

IDEAL GLASS TRANSITIONS BY RANDOM PINNING

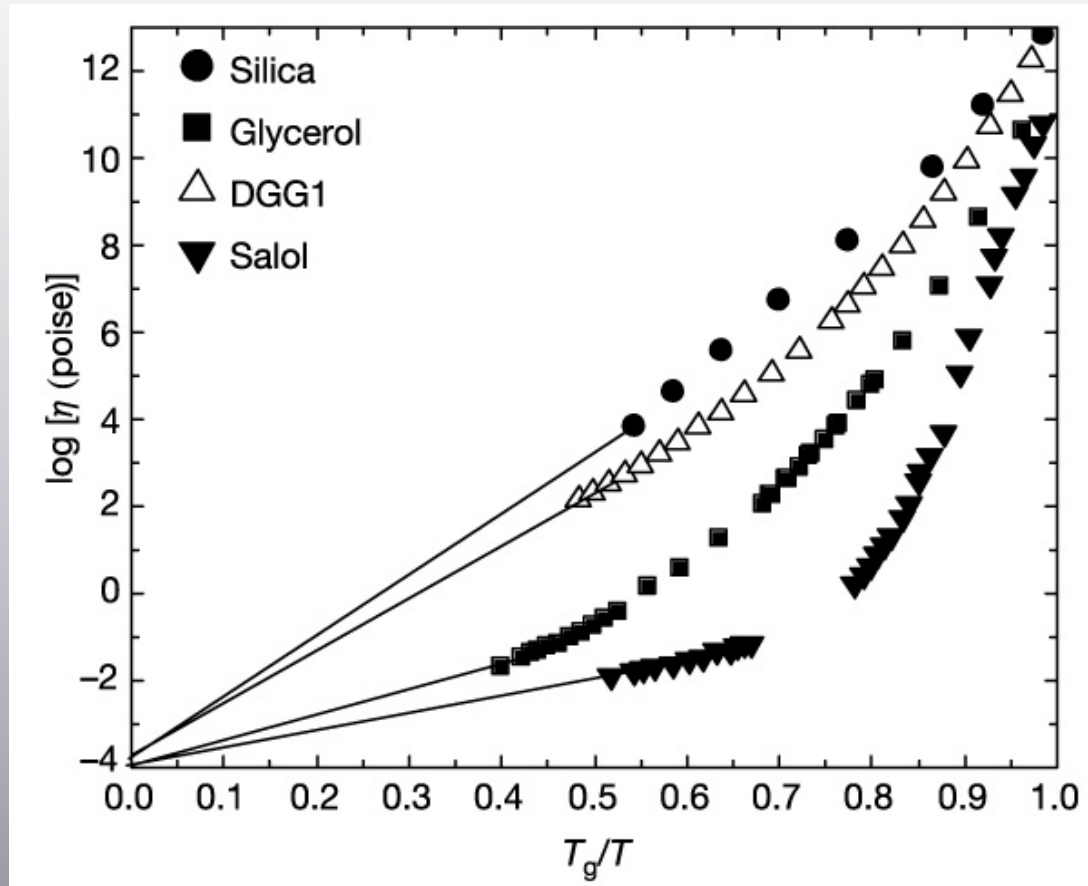
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Supercooled liquids & the glass transition



Vogel-Fulcher-Tammann (VFT) law:

$$\tau = \tau_0 \exp(A/(T - T_0))$$

- Does the ideal glass transition at T_0 exist really?
- How can one test glass transition theories?
- How can one study the critical properties?

A new kind of phase transition

- A lot of metastable states below a characteristic temperature

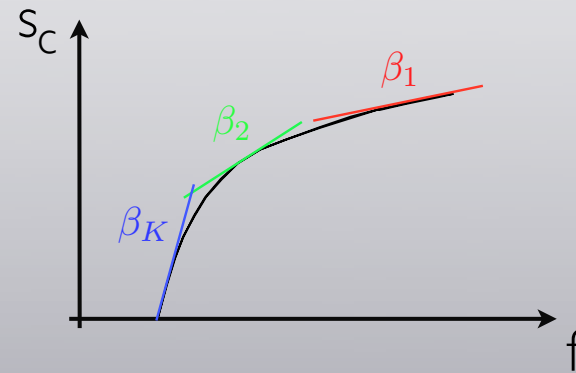
$$\mathcal{N}(f) = \exp(Ns_c(f))$$

- Competition between free-energy and configurational entropy

$$Z = \int df \mathcal{N}(f) \exp(-\beta N f)$$

$$\phi(f) = f - T s_c(f)$$

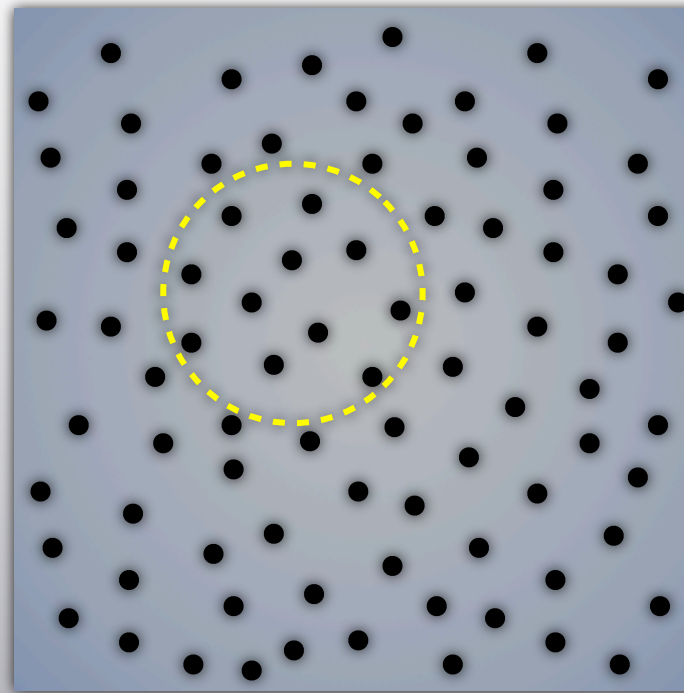
IRSB transition at $T_K = 1/\beta_K$



Above the transition many states dominate the equilibrium measure

Below the transition few amorphous states with the lowest free energy dominate

The Random First Order Transition theory



$$\mathcal{N}(f) = \exp(l^d s_c(f))$$

$$\Delta F_I = \Upsilon l^\theta$$

$$Ts_c(T)l^d \text{ vs } \Upsilon l^\theta$$

A kind of microphase-separated system with a huge number of phases

$$l_s = \left(\frac{\Upsilon}{Ts_c} \right)^{1/(d-\theta)} \quad \text{coherence length diverges when } s_c \text{ goes to zero}$$

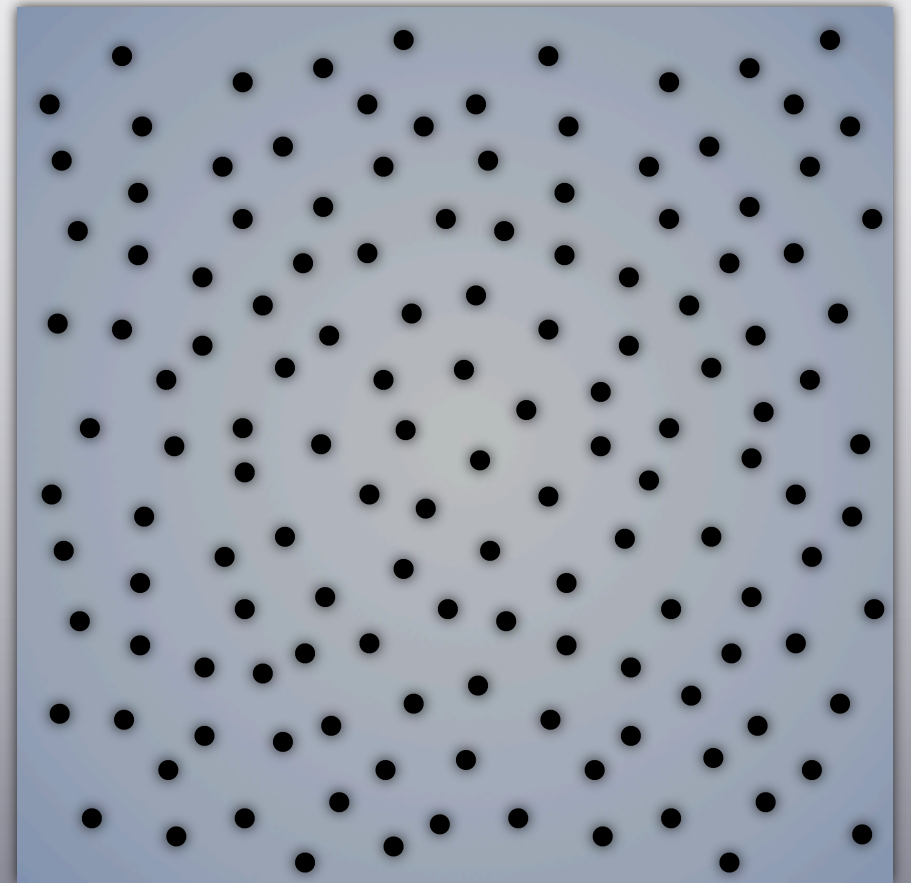
Below the transition an amorphous state with low free energy spans the system

$$\tau = \tau_0 \exp \left(Al_s^\psi / T \right) \quad \text{the correlation time diverges exponentially}$$

T. R. Kirkpatrick, D. Thirumalai, and P. G. Wolynes, Phys. Rev. A 40, 1045 (1989)

J.-P. Bouchaud and G.B., J. Chem. Phys. 121, 7347 (2004)

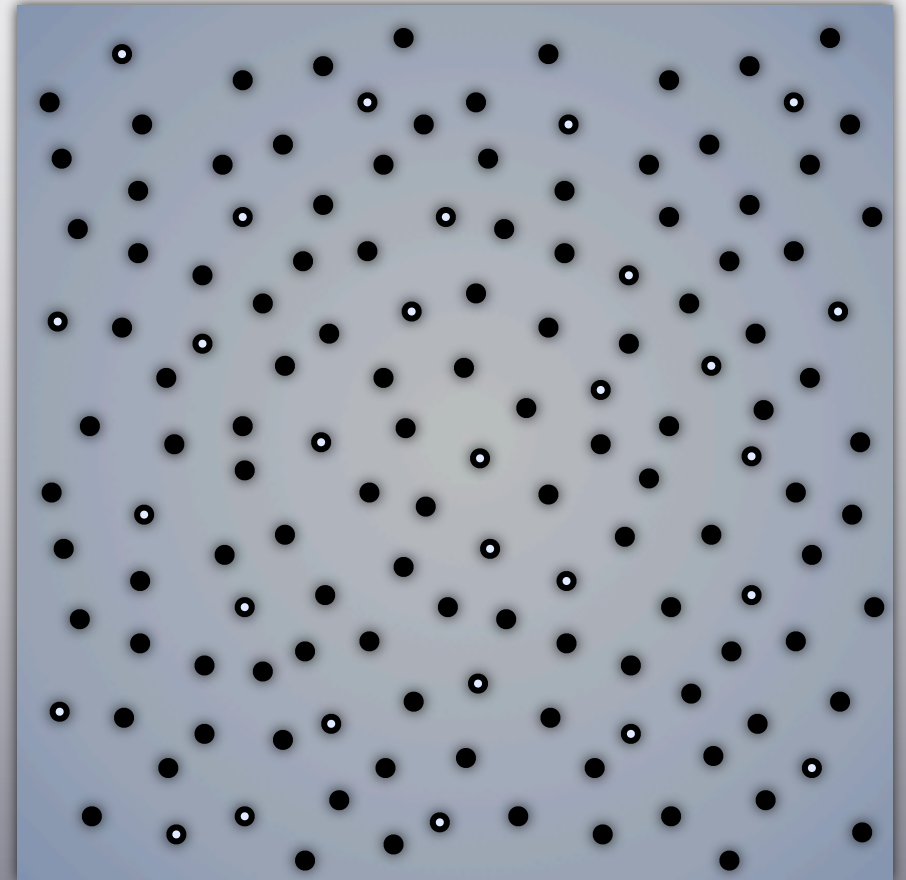
Glass Transition by Pinning Particles



Glass Transition by Pinning Particles

We freeze a fraction c of particles randomly chosen in an equilibrium configuration

Parameters of the problem: T c



Glass Transition by Pinning Particles

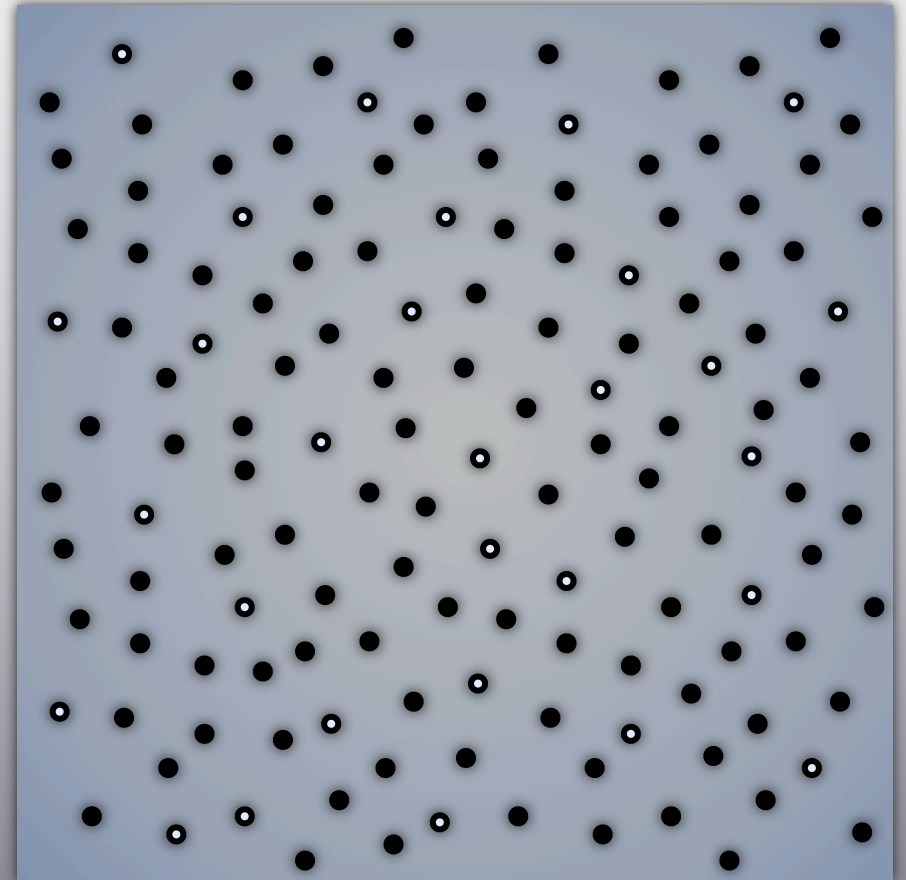
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Parameters of the problem: T c

Pin particles $s_c \downarrow$

$l_s^p \uparrow\uparrow$

$\tau^p \uparrow\uparrow$



Glass Transition by Pinning Particles

We freeze a fraction c of particles randomly chosen in an equilibrium configuration

Parameters of the problem: T c

- RFOT phenomenological argument

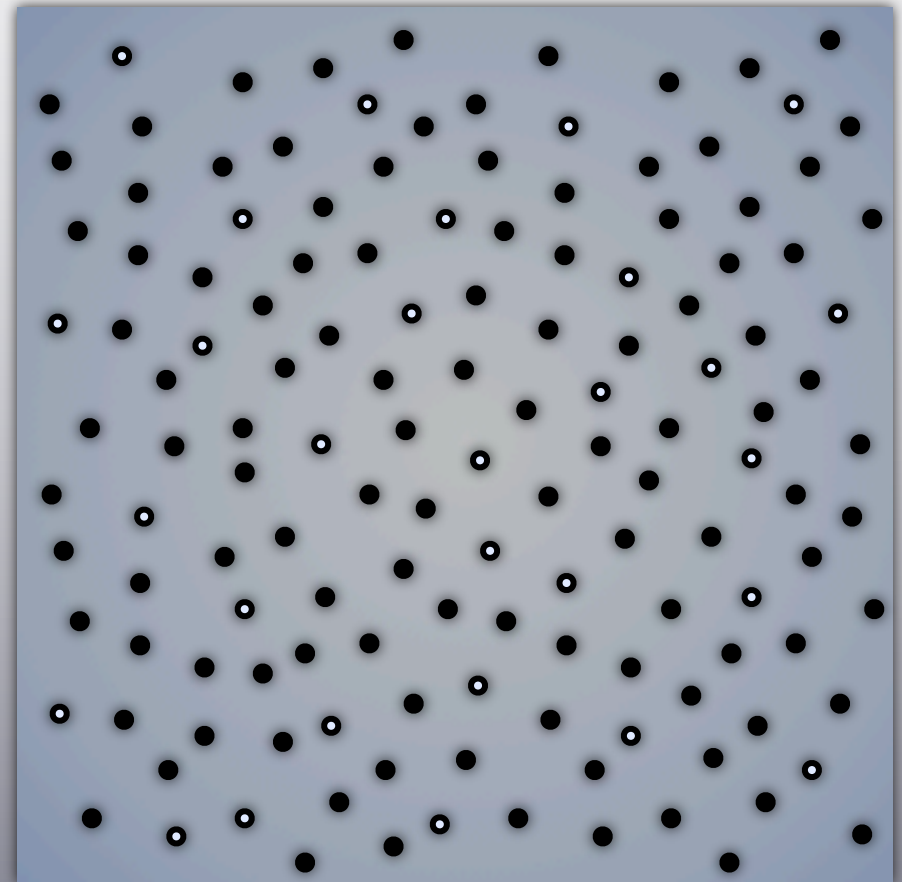
$$s_c^P(T, c) \simeq s_c(T) - cY(T)$$

$$l_s^P = \left(\frac{\Upsilon}{T(s_c - cY)} \right)^{1/(d-\theta)} \gg l_s$$

$$\tau^p \sim \exp [A(l_s^p)^\psi / T]$$

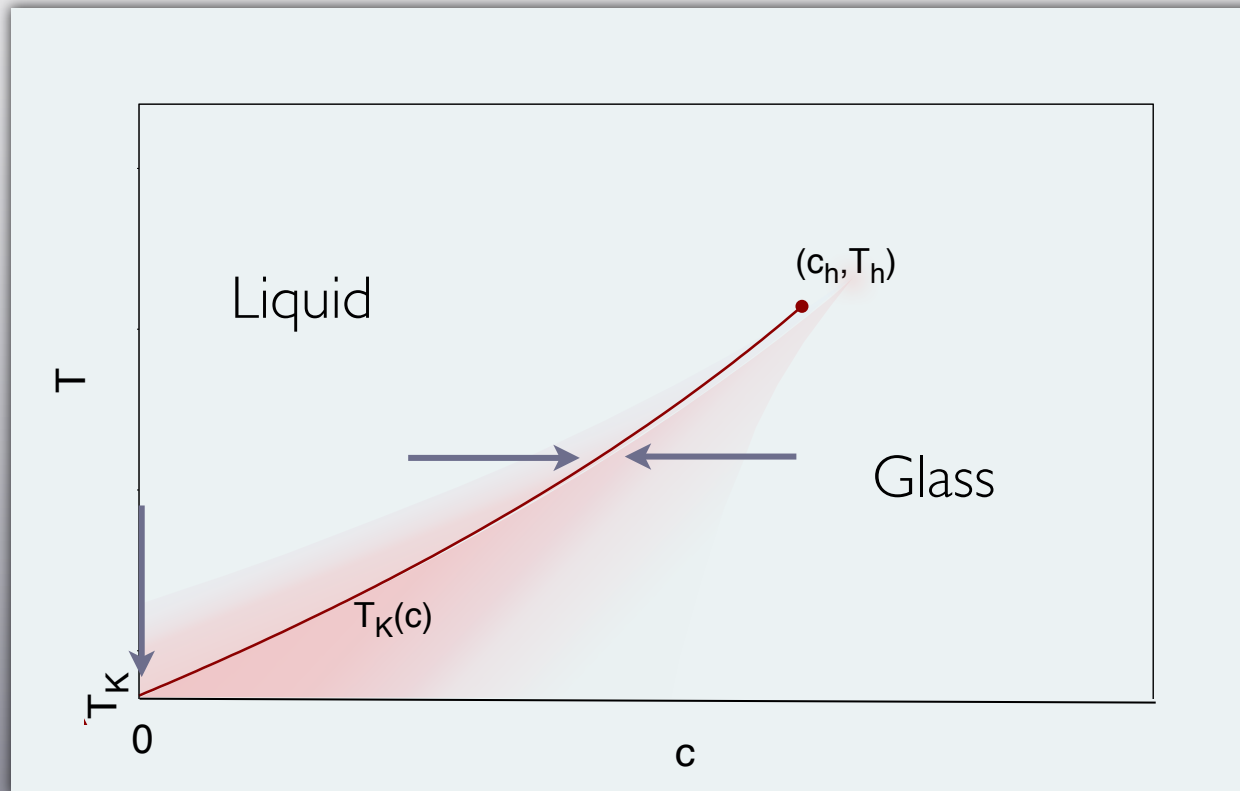
$$c_K(T) = s_c(T)/Y(T)$$

Outcome: A line of ideal glass transitions



The Glass Transition by Random Pinning

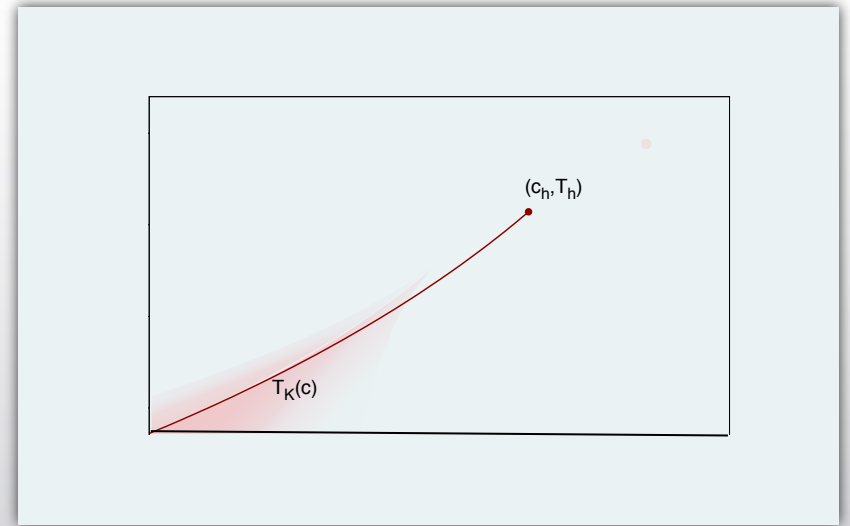
- Phase diagram c, T obtained by mean-field and real space RG analysis



- Same scaling approaching the transition by increasing c or lowering T
- Overlap with initial configuration jumps at the transition
- The relaxation timescale diverges exponentially at the transition

The low temperature (ideal glass) phase is known!

The configuration chosen to pin particles provides the best glass configuration



- Equilibrium can be observed in the glassy phase
- The transition (and its existence) can be approached from both ends, hence studied in a much more stringent way
- Several scaling predictions for equilibrium and out of equilibrium dynamics in presence of pinned particles.
- Some numerical confirmations, others (including some experiments) on the way.