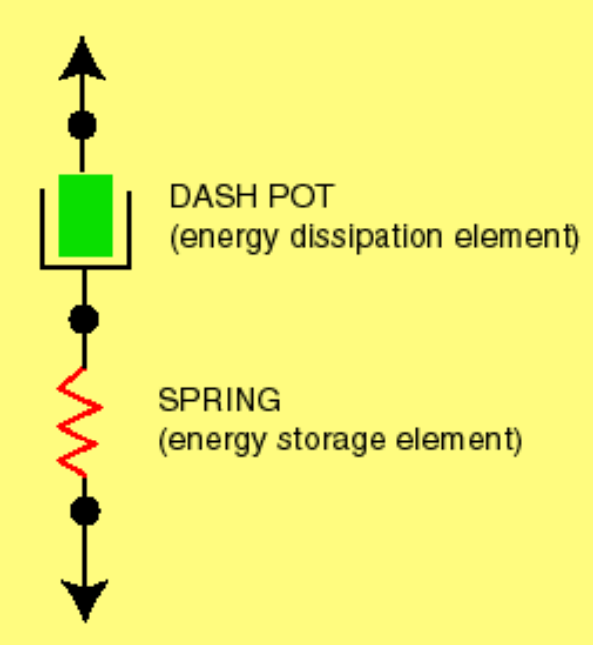
Other example,old leaded window:
- De >> 1
- flow due o gravity (sagging)
- thickness difference measurable

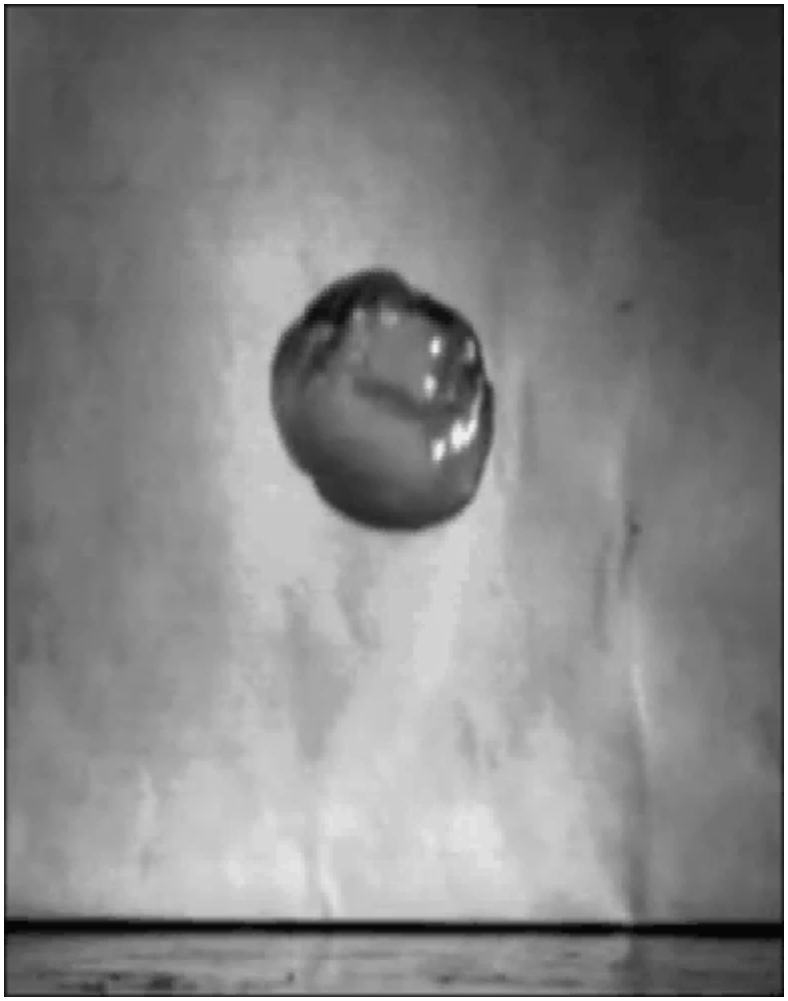
viscous & elastic: viscoelastic behavior

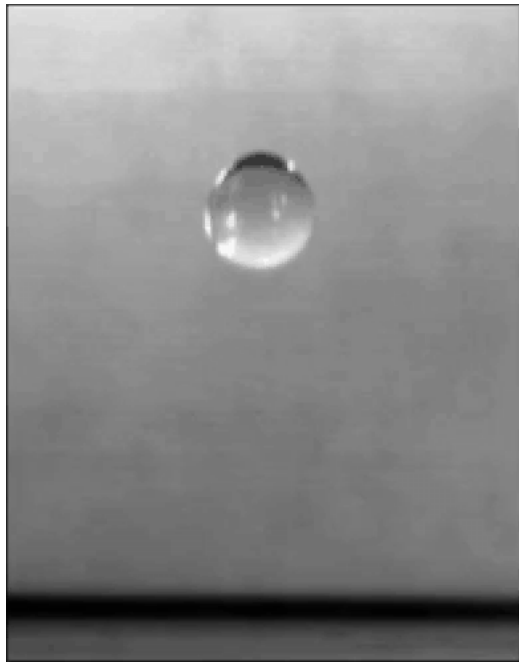


depending on the time scale, viscous, elastic or both behaviors are observed

examples of viscoelastic behavior; it’s showtime

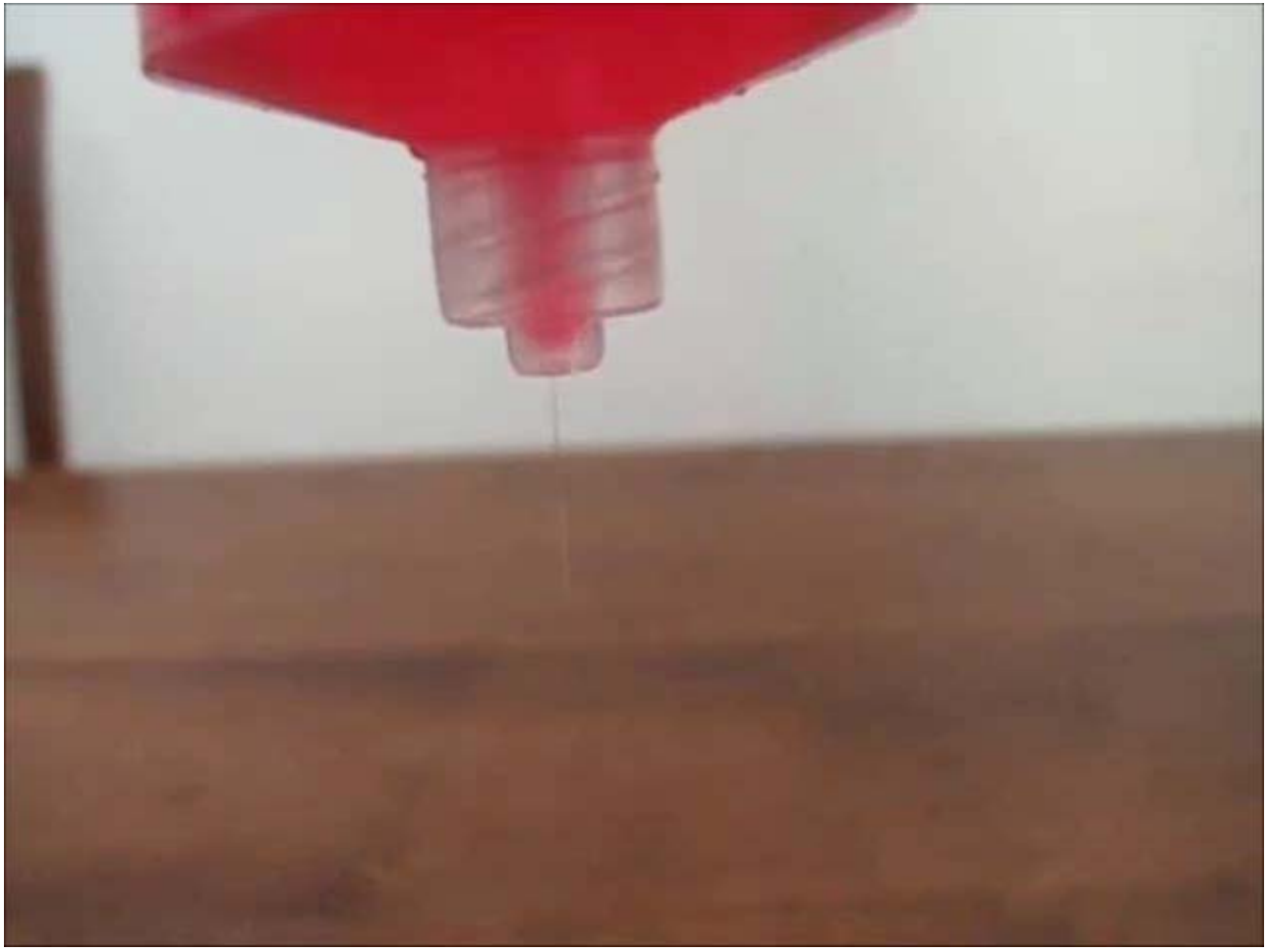
dropping things





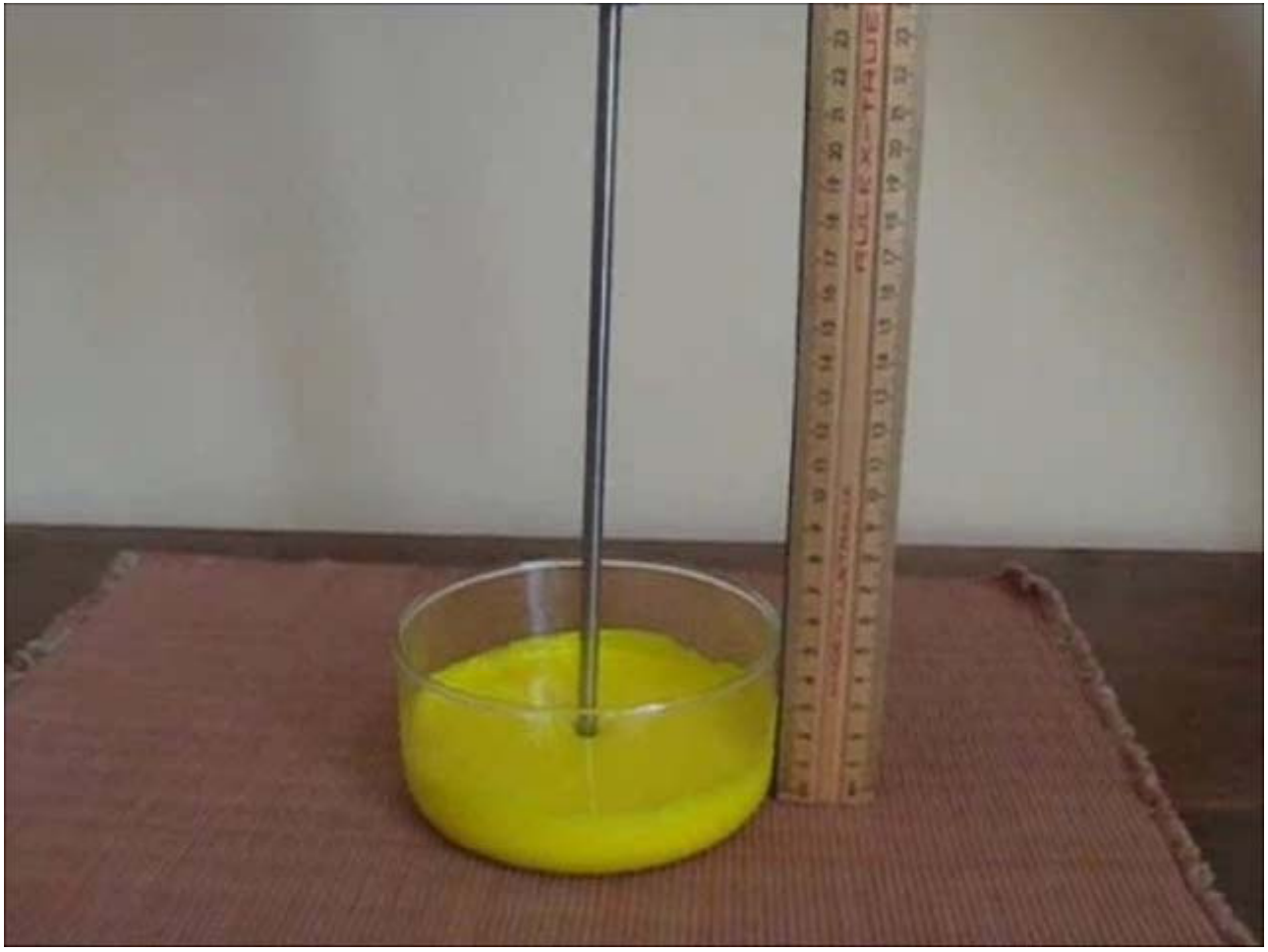
viscoelastic behavior: example 1

die swell



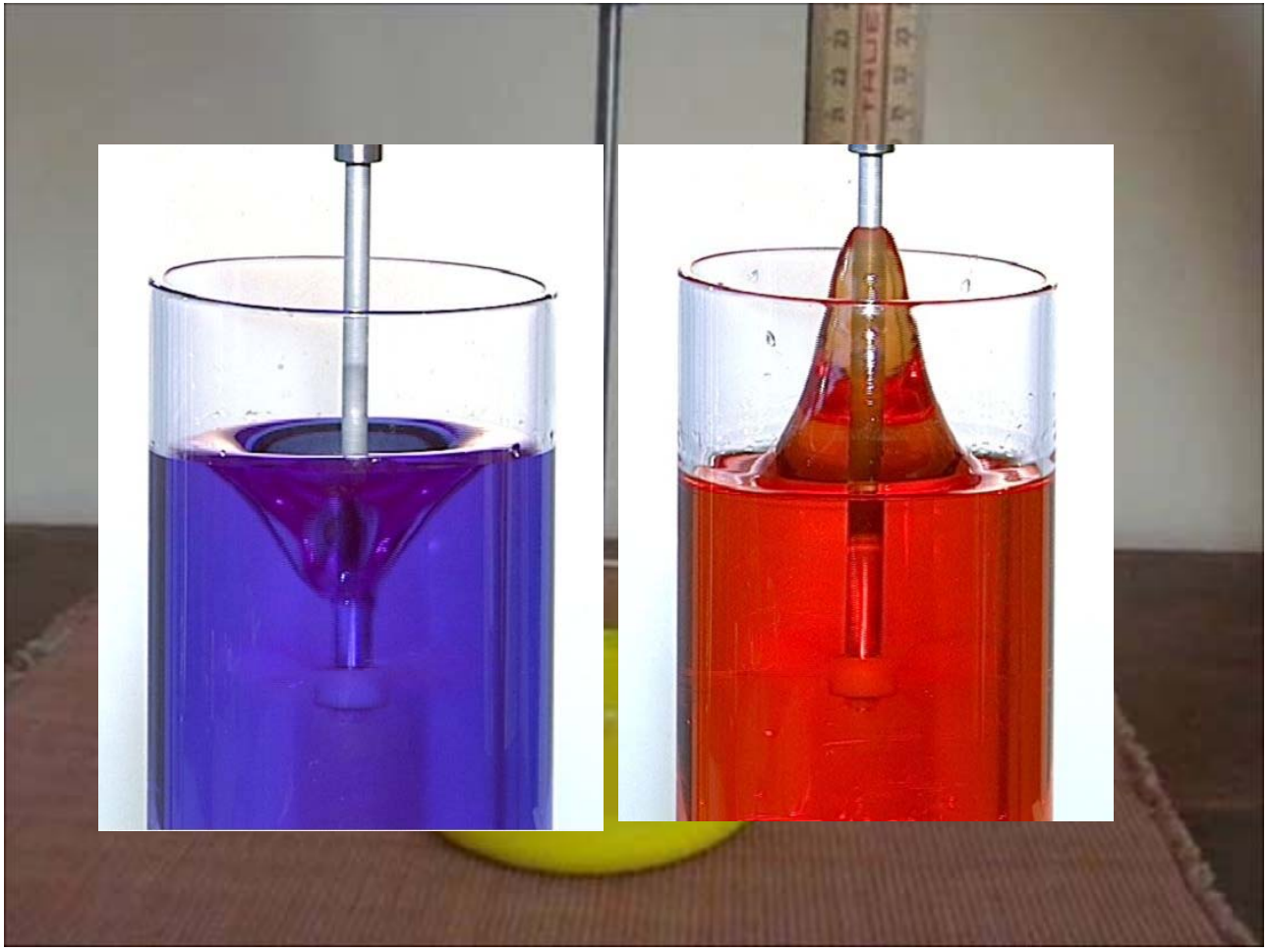
viscoelastic behavior: example 2

rod climbing



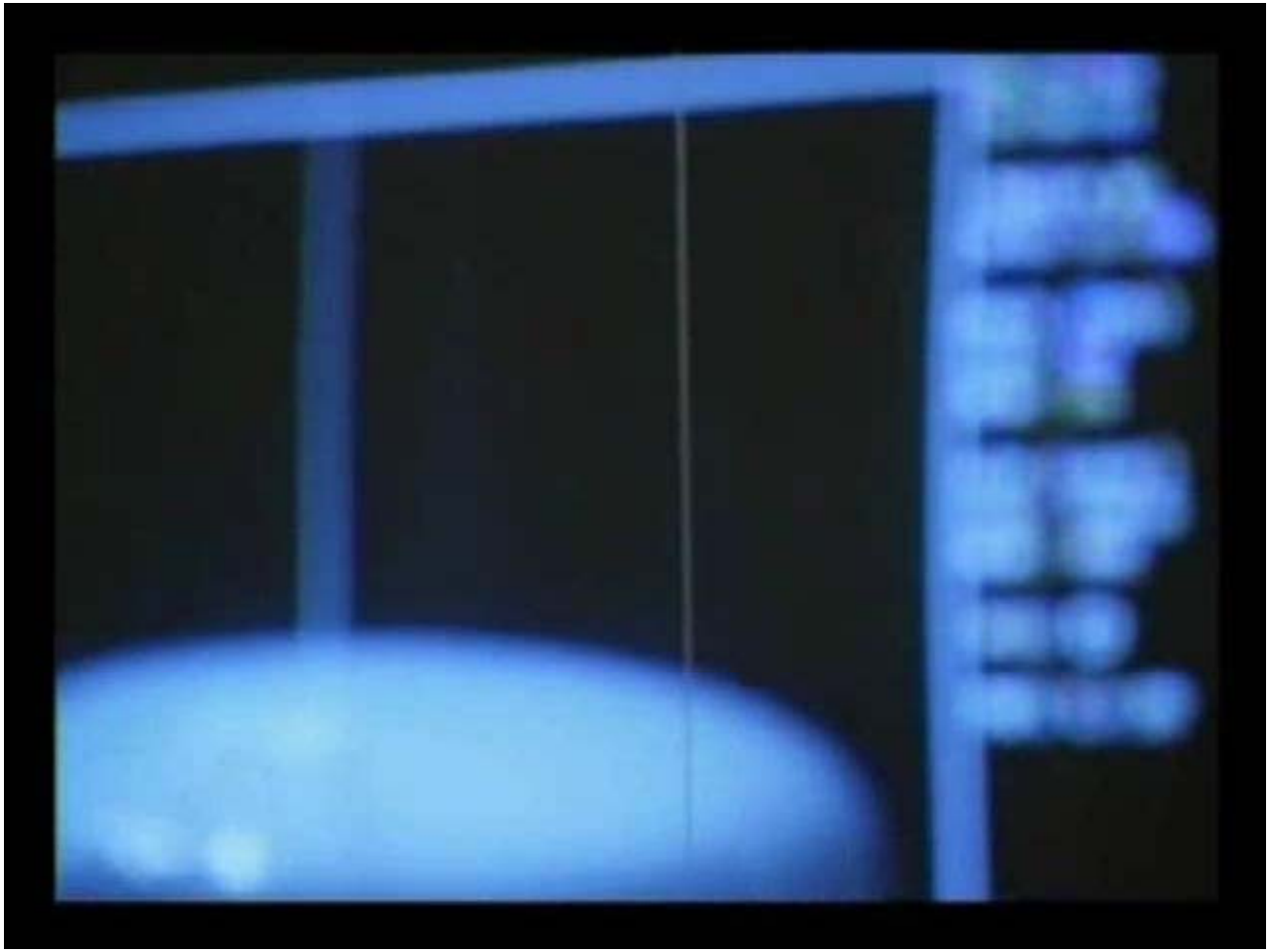
viscoelastic behavior: example 2

rod climbing



viscoelastic behavior: example 3

Kaye effect



movie from Twente University

viscoelastic behavior: example 4

shear thickening 1

viscoelastic behavior: example 4

shear thickening 3

so far for the funny phenomena