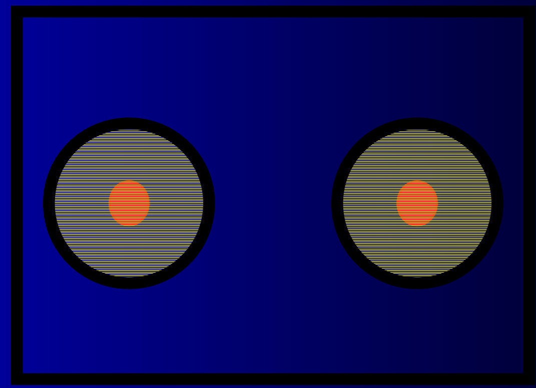
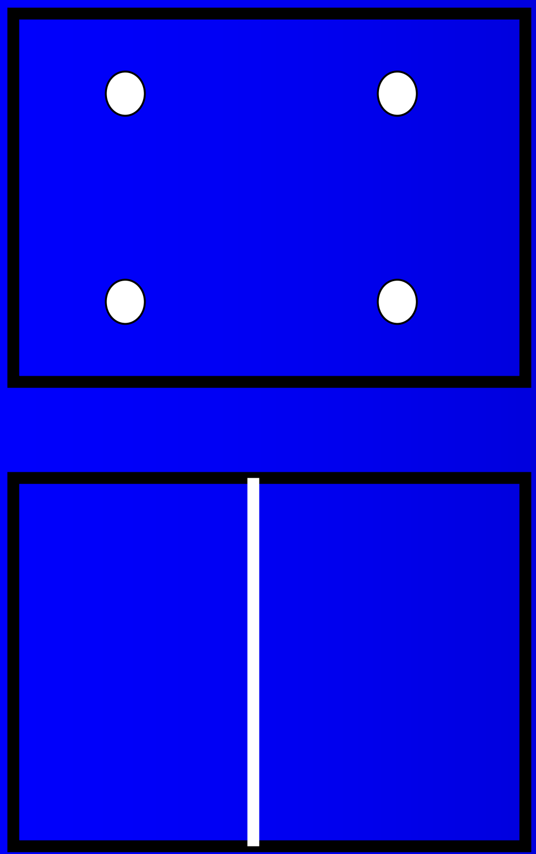
Systèmes ``Elastiques'' désordonnés

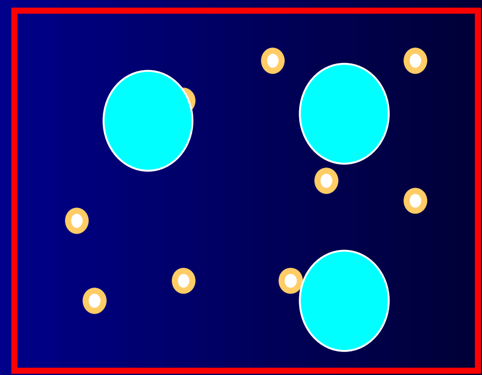
• Basic Features :



(Thermal, quantum) fluctuations



Elasticity



Disorder

Many physical systems

- Interfaces
- Periodic systems
- Quantum systems

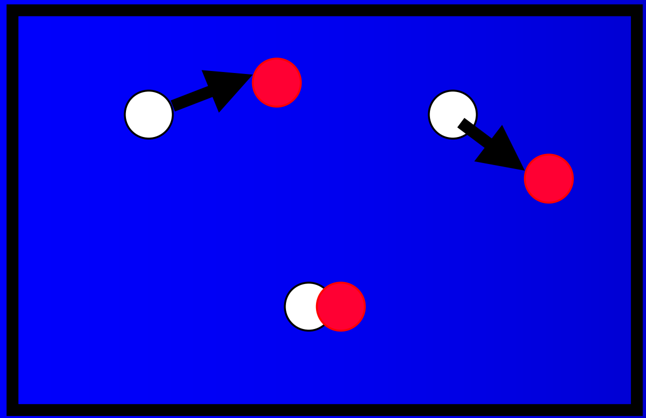
Competition ``Order'' / ``Disorder''

- Melting
- Glassy phases
- Defects

Questions

- Statics
- Dynamics
- Link with other systems :
  - conventional glasses
  - non reversible systems

Elastic description



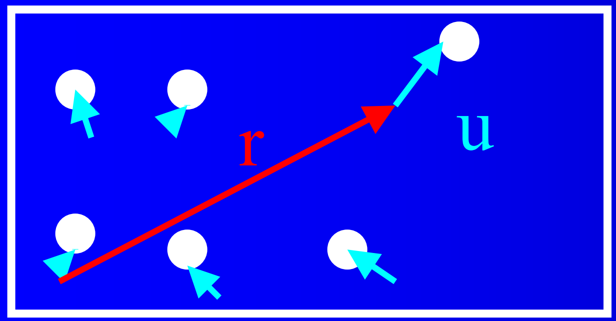
R^0_i : crystal

u_i : displacements

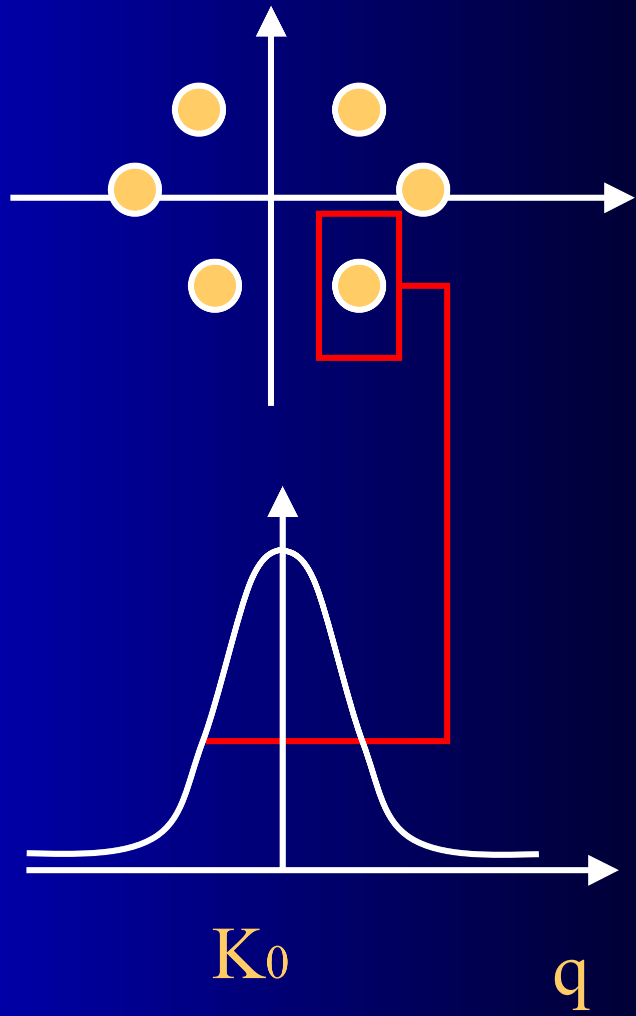
n=2 d=3 vortices

Elastic hamiltonian

$$H = \frac{1}{2}\sum_{\alpha\beta}\int c_{\alpha\beta}(q)u_\alpha(q)u_\beta(-q)dq$$



$$S(q) = \langle \rho(q)\rho(-q) \rangle$$



$$B(r) = \overline{\left\langle [u(r) - u(0)]^2 \right\rangle}$$

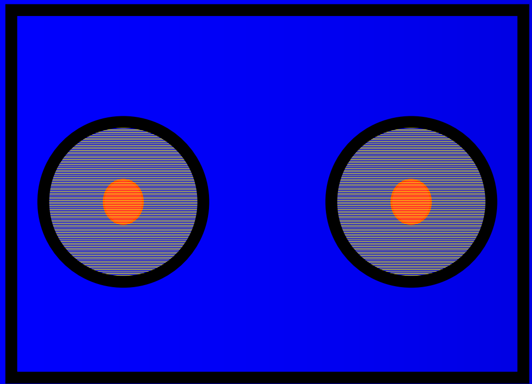
Fourier transform of:

$$C(x) = \overline{\left\langle e^{iK_0 u(r)} e^{-iK_0 u(0)} \right\rangle}$$

Decorations

Neutrons

Thermal fluctuations : Melting



$$\langle u^2 \rangle = l_T^2 \propto \frac{T}{c}$$

Lindemann criterion of melting :

$$\langle u^2 \rangle = l_T^2 = C_L^2 a^2 \qquad C_L \approx 0.1 - 0.2$$

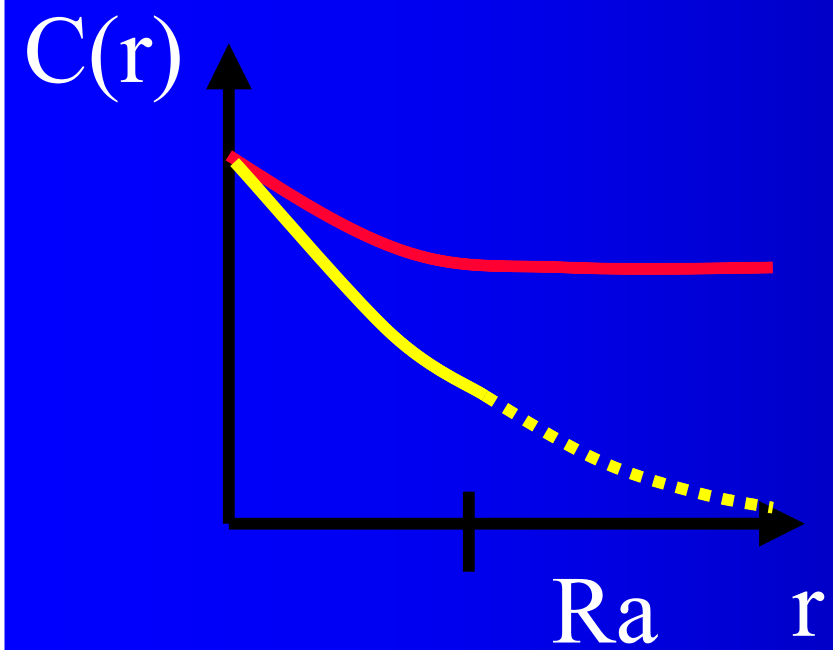
Two crucial lengthscales

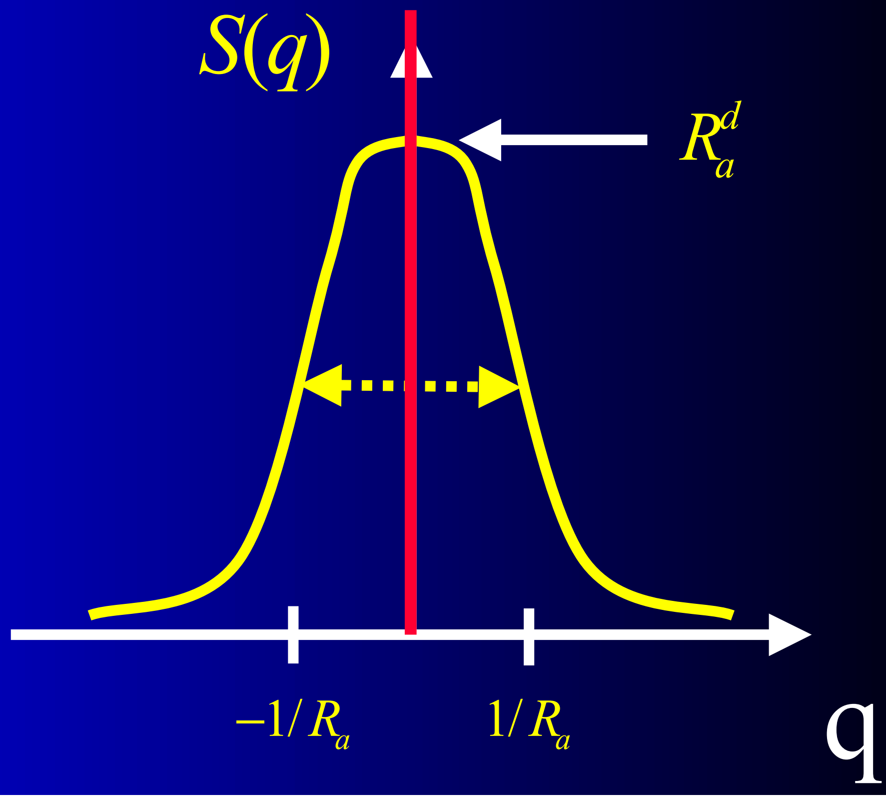
- Positional order

$$u(R_a) \approx a$$

- Larkin length

$$u(R_c) \approx \xi$$





Loss of translational order (Larkin)

$$u(R_a) \approx a$$

$$H_{el} = \frac{c}{2}\int (\nabla u(r))^2 d^d r \qquad H_{dis} = \int V(r)\rho(r) d^d r$$

$$c R_a^{d-2} a^2 \qquad V R_a^{d/2} \rho_0$$

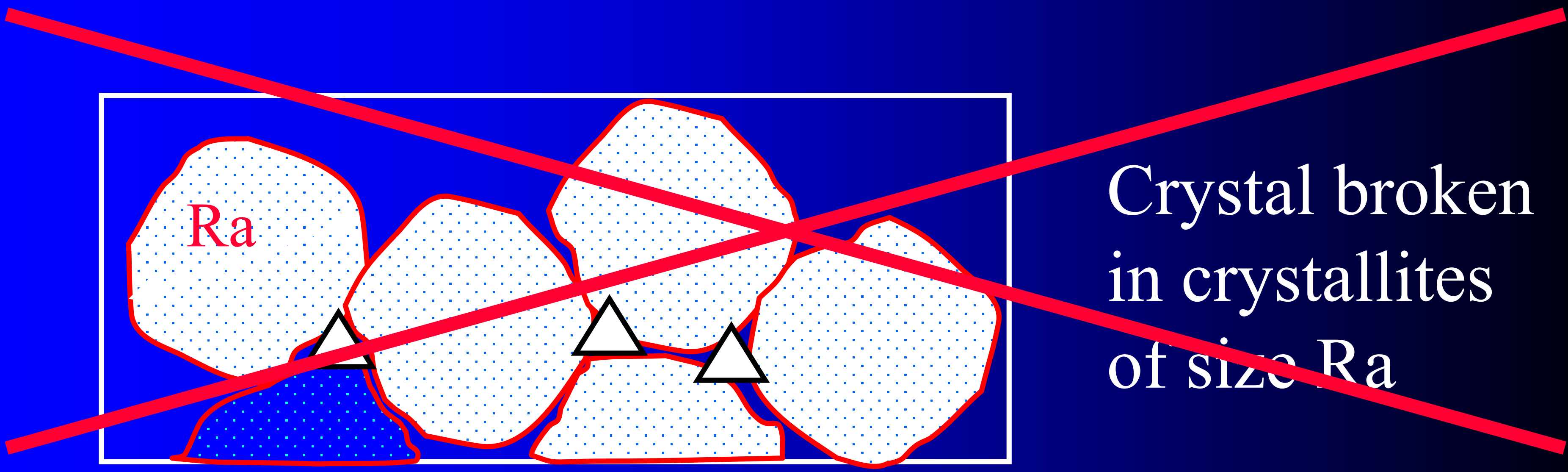
$$R_a \propto a \left(\frac{c^2 a^d}{V^2 \rho_0^2} \right)^{1/(4-d)}$$

No crystal below four spatial dimensions

Naive vision of a DES

• Loss of translational order beyond Ra

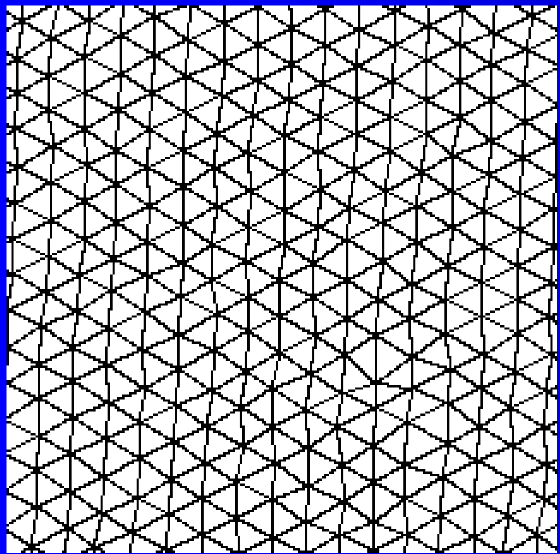
• (Wrong) argument: disorder induces dislocations at Ra

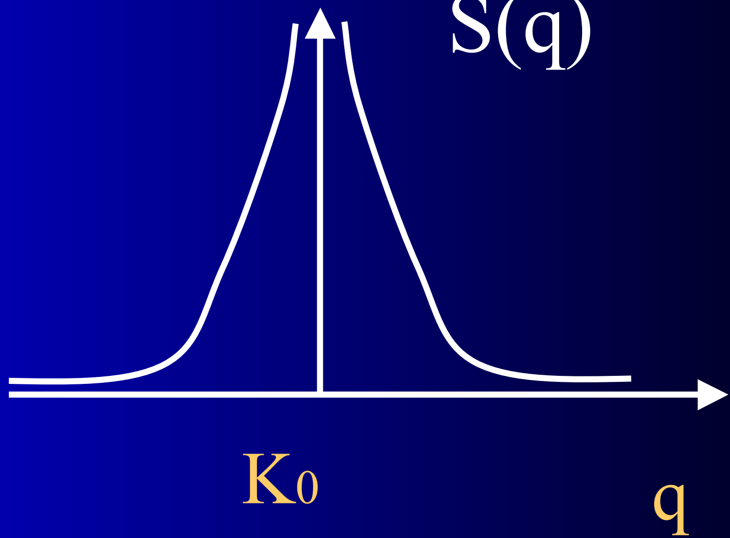


Crystal broken in crystallites of size Ra

Bragg Glass

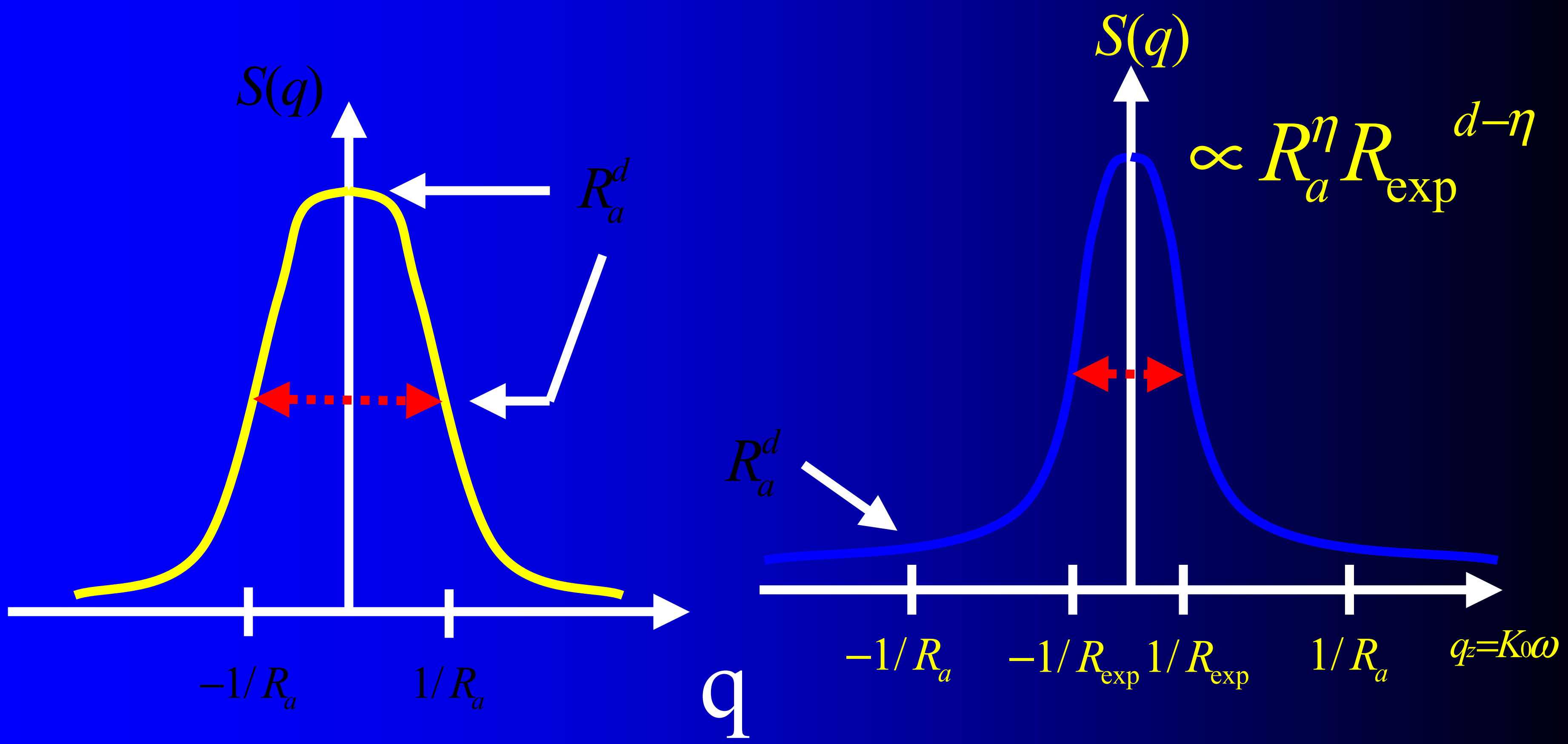
TG + P. Le Doussal PRB 52 1242 (1995)





•Existence of a **thermodynamically** stable glassy phase with quasi long range translational order (power law Bragg peaks) and perfect topological order (no defects)

Neutrons

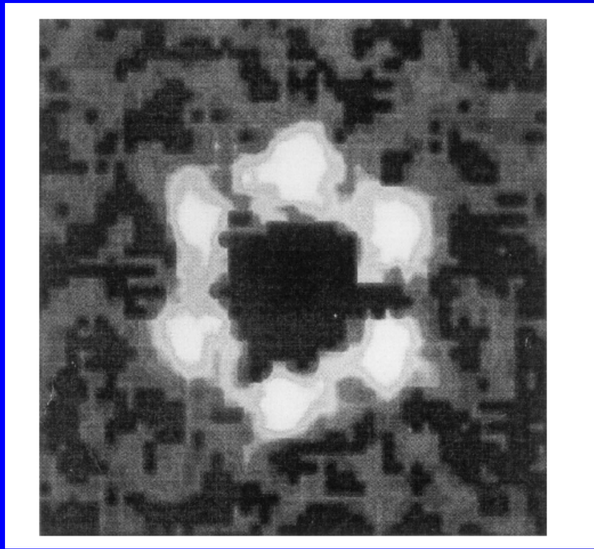


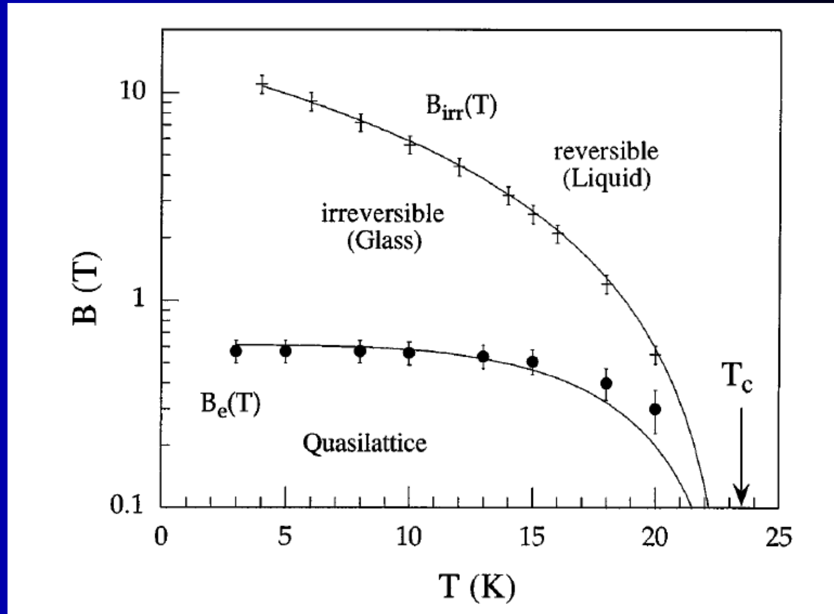
No positional order

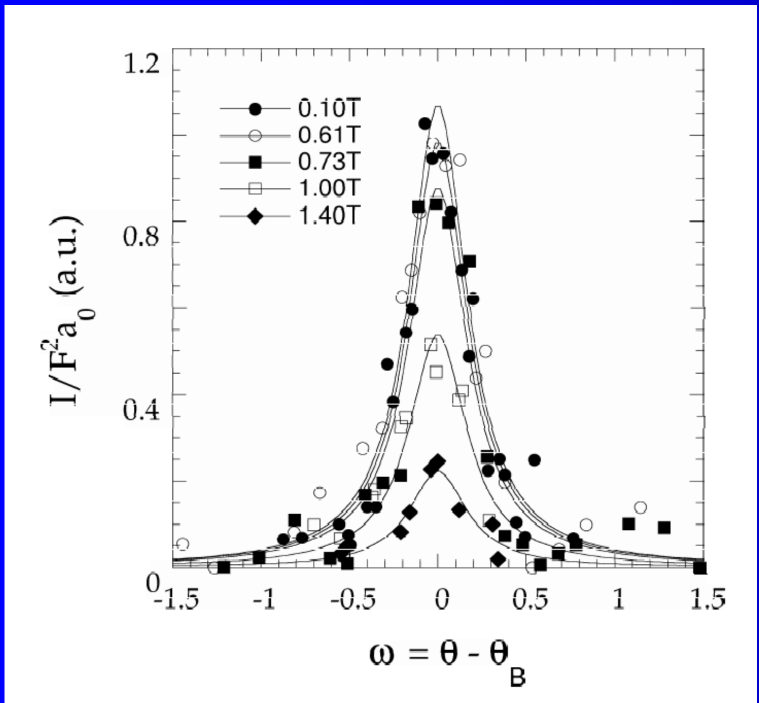
Bragg Glass

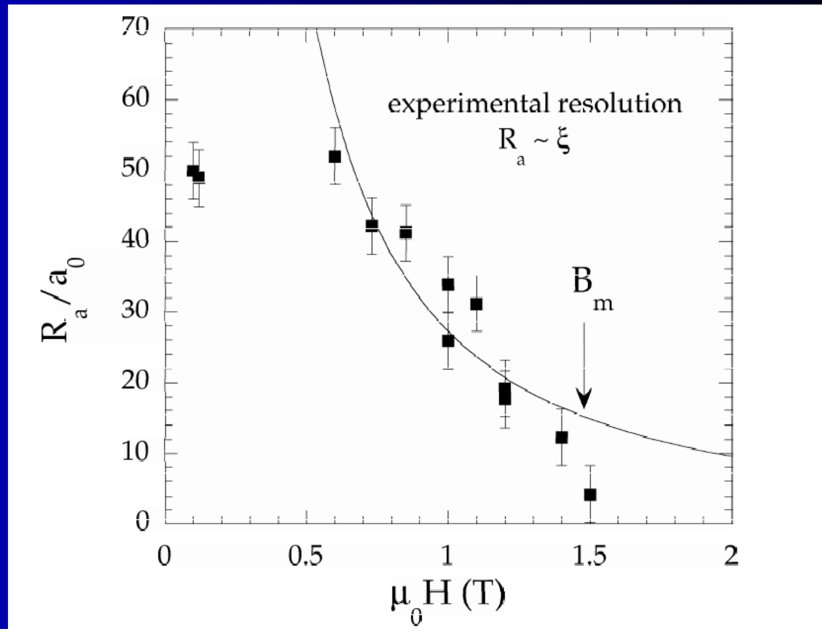
- Collapse of intensity without broadening

I. Joumard et al. PRL 82 4930 (99); T. Klein et al. nature (01)

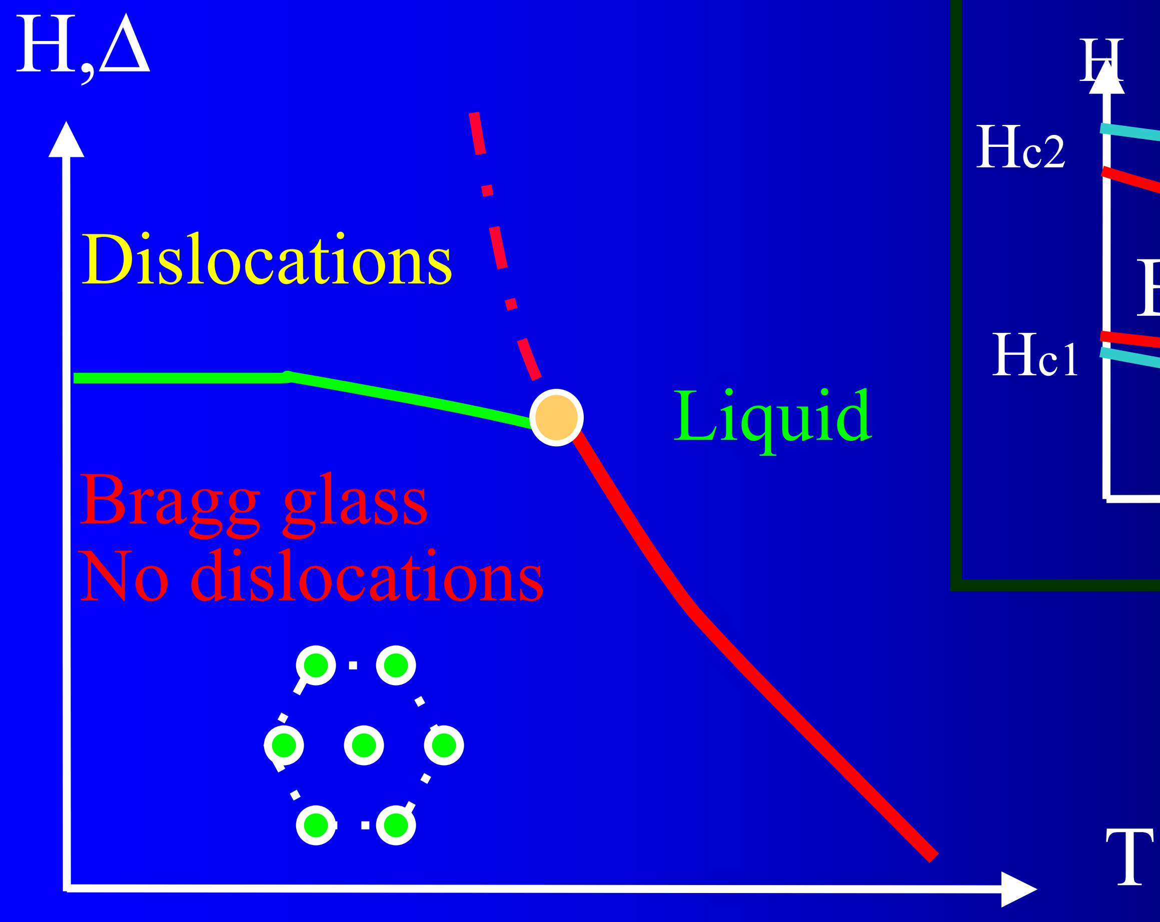


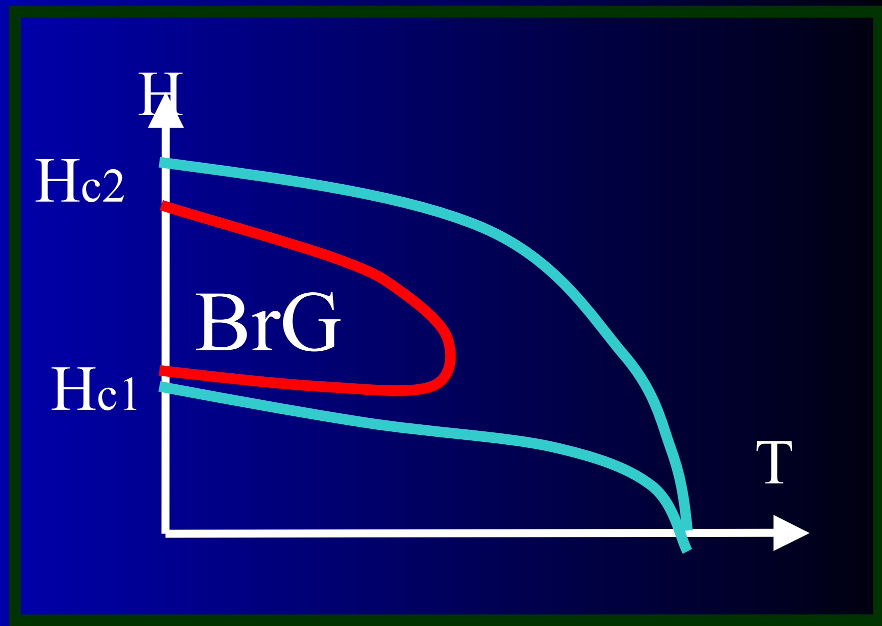






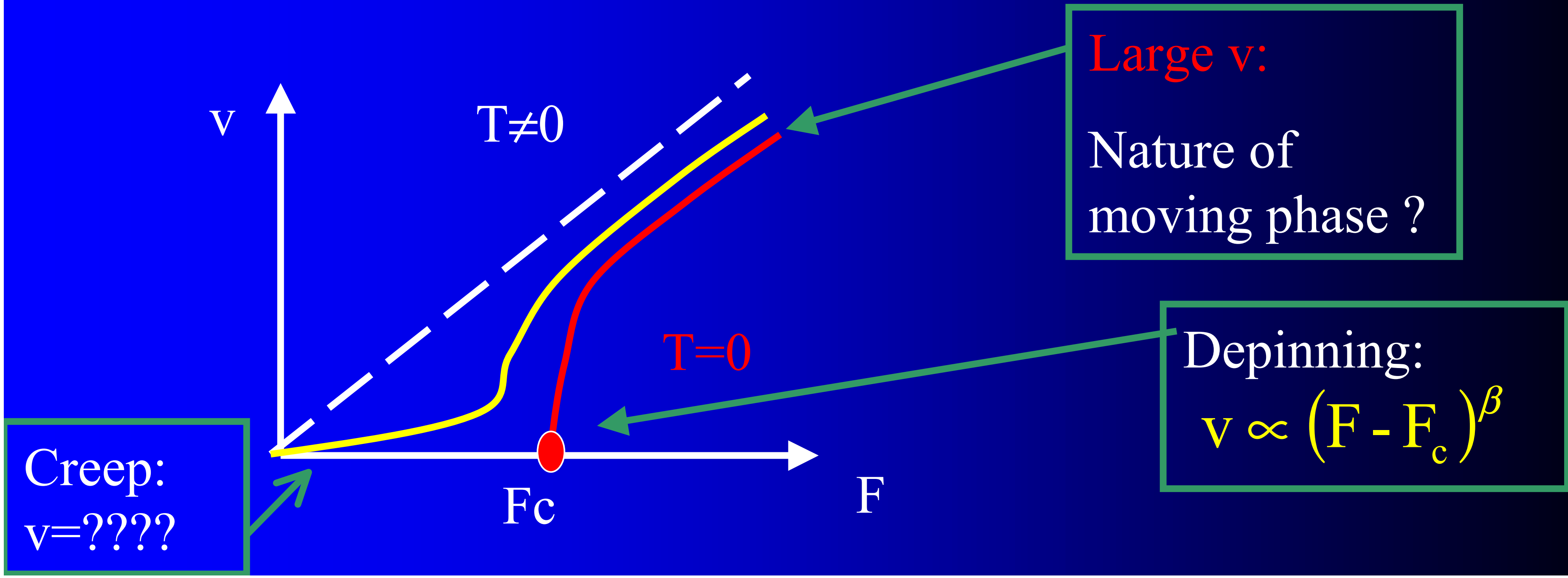
Unified phase diagram



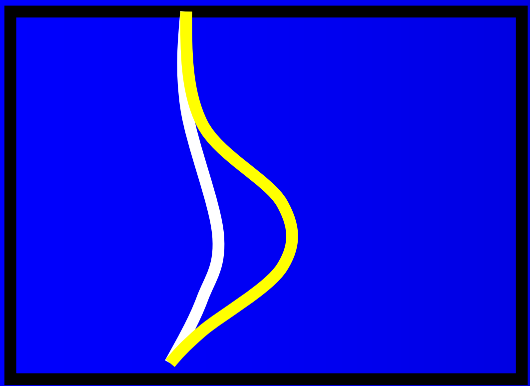


Dynamics

- Competition between disorder and elasticity: glassy properties
- Dynamics ?



Pinning (Fc) and Larkin length (Rc)



$$F_c = \frac{c\xi}{R_c^2}$$

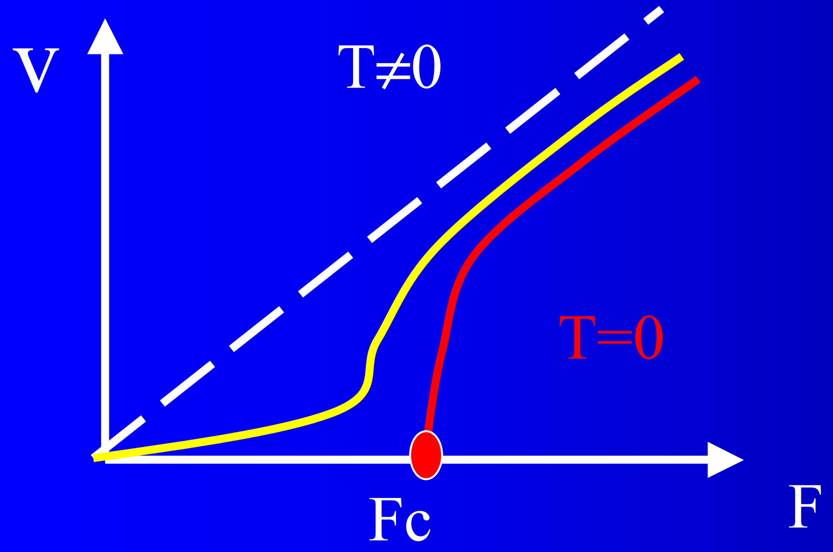
$$H_{el} = \frac{c}{2}\int(\nabla u(r))^2 d^d r$$

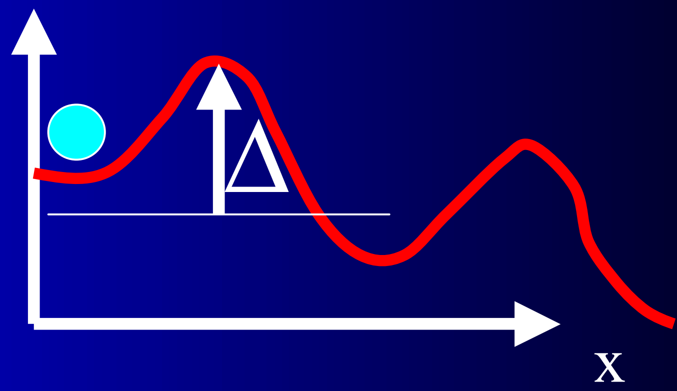
$$H_{el} = \int F u(r) d^d r$$

$$c R_c^{d-2}\xi^2$$

$$F R_c^d \xi$$

TAFF vs Creep





- TAFF : typical barrier
- Linear response

$$v \propto e^{-\beta\Delta} F$$

Creep

- Glassy system
- Slow dynamics determined by statics qty

$$H_{el} = \frac{c}{2}\int (\nabla u(r))^2 d^d r$$

$$H_{el} = \int F u(r) d^d r$$

$$cR^{d-2+2\varsigma}$$

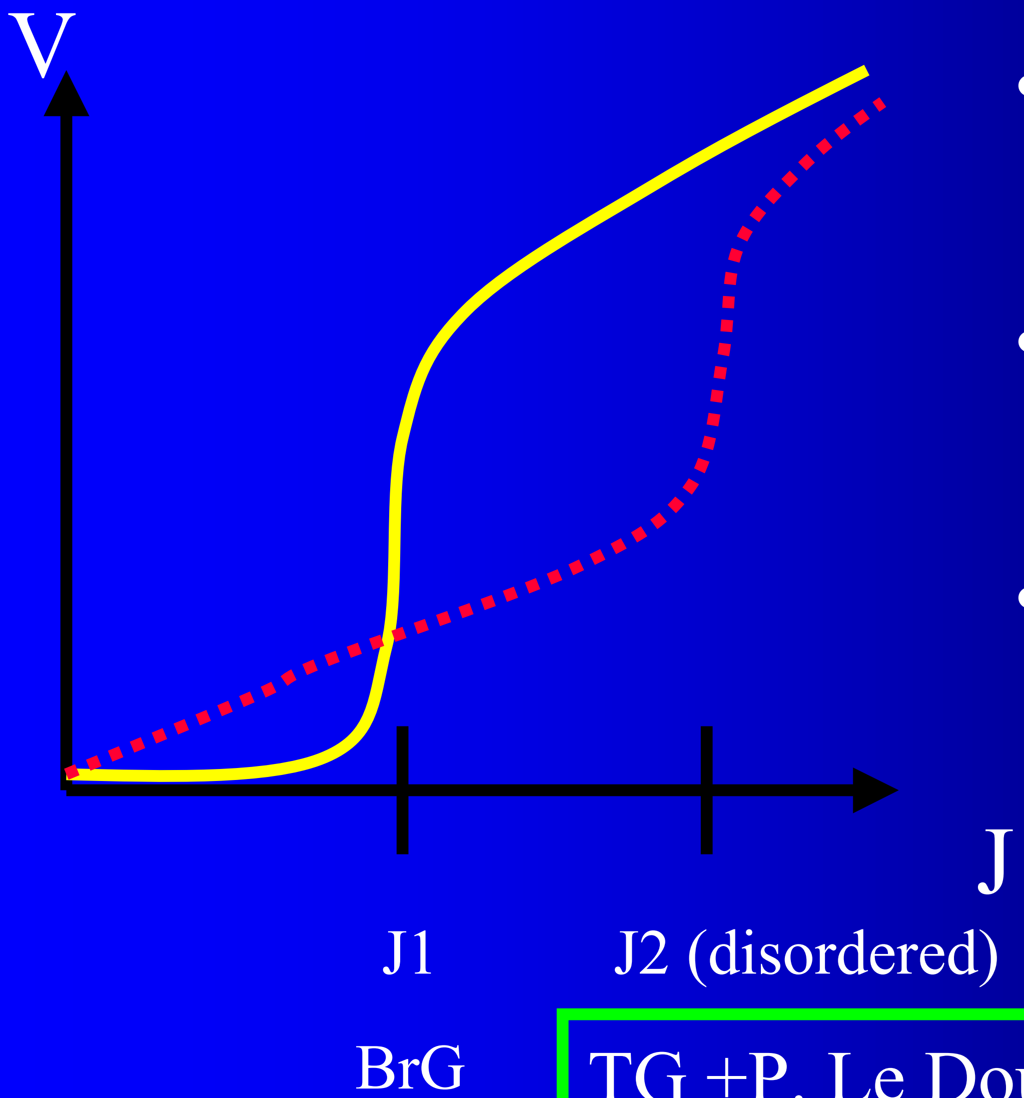
$$FR^{d+\zeta}$$

$$L_{opt} \approx F^{\varsigma-2}$$

$$v \approx e^{-\beta U(L_{opt})}$$

$$U(L_{opt}) \approx F^{\frac{d+2\varsigma-2}{\varsigma-2}}$$

Peak Effect

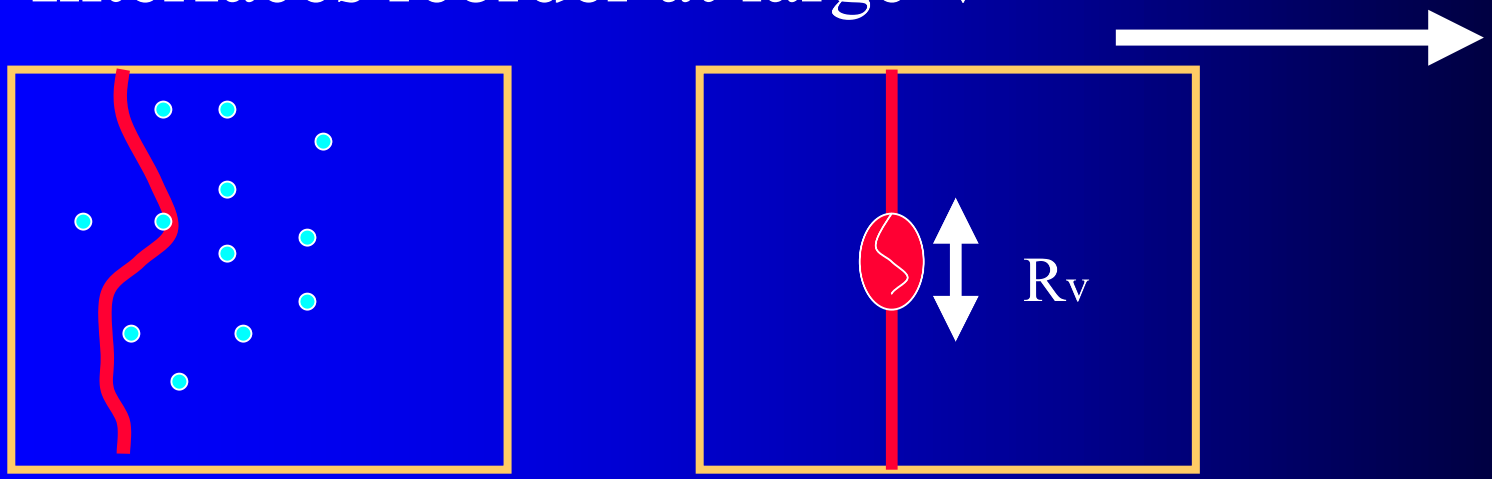


- Peak at « melting » of the Bragg glass :
- second peak in magnetization
- Peak effect in transport

TG +P. Le Doussal PRB 55 6577 (97)

Large V

Interfaces reorder at large V

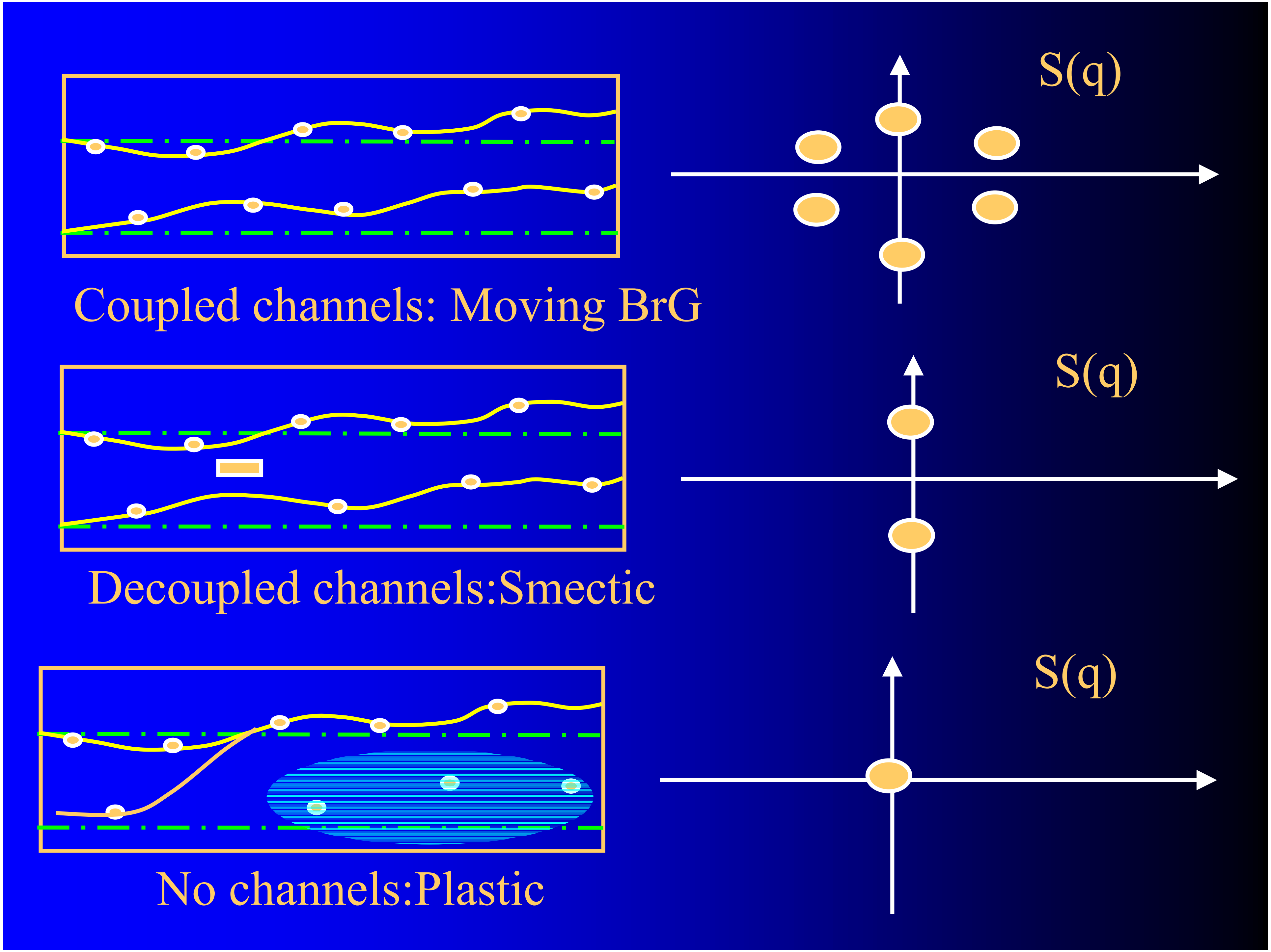


Naively: periodic structure is the same !

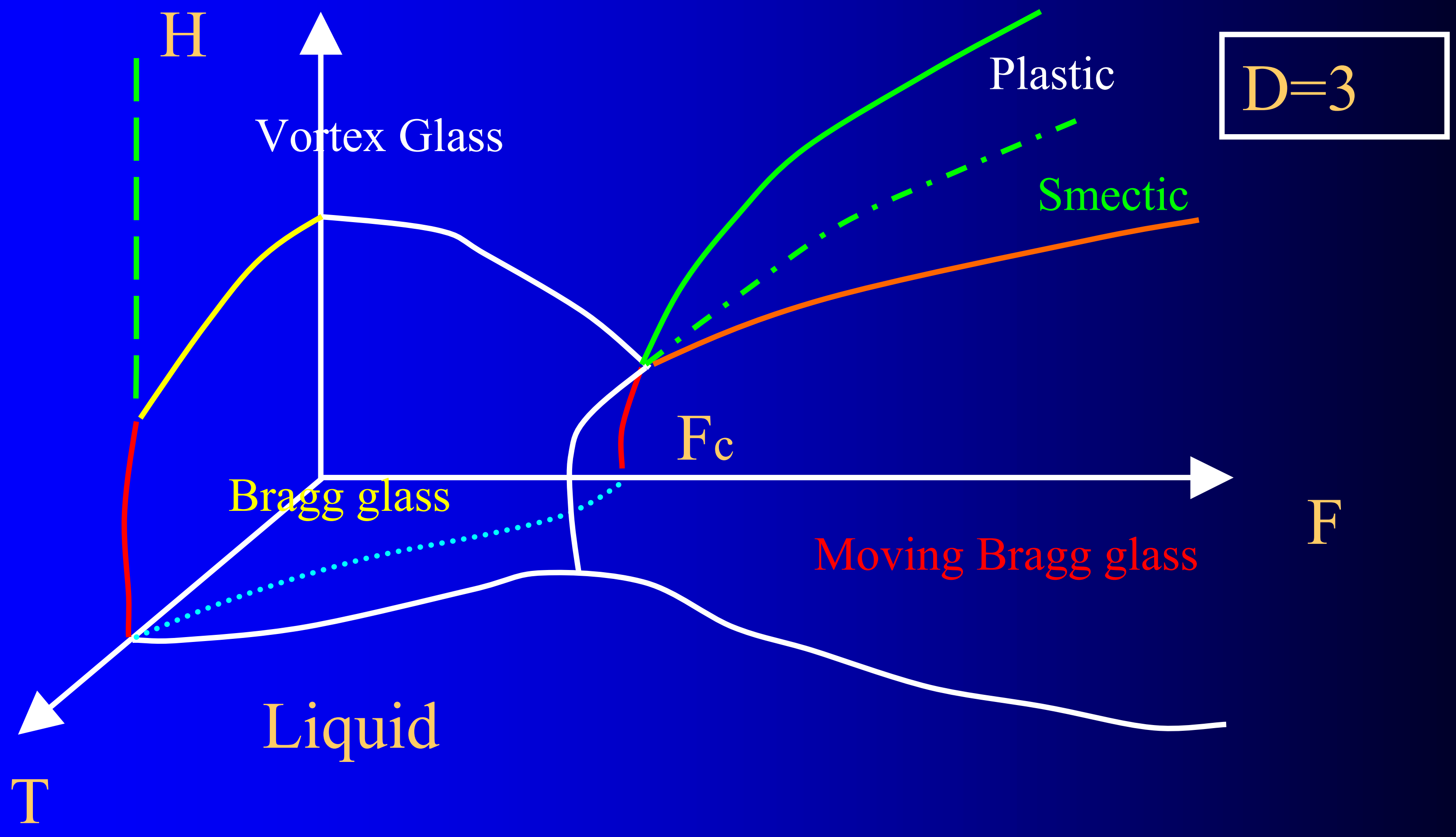
Crystal at large v ?? (T changed by disorder)

Moving glass

TG + P. Le Doussal PRL 76 3408 (1996);
P. Le Doussal + TG PRB 57 11356 (1998).

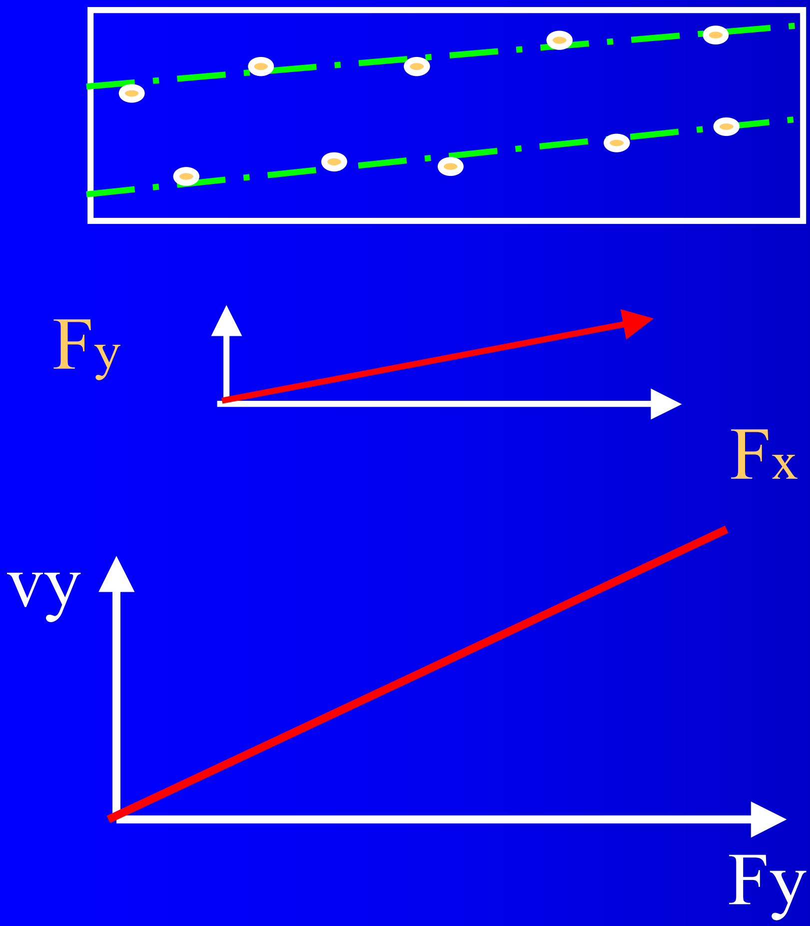

S(q)
Coupled channels: Moving BrG
S(q)
Decoupled channels:Smectic
S(q)
No channels:Plastic

Dynamical Phase Diagram

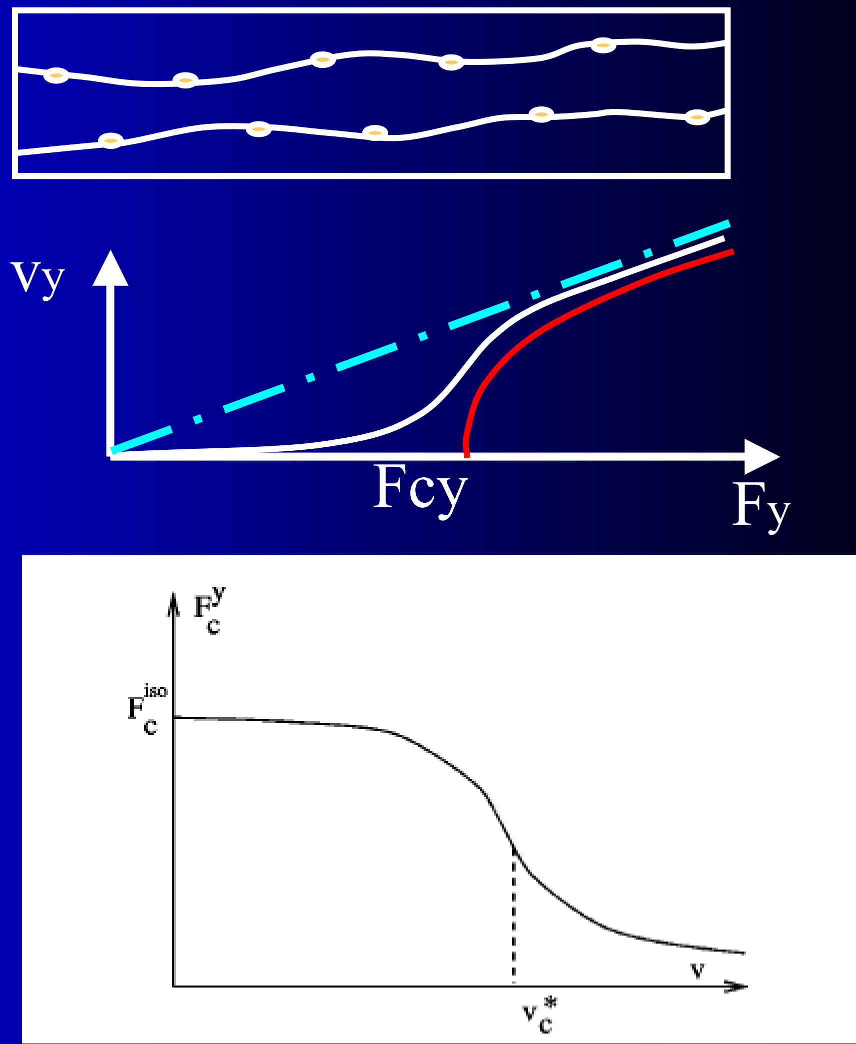


Transverse critical force

Crystal



Moving glass



• General on vortices :

G. Blatter et al. Rev. Mod. Phys 66 1125 (1994).

• Bragg glass :

T.G. + P. Le Doussal Phys. Rev. B 52 1242 (1995).
T.G. + P. Le Doussal Phys. Rev. B 55 6577 (1997).
P. Le Doussal + T.G. Physica C 331 233 (2000).

Review: T.G. + P. Le Doussal In ``Spin Glasses and Random Fields", ed. A.P. Young, World Scientific (Singapore) 1998, p. 321, cond-mat/9705096

• Moving glass:

T.G. + P. Le Doussal Phys. Rev. Lett. 76 3408 (1996).
P. Le Doussal + T.G. Phys. Rev. B 57 11356 (1998).

• Creep from RG:

P. Chauve + T.G. + P. Le Doussal Phys. Rev. B 62 624 (2000).

• Quantum problems:

T.G. + P. Le Doussal Phys. Rev. B 53 15206 (1996).
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Review: T.G. + E. Orignac cond-mat/**0005220**

And references therein...