D. Huse, Stillwater 07/07.

Anneals + Growths

- T.O. results <u>do</u> depend on growth conditions.
  (reproducibly + controllably?)
- But sufficient annealing appears to erase "memory" of growth conditions.
  (Clark, West, Chan '07) generally true?
- What aspects of anneal (+ subsequent cool-down) affect T.O. results?

T yes.

P (?) — can you anneal at various P, but measure at fixed P?

cell surfaces + shape (?)

heat current in sample (?) — controllable in a so-designed cell.

Solid He has high compressibility + thermal expansion.

Can a modest heat current (as in most current anneals) alter sample quality?

By: thermal stress
driven motion of defects (?)

Proposal:

Make a cell designed so heat current in sample during anneal + cool down is as small as possible.

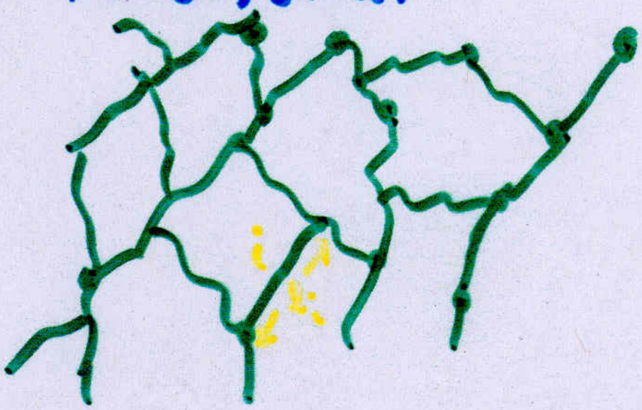
Also have heater to add controllable heat current.

Can this make a family of samples with reproducibly controllable T.O. properties?

Superfluidity on a random network of dislocation lines.

(An incomplete "scenario")

Shevchenko
Pollet, et al.

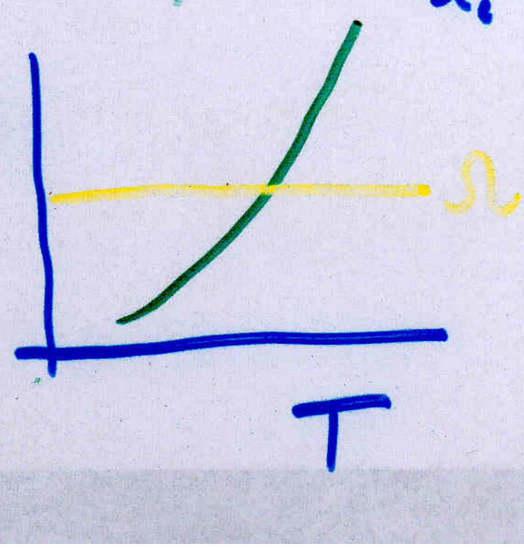


$E = \sum_i J_i \cos(\theta_{i+} - \theta_{i-}$

- 1D Superfluid has $T_c = 0$

Each link i of network has coupling $J_i \propto \frac{1}{l_i}$

Phase slip rate $\Gamma_i(T)$



"Shevchenko state":

T.O. sees onset of apparent ρ_s when a connected network of links have $\Gamma_i(T) \lesssim \Omega$.

T.O. frequency

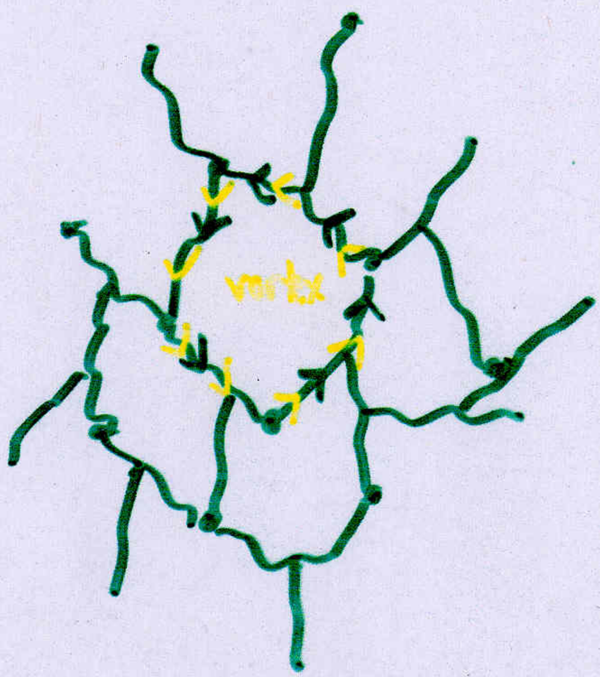
As T drops: link i becomes superfluid as $\Gamma_i(T)$ drops through Ω.

Dissipates when $\Gamma_i(T) \hat{=} \Omega$, but not when $\Gamma_i(T) \ll \Omega$ (low T)

But many links may still have $J_i \ll k_B T$ even though $\Gamma_i \ll \Omega$.

Local superfluidity but no long range order: A "vortex liquid".

In this state vortices have no core, are "cheap":



local phase $\theta(\vec{r})$ changes by $\pm 2\pi$ on encircling vortex on network.

Vortex liquid: many vortices present at equilibrium (because $J_i < k_B T$)

But: NCRI due to $\Gamma_i < \Omega$

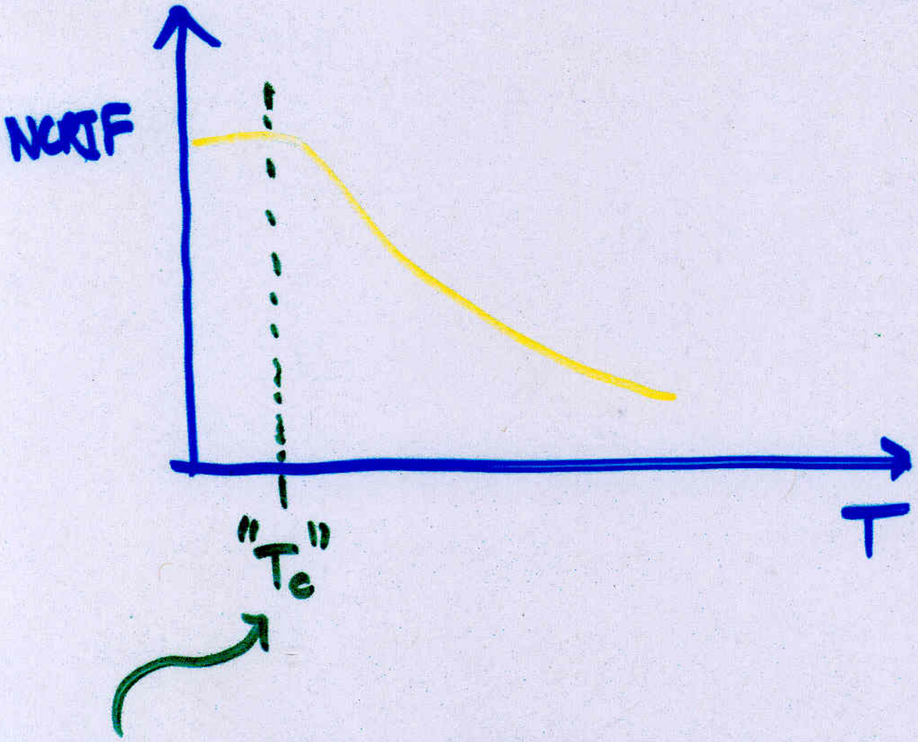
Links look superfluid at frequency Ω

Here as T is lowered more + more links get $\Gamma_i(T) \lesssim \Omega$ and join apparently SF network; NCRIF grows.

Links with $\Gamma_i(T) \cong \Omega$ are joining and are dissipating as they join: (dissipation peak)

But it's a vortex liquid with many vortices and no ODLRO.

[Rotation of cryostat slightly biases vortex population (no effect)]



Here either: Network forms that is dense enough with $\Gamma_i < \frac{1}{\text{hours}}$ to freeze all vortices in place: "vortex glass"

and/or: Network forms with $J_i \gtrsim k_B T_c$ so 3D phase transition really happens. ODLRO.

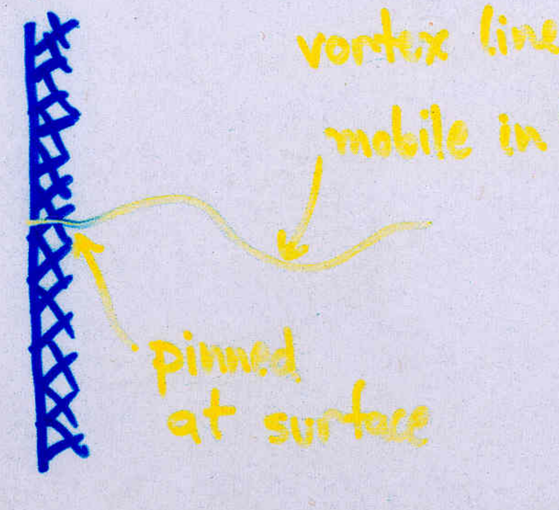
[or quasi-2D transition in more disordered layer near surface of sample.]

T - v_{rim} "hysteresis" (Rutgers, PSU)

Stable states of different NCRIF can be prepared by thermal histories (staying with T < 0.5K ; no annealing of crystal).

If they differ in vortex density, we need
- Pinning to maintain vortex number
- Vortex motion to disrupt NCRIF (?)

Perhaps: stronger pinning near surface due to higher dislocation density



Question:

What is the effective mass m^* that enters in to setting NCRIF?

Can it be $m^* \gg m$?

(thus surprisingly large NCRIF?)