

Edinburgh

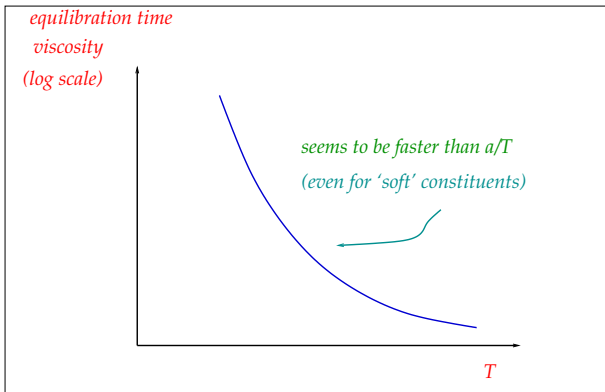
Jorge Kurchan

LPS-ENS, Paris

Questions related to complexity

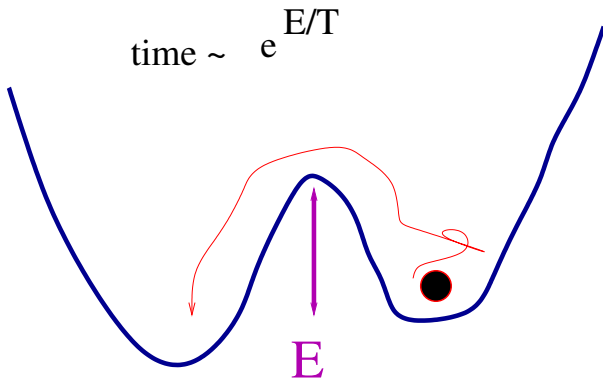
- How it is possible that the information needed to make a full organism is a mere 3Gb? ~ **the TeXShop program!**
Also: information in synapses is \gg information in DNA
- Which axioms imply rich systems and which don't.
Which rules produce a rich game (e.g.. chess) and which don't (tic-tac-toe).
Which set of elements produce a rich chemistry and which don't (imagine chemistry without carbon and hydrogen).
- A chemical path is chemistry. A set of a thousand interacting chemical paths is ... stat mech?

The glass problem

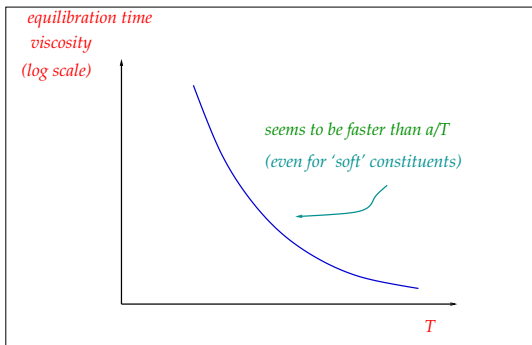


This seems a very modest phenomenology, and yet...

Arrhenius law

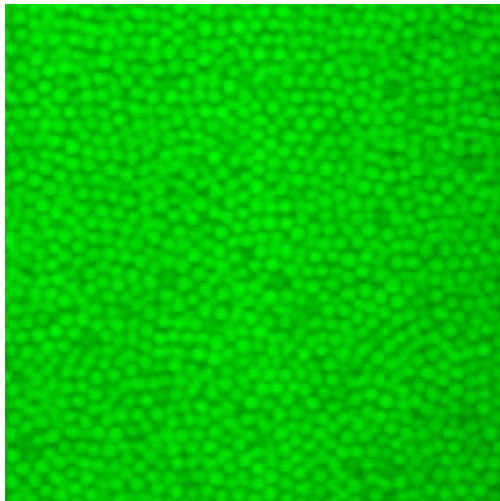


The glass problem



This seems a very modest phenomenology, and yet...

Super-Arrhenius *implies order ...* but

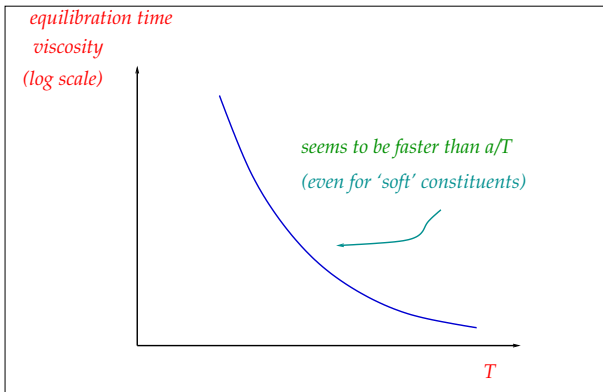


no order seems to develop.

Why is the study of glasses formative?

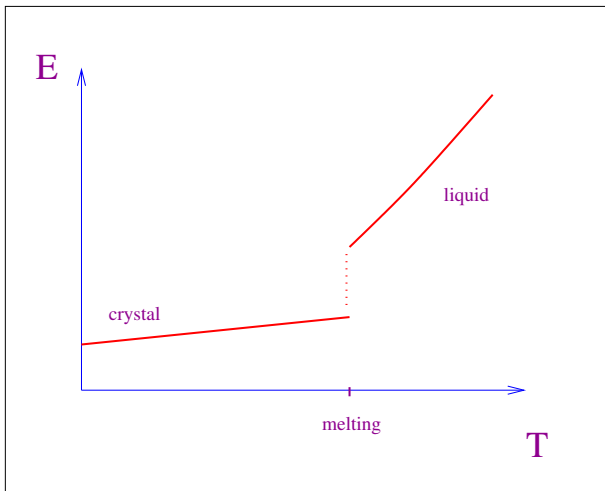
- How to deal with hidden forms of order behind an apparently amorphous structure
- The (out of equilibrium) dynamics of an interacting system with many *relevant* degrees of freedom has little in common with ‘dynamical systems’ with two or three degrees of freedom

The glass phenomenology



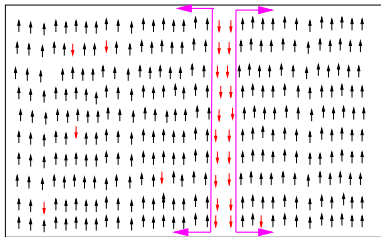
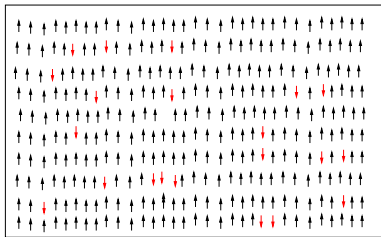
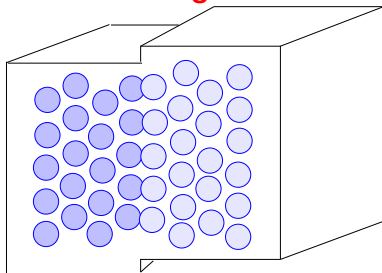
is *the same* if the constituents are 'soft' (inter-penetrable)

A crystal of *soft* constituents



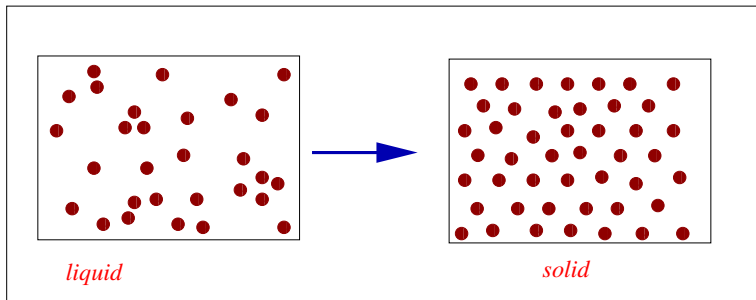
A hard building may be made of soft bricks

energetic

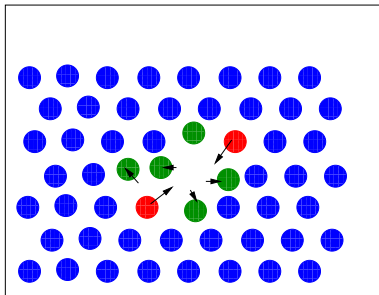
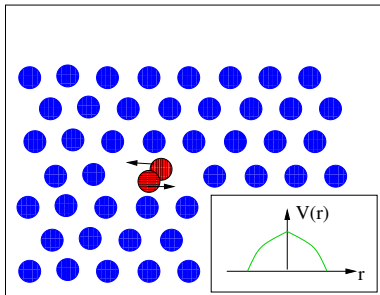


entropic

Ordinary solidification: a magic trick of crystalline order

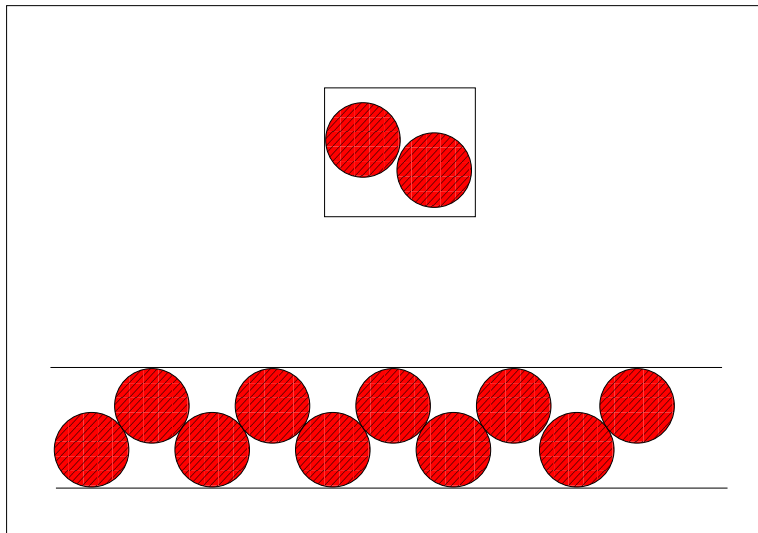


Individual particles are free to rearrange

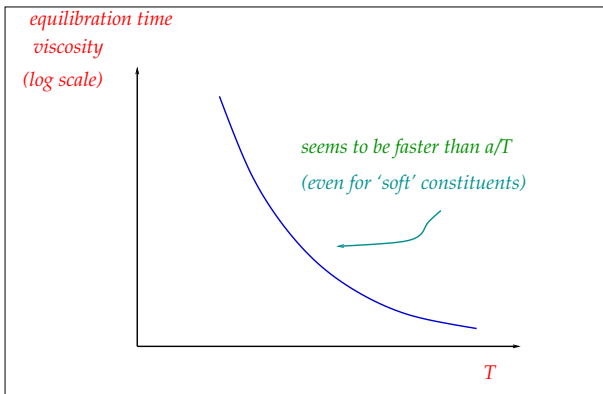


... like an army with well-defined roles but interchangeable individuals.

Compare with non-thermodynamic solidity



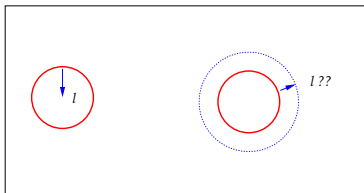
**we are led to the conclusion that there is a hidden order
developing**



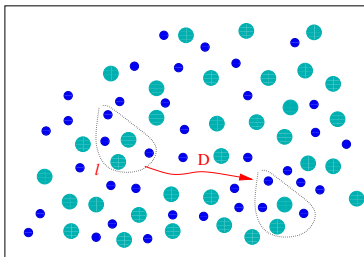
**again with interchangeable particles in definite roles, but this
time analogous to a secret army.**

Point-to-set length: boundary determines interior for $\ell < \ell(T)$

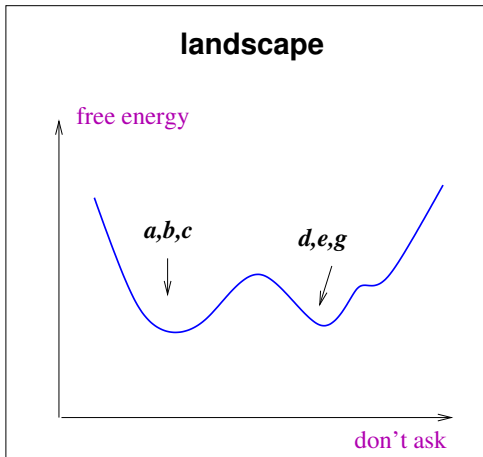
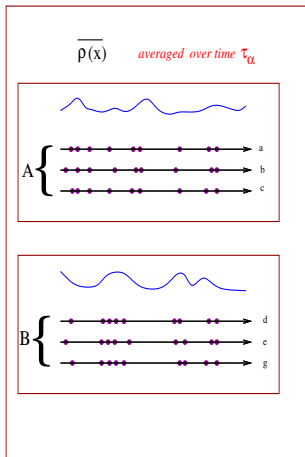
$\ell \rightarrow \infty$ if (timescale $\rightarrow \infty$) Montanari-Semerjian, Biroli-Bouchaud



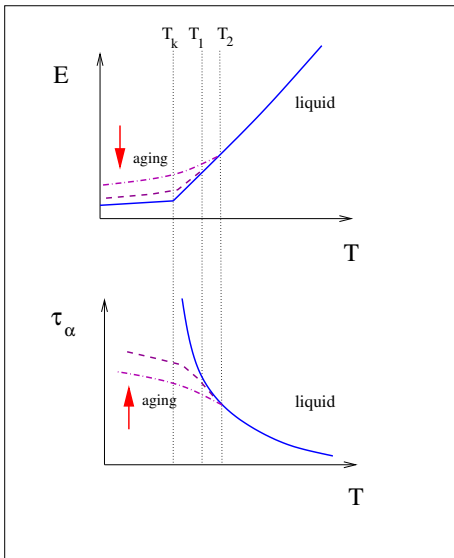
Patch repetition length



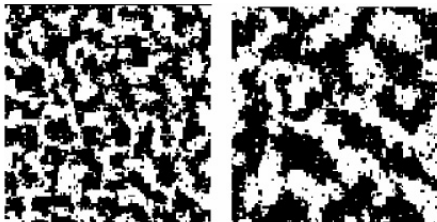
Many states \equiv complex landscape



Slow out of equilibrium 'aging' dynamics.

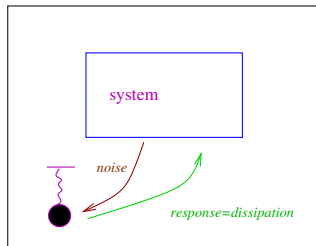
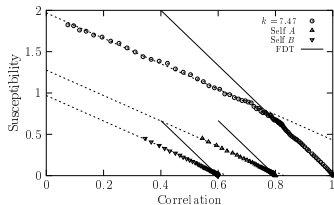


An example of slow out of equilibrium



universality: phase-ordering dynamics depends on the symmetry broken and on conserved quantities.

Does slow glassy dynamics have also universal features?



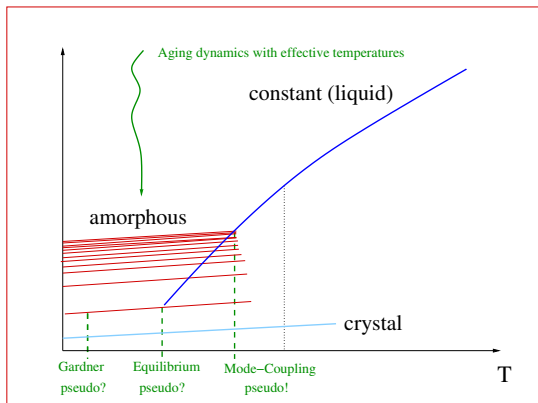
Effective temperatures: a symptom of thermalization at different timescales

an ergodic property for which there is no true understanding

Random First Order Scenario

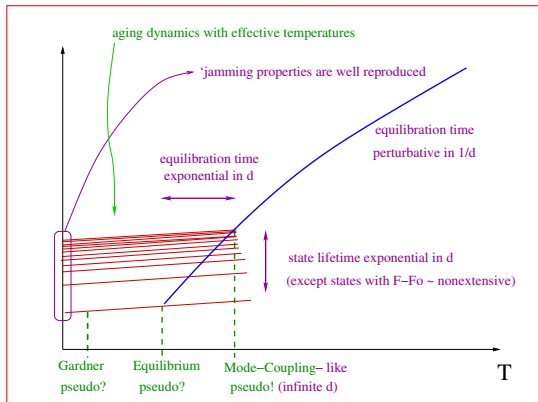
Kirkpatrick Thimuralai Wolynes, late 80's ff

originally a remarkable intuition based on an analogy with a kind of spin-glass model



Today we may see it thus: Frisch et al,..., Zamponi et al,...

particles with spherical potential in dimension d



'activated' \equiv nonperturbative in $1/d$