Surprise!
(Well what did you expect?):
Experimental contributions to physics of pattern formation

Original title intentionally provocative

Experiment:
- source of questions
- source of surprises
- source of answers
- source of verification

(Experiment - where theory comes to die)

Particularly in pattern formation and non-equilibrium physics

An interplay between theory, simulation and experiment

BIG questions -
questions that would open fields -- not close them

What are the effects of - how should we treat:

- non-linearity
- non-locality
- singularities
- disorder
- non-equilibrium

Involves:

- Self-organization
- Dynamics
- Feedback

Self-organized Jamming (ITP Workshop - 1997)

How does system get stuck in amorphous state far from equilibrium?

What is the physics of rigidity?

Examples:

- Glasses (structural)
- Granular matter
- Colloids, foams and suspensions
- Thermal and athermal systems

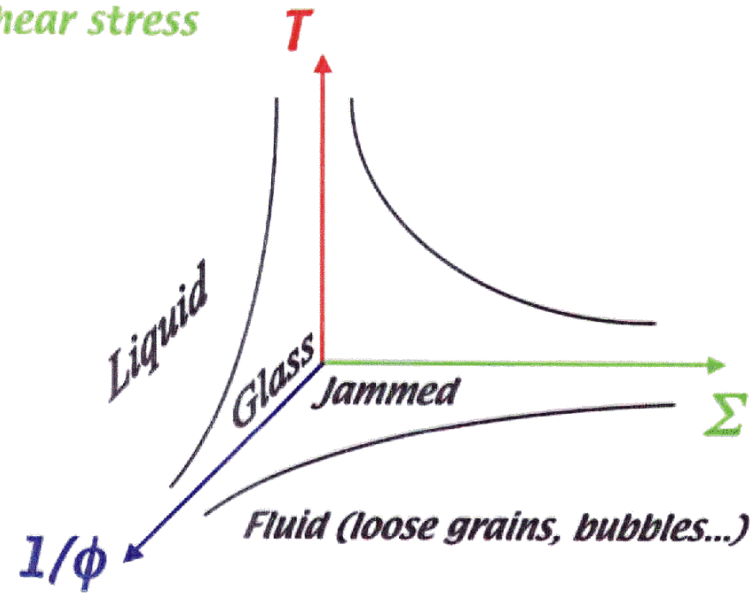
New point of view:

Glass transition related to jamming

Jamming phase diagram:

Link glasses and granular materials

ϕ density
T temperature
Σ shear stress

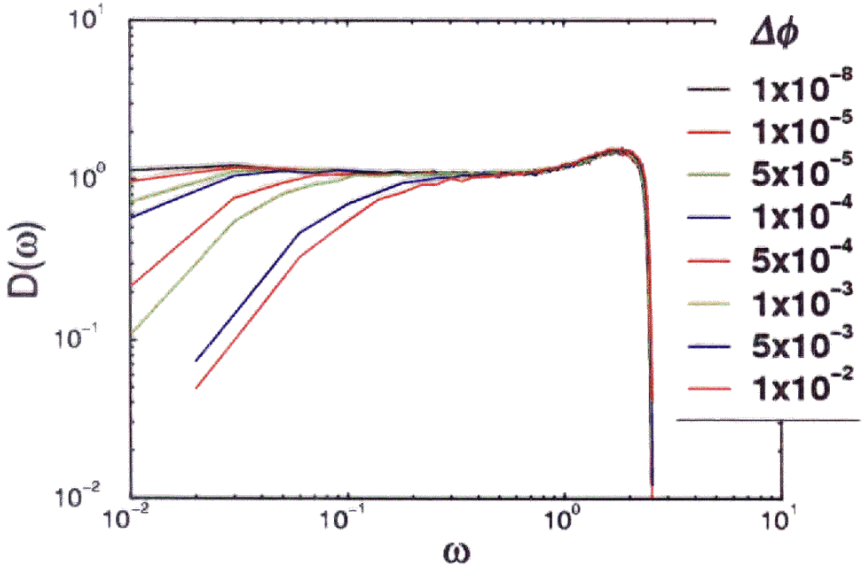


A. J. Liu

Density of normal-mode states

simulation

signature a transition approached



L. Silbert, A. J. Liu

Surprise!

--- No sign of Debye behavior!

Dynamics related to structure.

"Mean-field theory of the Potts glass," D. J. Gross, I. Kanter, H. Sompolinsky, PRL 55, 304 (1985)

Dynamic Singularities

Infinitesimally small; very short time.

How does one treat singularities?

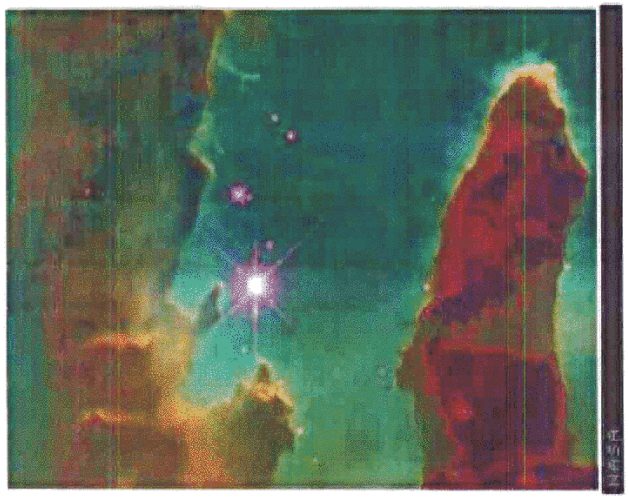
Simulations *cannot* pass through it
(but nature has no problem)

Similar dynamic singularities
appear everywhere in physics:

star formation
bacteria colony growth
turbulence . . .

nuclei??
biological cells??

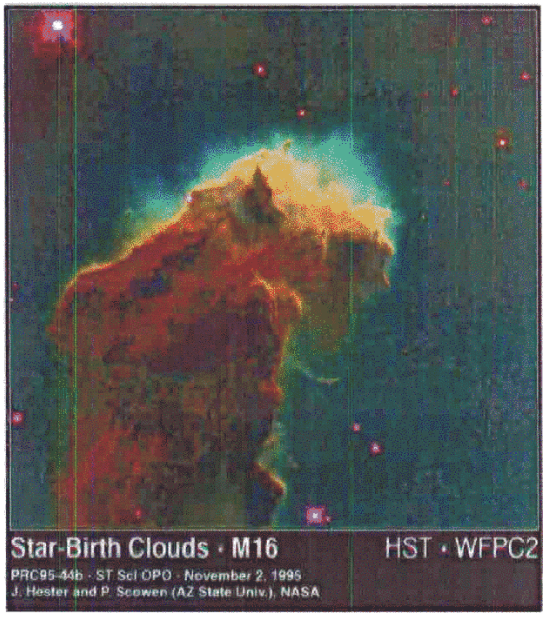
PILLARS OF CREATION IN A STAR-FORMING REGION



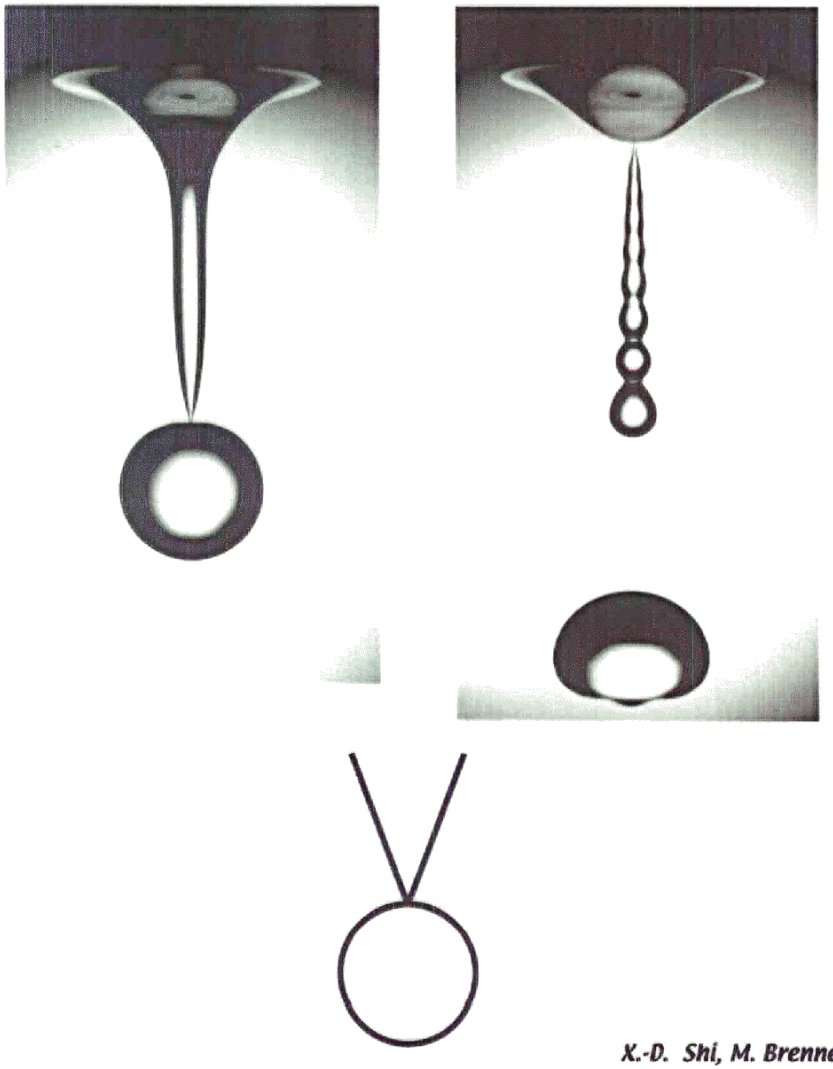
Gas Pillars in M16 - Eagle Nebula

Picture taken on April 1, 1995 with Hubble Space Telescope Wide Field and Planetary Camera 2.

Color image constructed from three separate images taken in the light of emission from different types of atoms. Red shows emission from singly-ionized sulfur atoms. Green shows emission from hydrogen. Blue shows light emitted by doubly- ionized oxygen atoms.

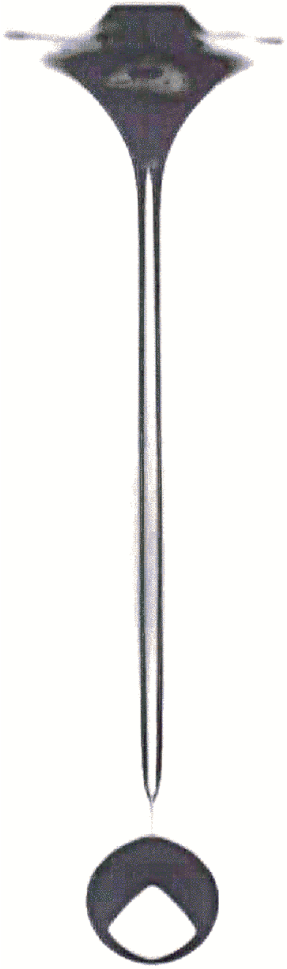


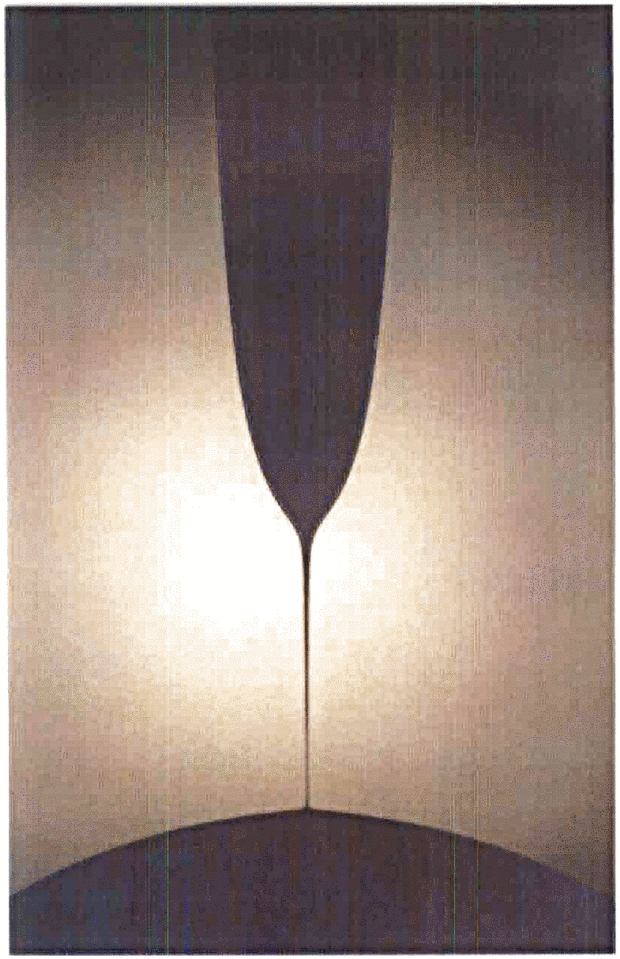
Water drop in air



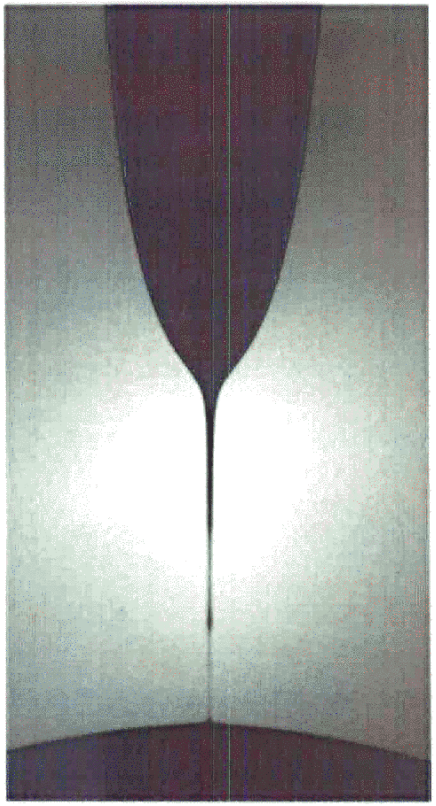
X.-D. Shi, M. Brenner

Glycerol/water drop into air





A little later: Surprise!

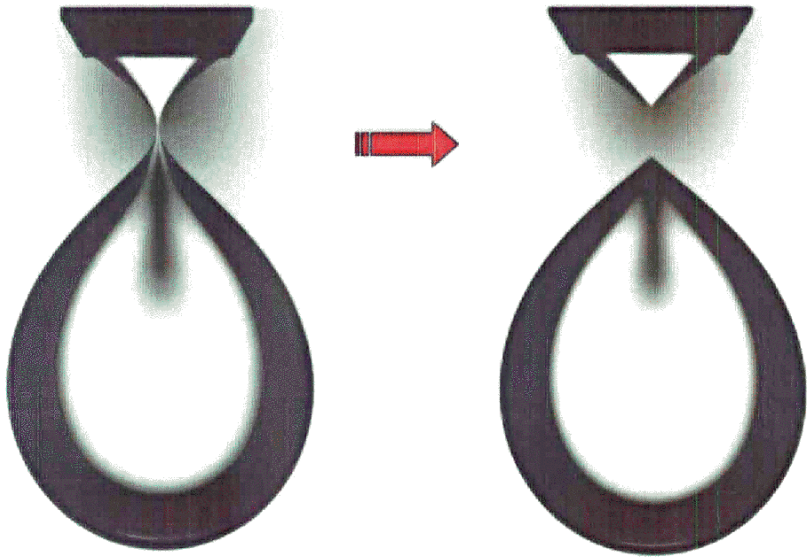


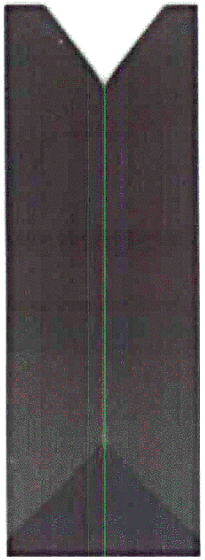
Surprise came from interaction of theory, experiment and simulation

X.-D. Shi, M. Brenner

Water drop in oil

Surprise!





η_{water} = 0.01 P

η_{oil} = 120 P

I. Cohen
W. Zhang
Doshi & Basaran

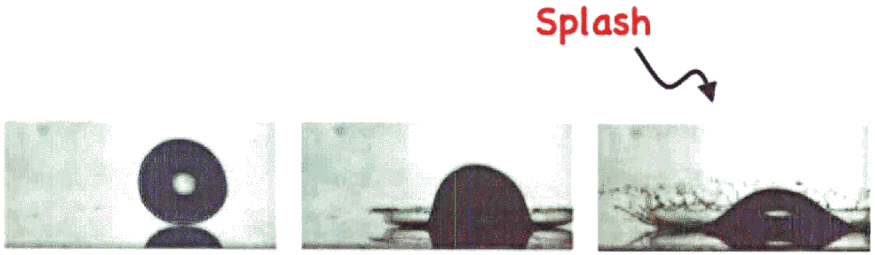
The drop falls ⇒ splashes

Is splash interesting?

Break-up localizes energy from the kinetic energy into singular points as surface ruptures.

How?

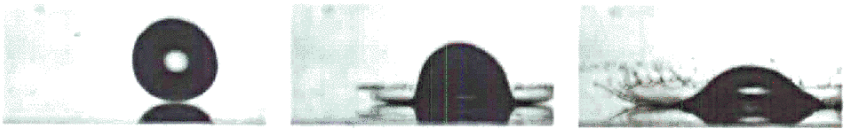
Coronal splash



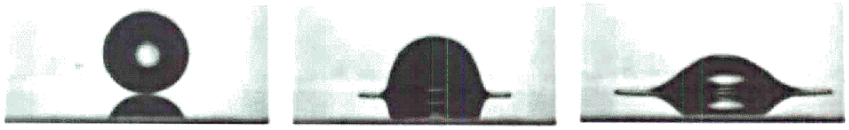
Surprise! Its the air

air 763 Torr

Splash



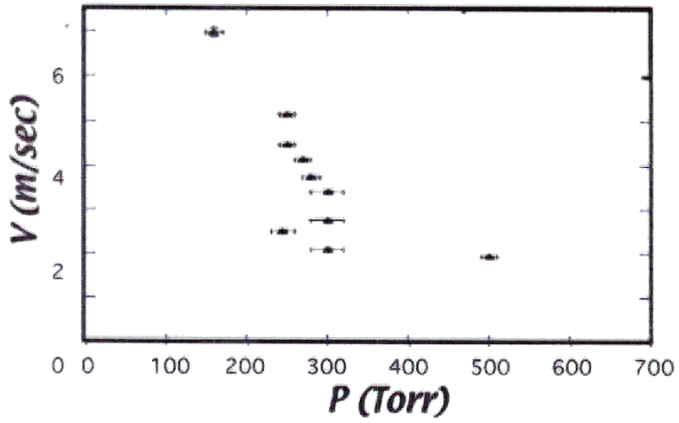
0 ms 0.276 ms 0.552 ms



less air 233 Torr

No splash!

And its not even monotonic



L. Xu, W. Zhang

Surprises abound!

There are more things in heaven and earth, Horatio,
Than are dreamt of in your philosophy.

From experiment and simulation as well as theory

Questions connect disparate areas of physics -

non-equilibrium
singularities
disorder

Future is bright --

if we work together