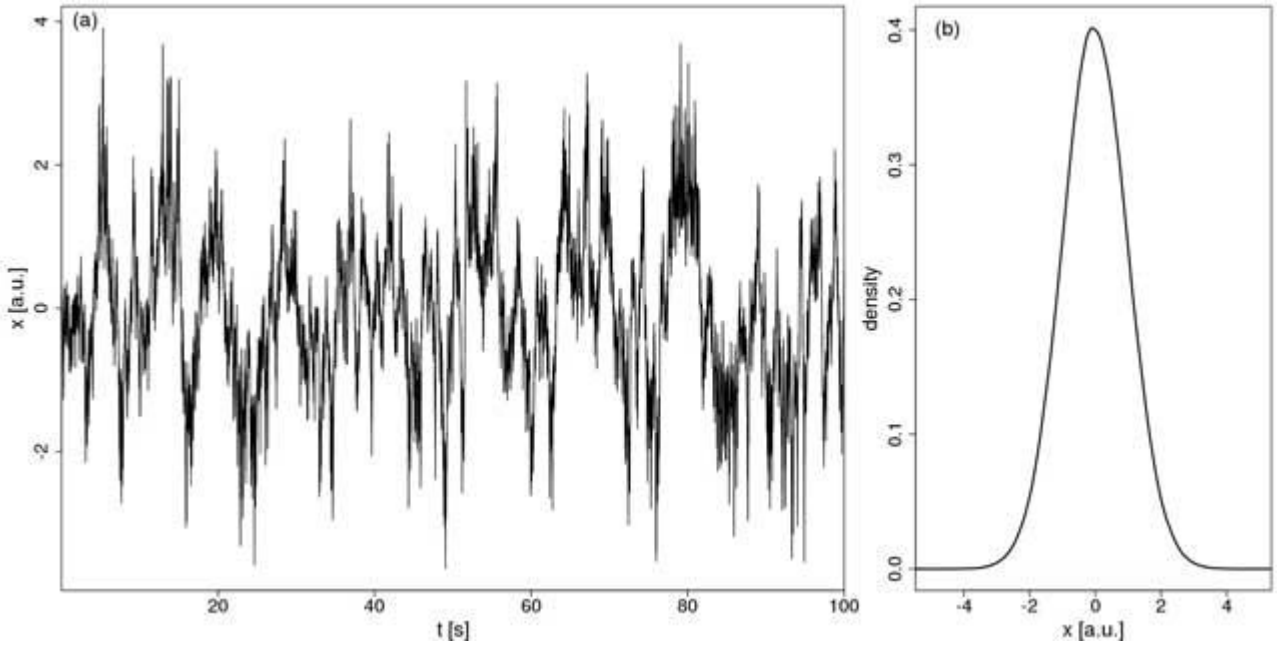
Equilibrium: some remarks (from a physicist viewpoint)

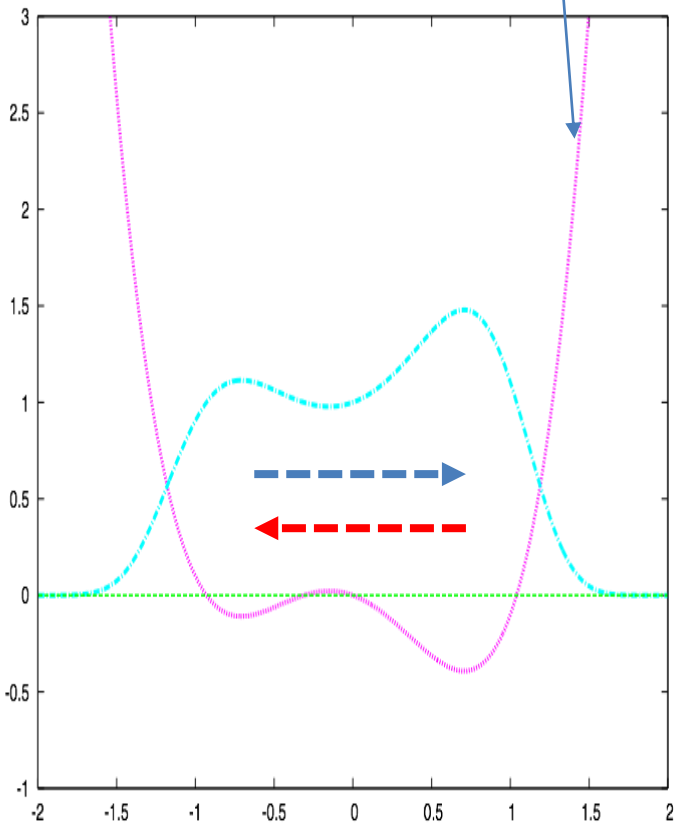
- Mechanical equilibrium (XIXth century): nothing moves at all
- Statistical equilibrium (XXth century): everything moves all the time, but the probability distribution does not change with time



Two types: « Boltzmann-Gibbs » Equilibrium vs. Stationary state

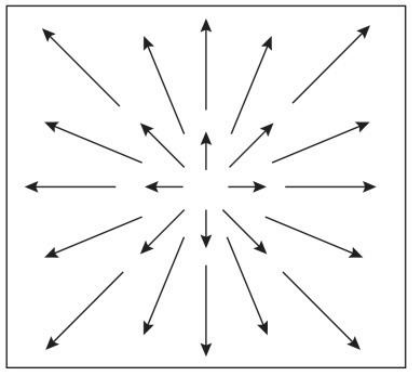
$$P_B(X) = \frac{1}{Z} \exp[-\frac{U(X)}{k_B \theta}]$$

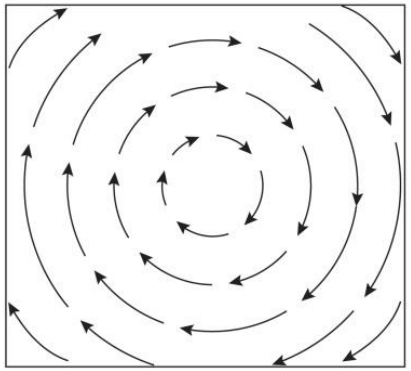
X: full « micro » configuration



Potential flow:
stationary state without currents
« Detailed Balance »
(→ Potential games)

Rotational flow:
stationary state with non zero currents – but much less is known

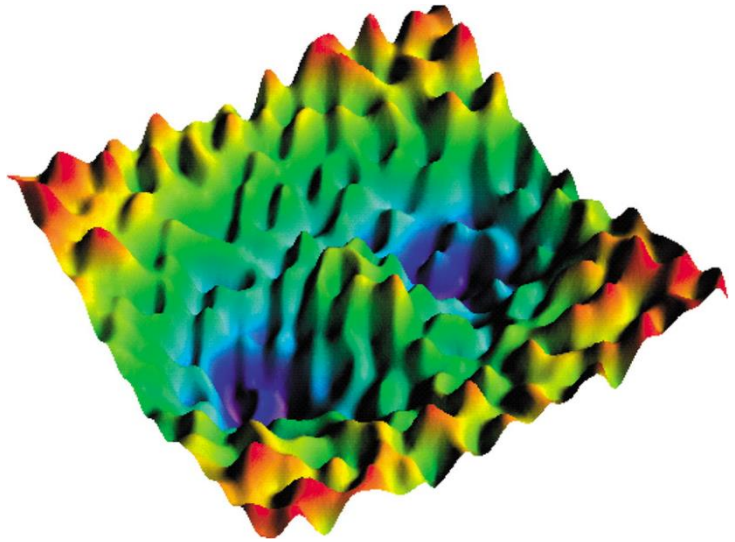




Fast vs. Slow equilibration

- How is equilibrium approached (/not)?
- Equilibration time: from a generic initial distribution, statistical equilibrium is only reached after some time
- This equilibration time can be very short (e.g. liquids), astronomically long (e.g. glasses), or even infinite (ergodicity breaking)
- Complex systems often have a very large number of « metastable states » (aka pseudo-attractors) that lead to long time scales

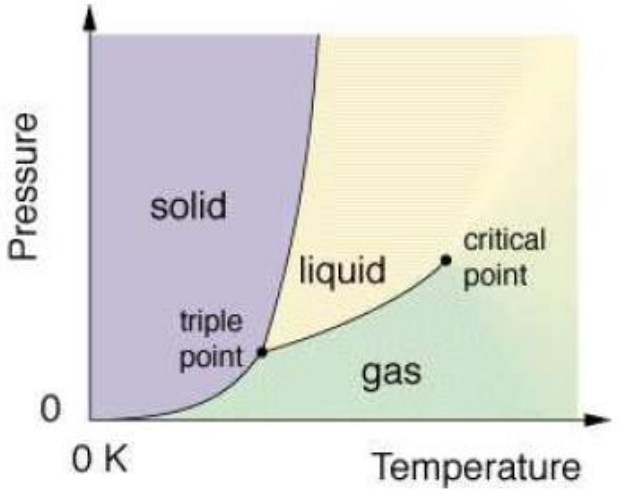
Simple landscape → Rugged landscape
Fast equilibration → « Glassy » dynamics

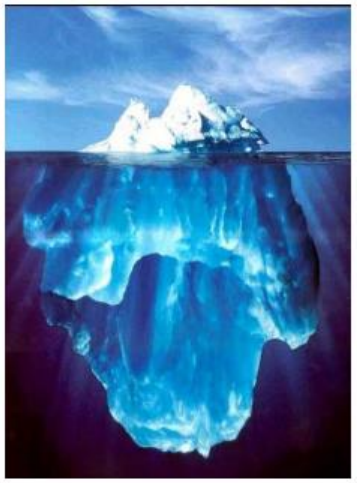


- Often: (exponentially) many approximate solutions to the same problem (e.g. gait)

Phase transition, Ergodicity breaking, Instabilities

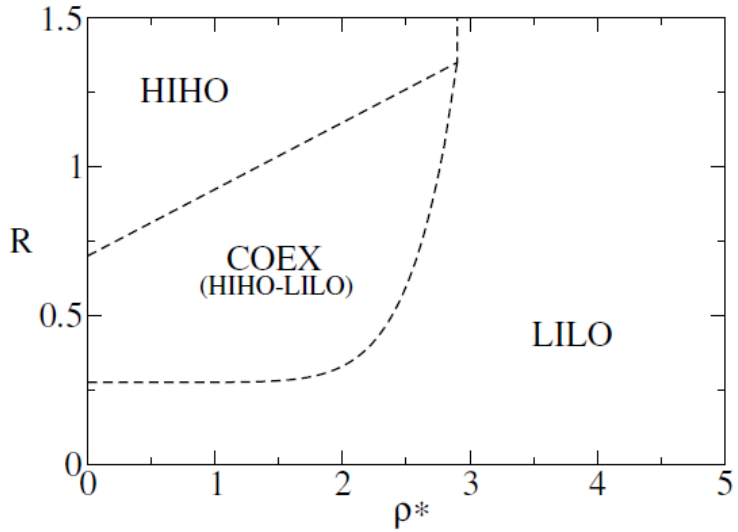
- Phase transition: depending on external parameters, the equilibrium state can *jump discontinuously* (a paradigm for crises?)
- Different equilibrium states can coexist and be chosen by initial conditions (*ergodicity breaking*), or lead to regime switching
- Some bona fide equilibria can be *dynamically unreachable* (e.g. Long-Plosser)





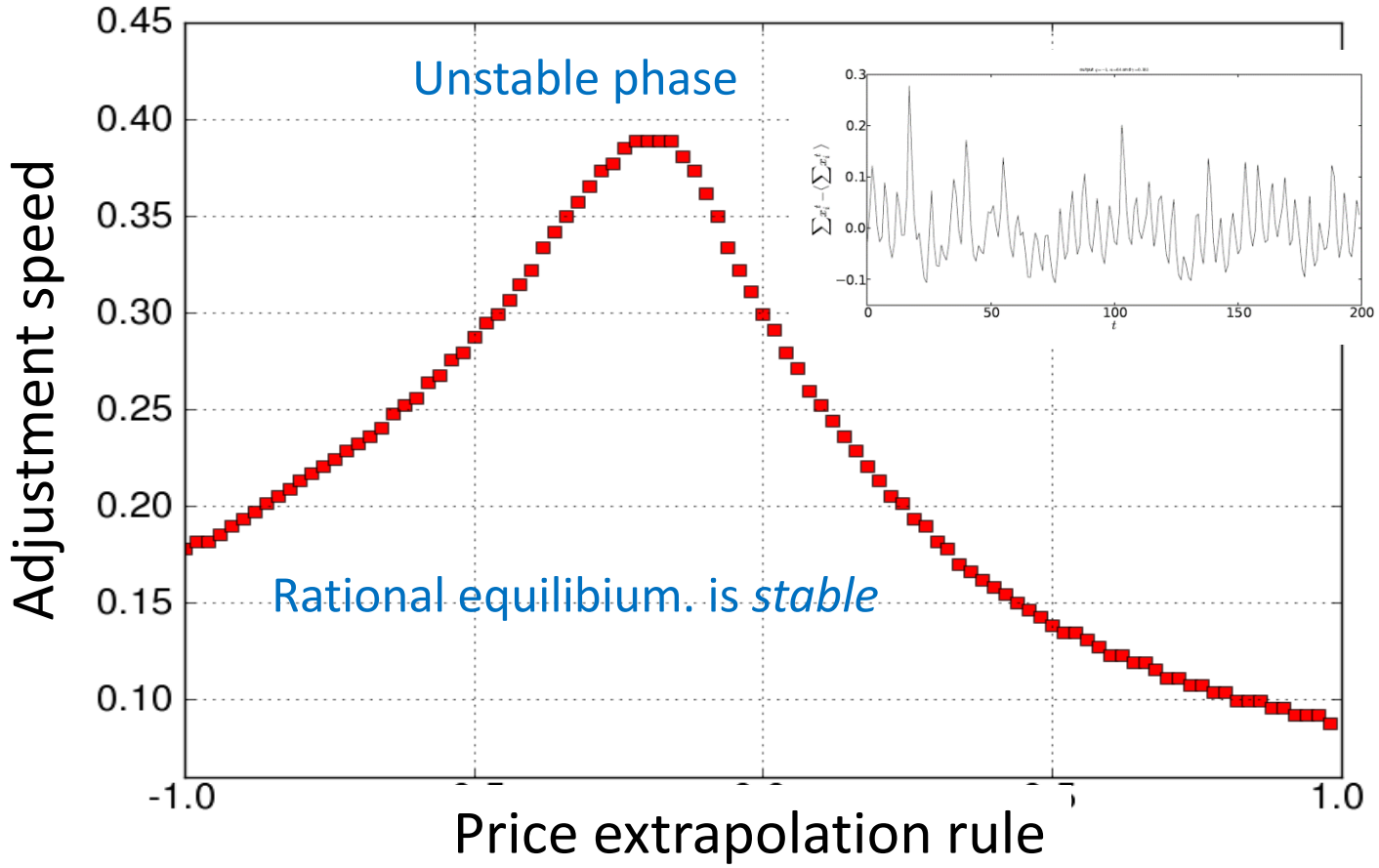
Small changes, large effects

Macro-Agent Based Model



HIHO: High inflation, high output
LILO: Low inflation, low output

A Dis-equilibrium Long-Plosser model



Aggregate volatility <u>without</u> any idiosyncratic shocks!

In the unstable phase, the rational equilibrium still exists but is unreachable