Dynamics of interfaces below depinning

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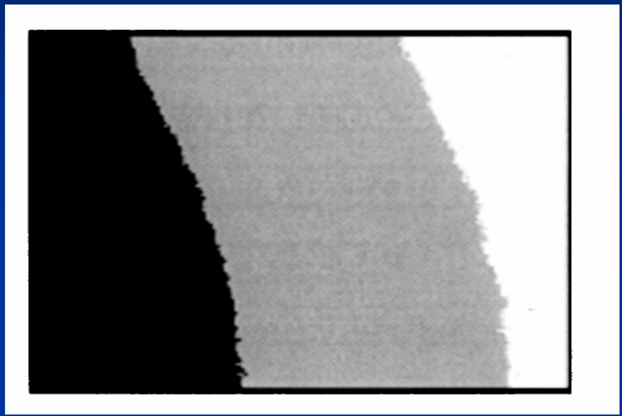
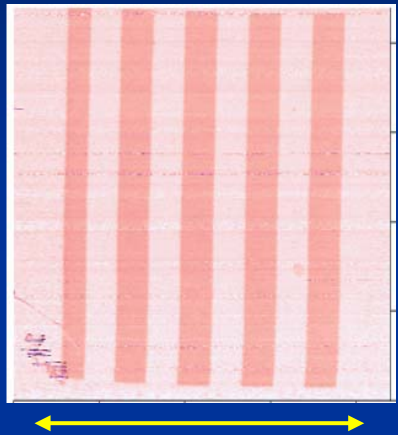
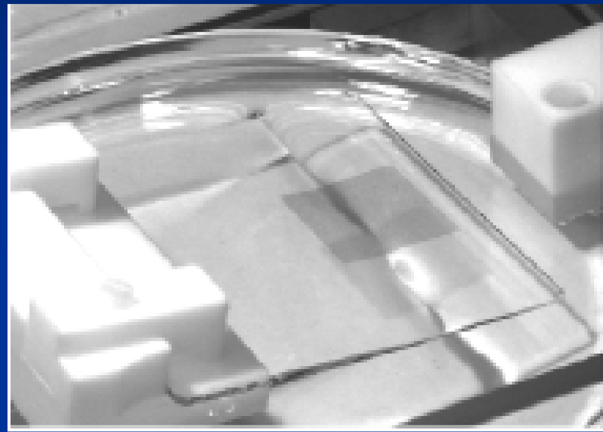
Many systems: interfaces







10 μm

Ferromagnets

S. Lemerle et al.
PRL 80 849 (98)

Ferroelectrics

P. Paruch et al. cond-mat/0411178

Contact line, wetting

S. Moulinet, E. Rolley

Other: crack propagation, growth, etc.

Statics

u(L) ~ L^{ζ}

ζ_{eq} = 2/3 in d=1

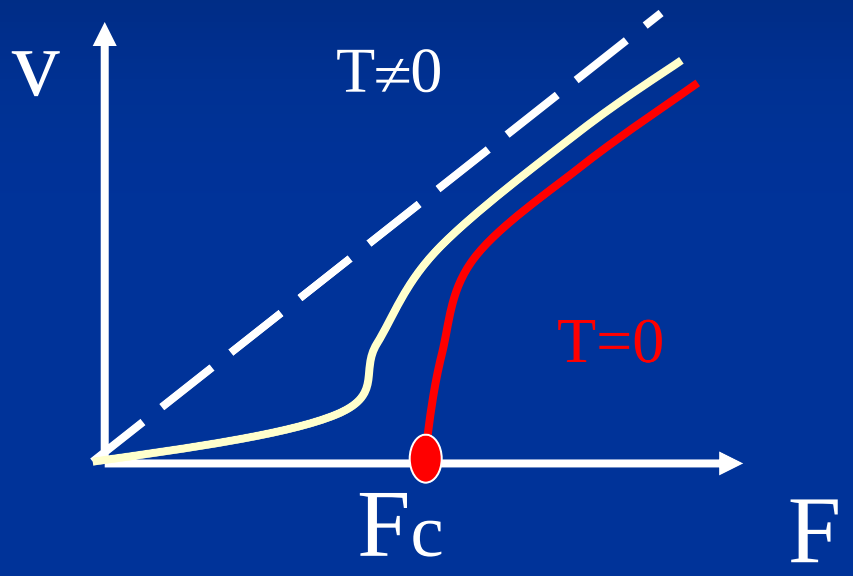
$$S_q = \overline{\langle |u(q,t)|^2 \rangle} \sim q^{-(1+2\zeta)}$$

$$H = \frac{c}{2}\int dz (\nabla u(z))^2 + \int dz V(u(z), z)$$

Elasticity disorder

Line is rough Line is glassy Line is pinned

Dynamics



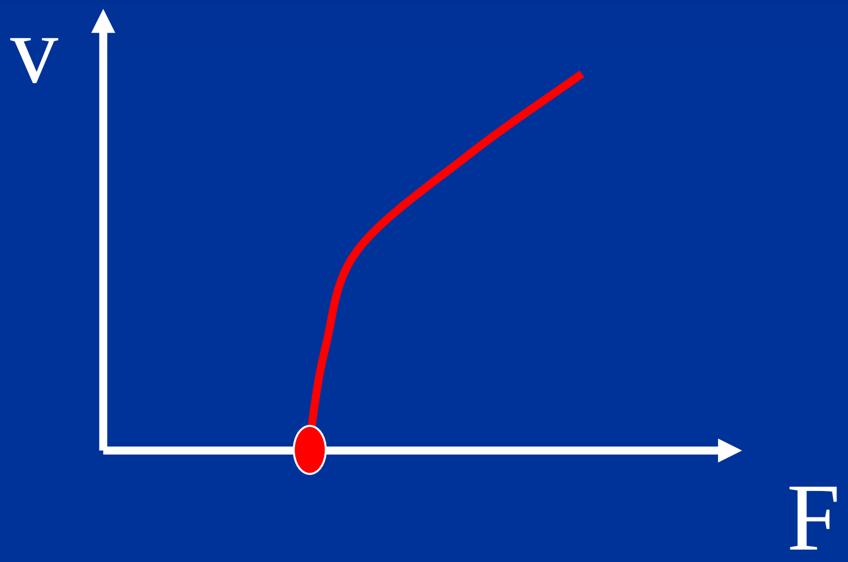
steady state motion

$$\eta\partial_t u(z,t) = c\nabla^2 u(z,t) + F_{\text{pin}}[u(z,t)] + F + \xi(z,t)$$

How to view depinning ?

Depinning as a critical phenomena ?

(D.S. Fisher)



Depinning	Crit. phen.
F	T
v	magn.

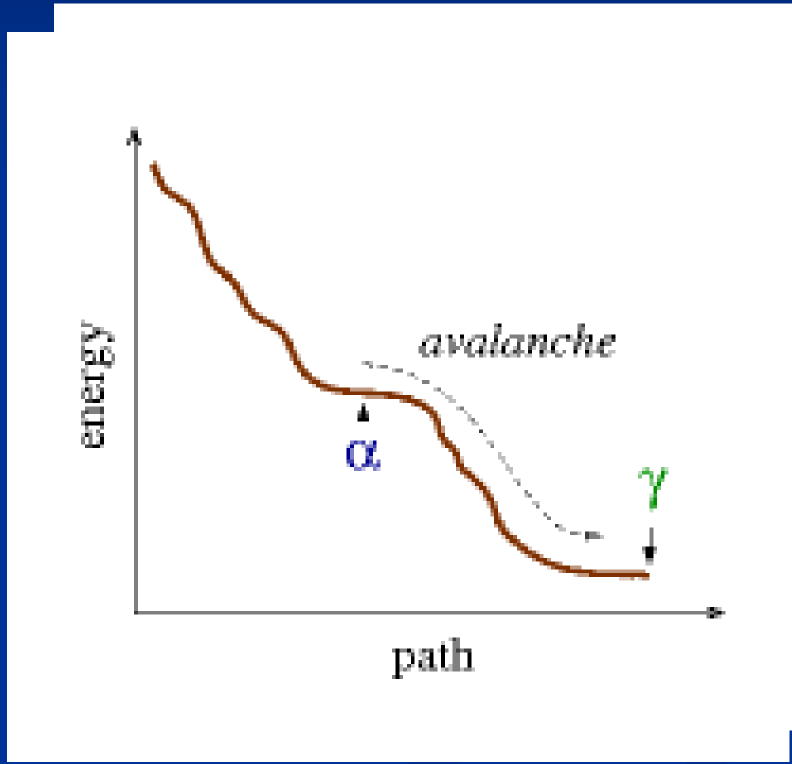
Suggests : critical exponents for $F \sim F_c$

Exponents and divergent lengthscales

Order parameter: $v \sim (F\text{-}Fc)^{\beta}$

Divergent length: $\xi \sim (F\text{-}Fc)^{-\nu}$

Divergent time: $t \sim \xi^{z}$



Scaling relations:

$$\nu = \frac{\beta}{z-\zeta} = \frac{1}{2-\zeta}$$

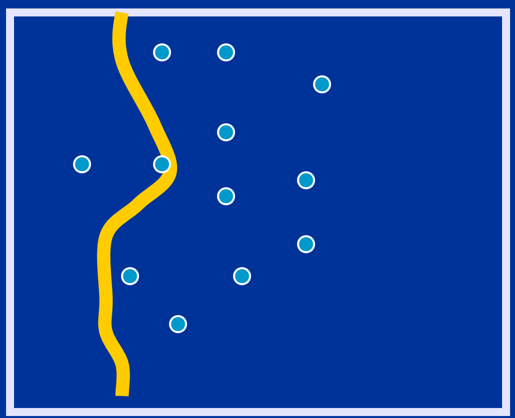
Roughness of line

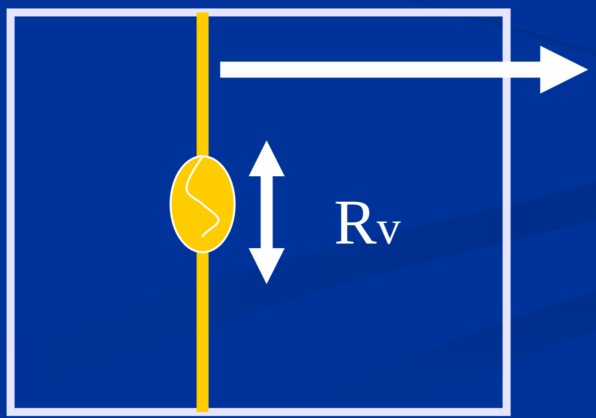
- $F = F_c$

Line is rough but with $\zeta = \zeta_{dep}$

$\zeta_{dep} \sim 1.2..$

- Large lengthscales $v \neq 0$

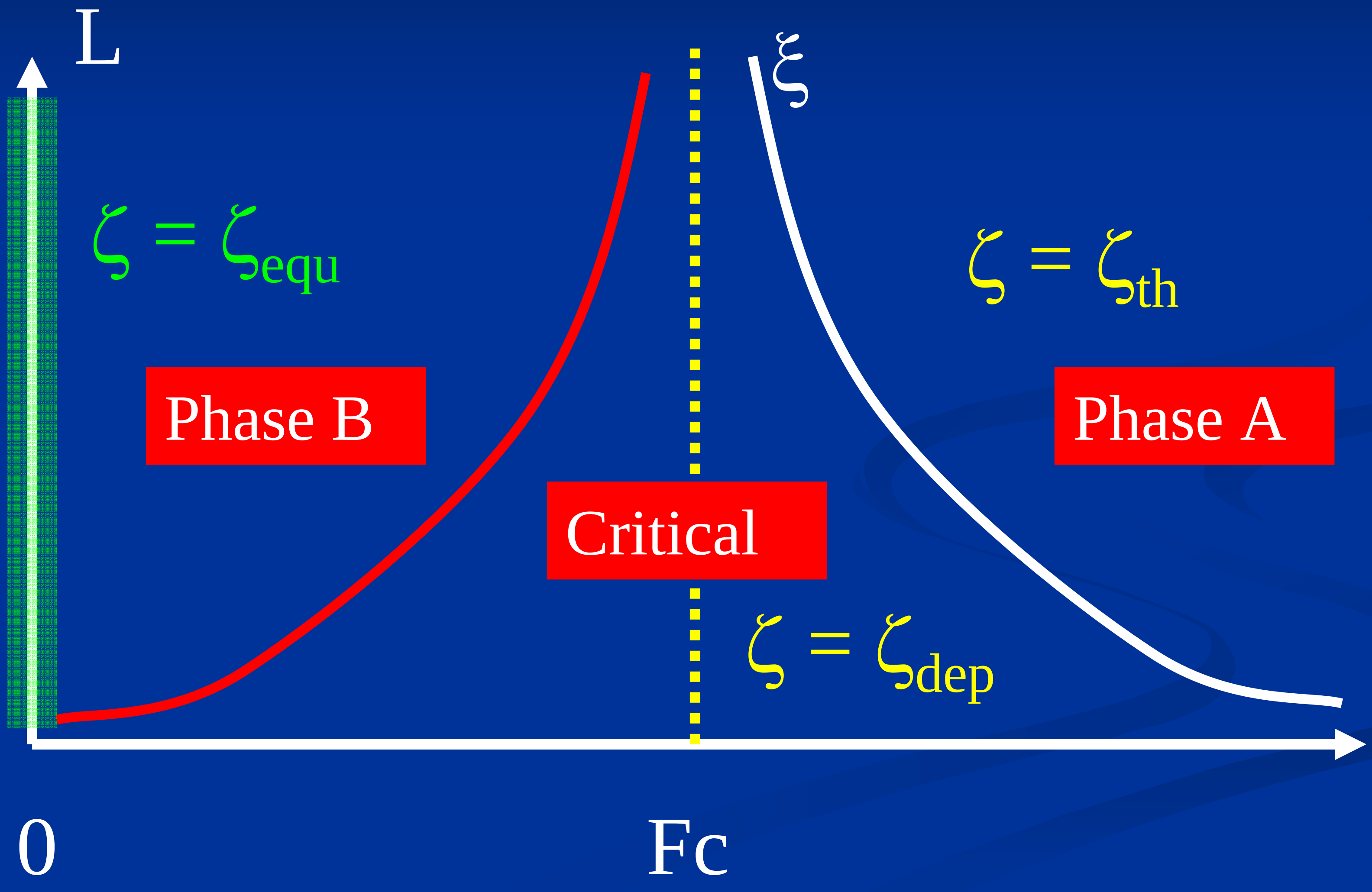




$\zeta = \zeta_{th}$

$\zeta_{th} \sim 0.5$

Consequence for aspect of line at $T=0^+$



How to study

- T = 0

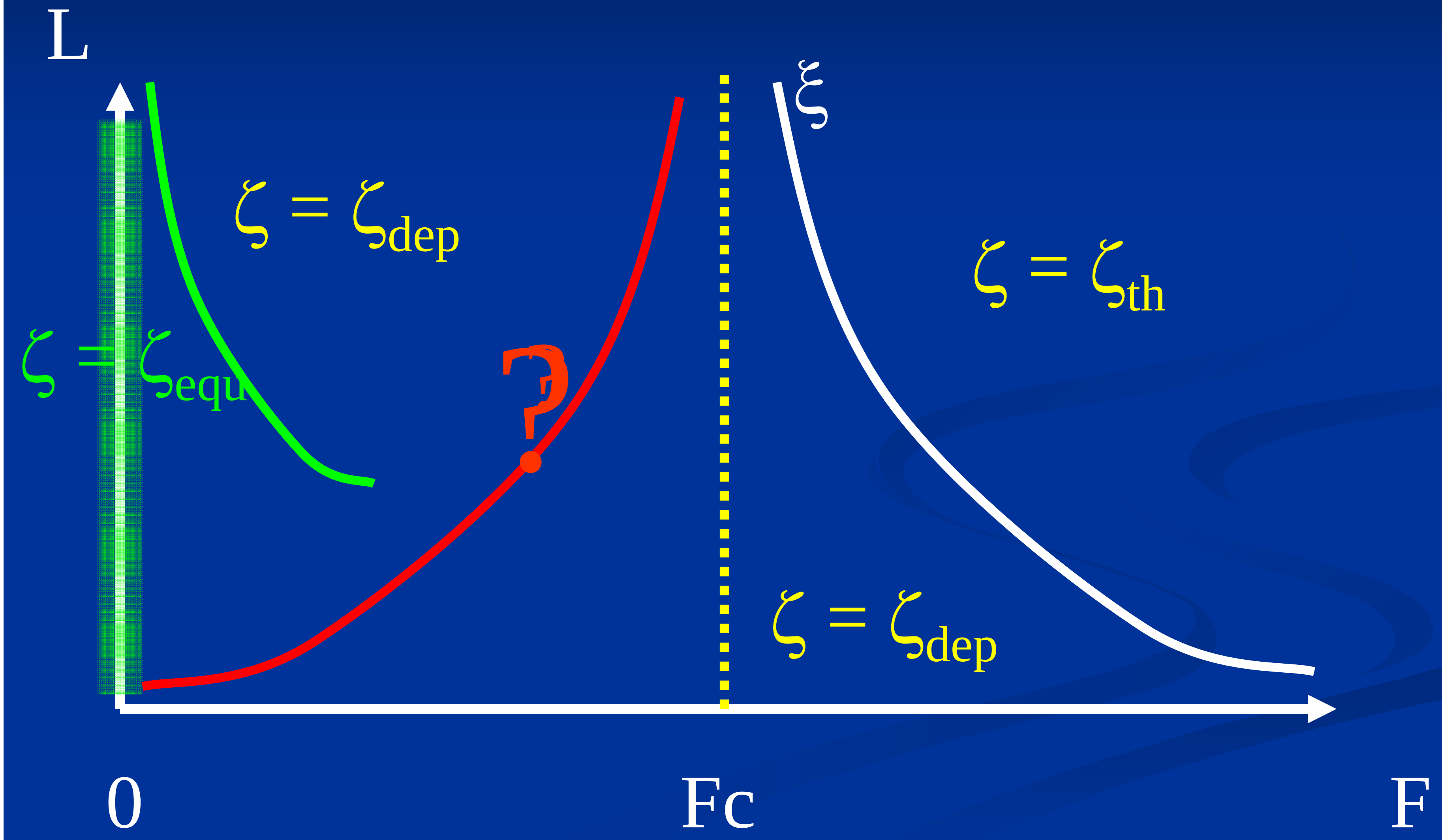
Only transient dynamics

Divergent lengthscale in transient
(Middleton, Fisher, Narayan, Chen, Marchetti)

- Very serious problem with FRG analysis of $F \to 0$ (creep)

(Chauve, TG, Le Doussal)

Consequence for aspect of line



Need to study $T \neq 0$ steady state motion

- Analytic

FRG Difficult ! and 4-d

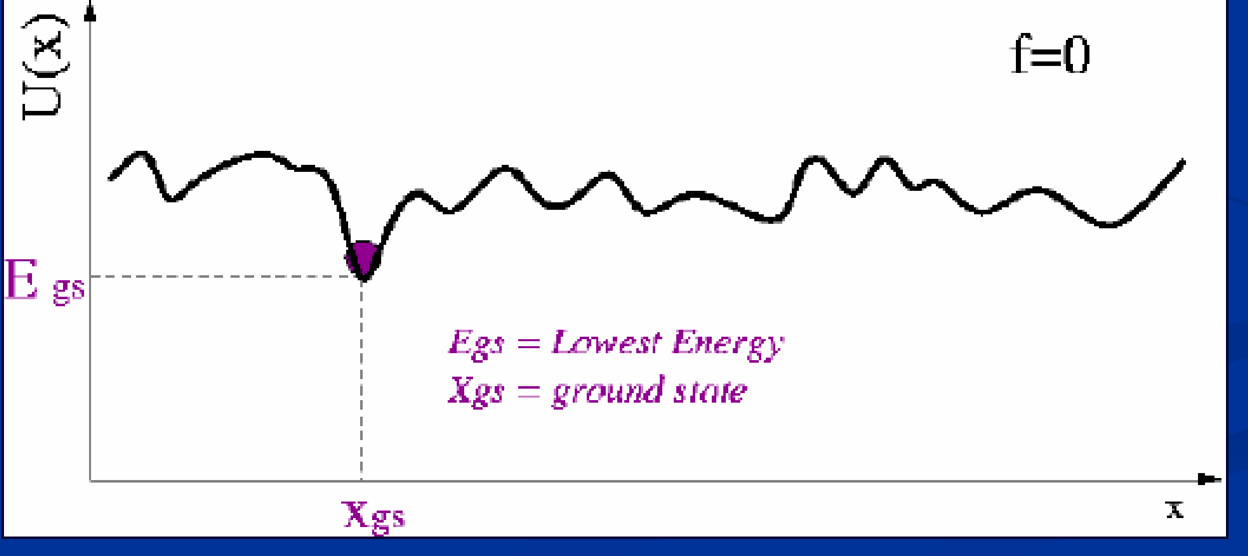
- Numerics

Molecular dynamics Extremely slow: inefficient

Novel Algorithm

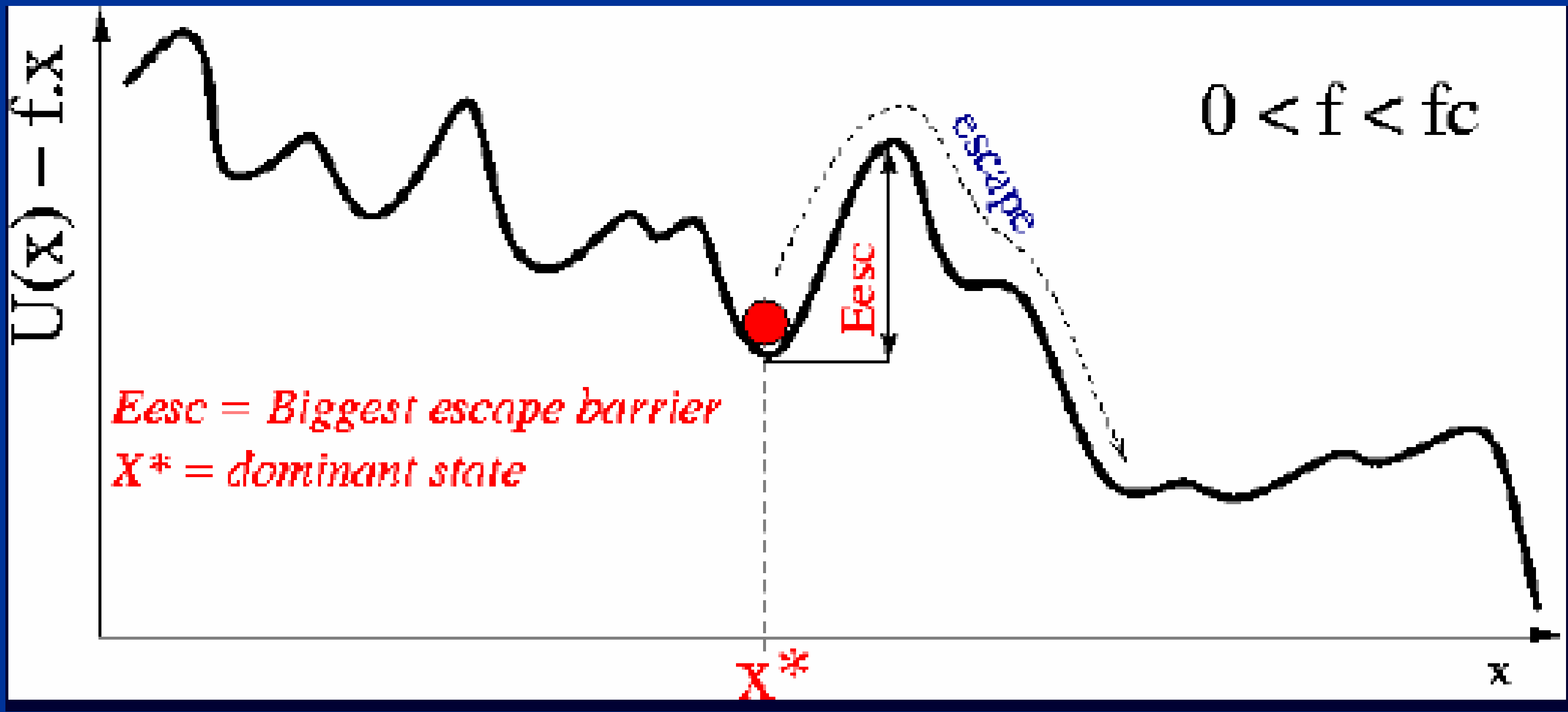
A.B. Kolton, A. Rosso, TG, W. Krauth cond-mat/0603297 (PRL)

- Equilibrium: One dominant configuration when T→ 0



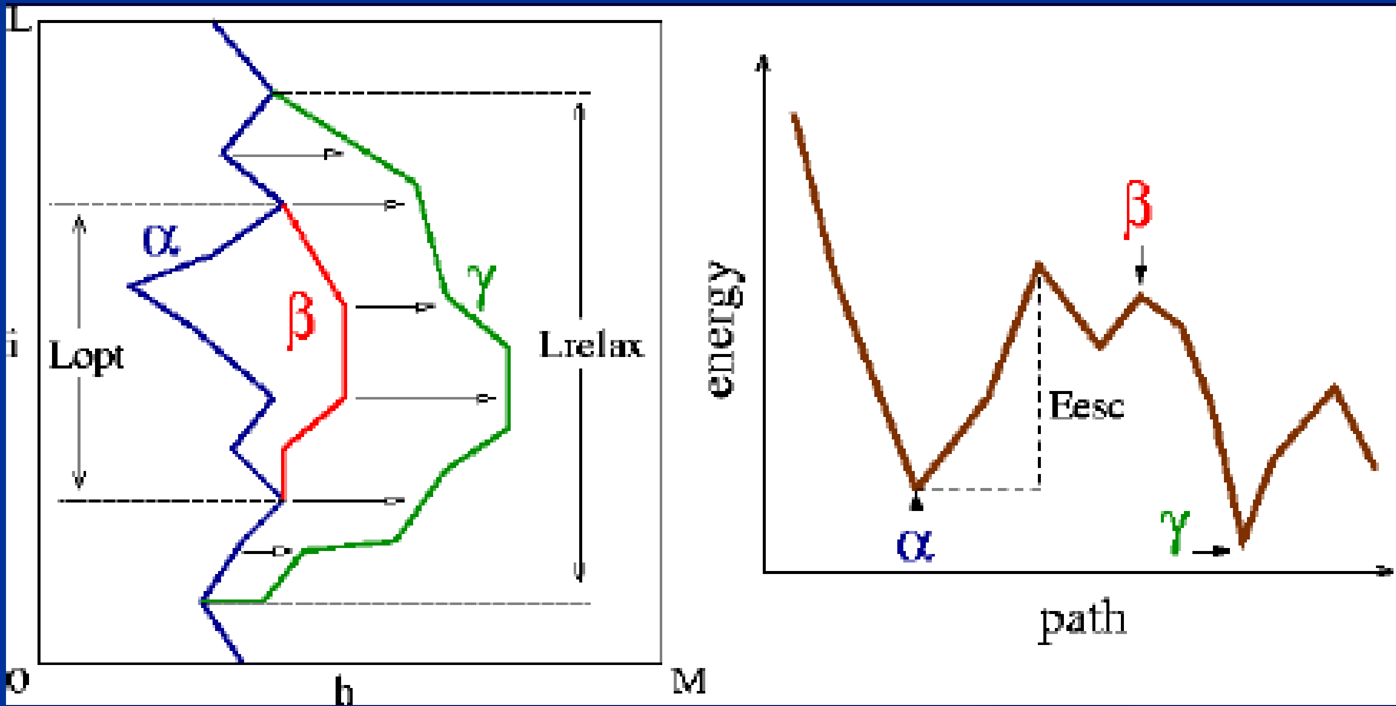
Dynamics for $T \rightarrow 0^+$

Also one dominant configuration



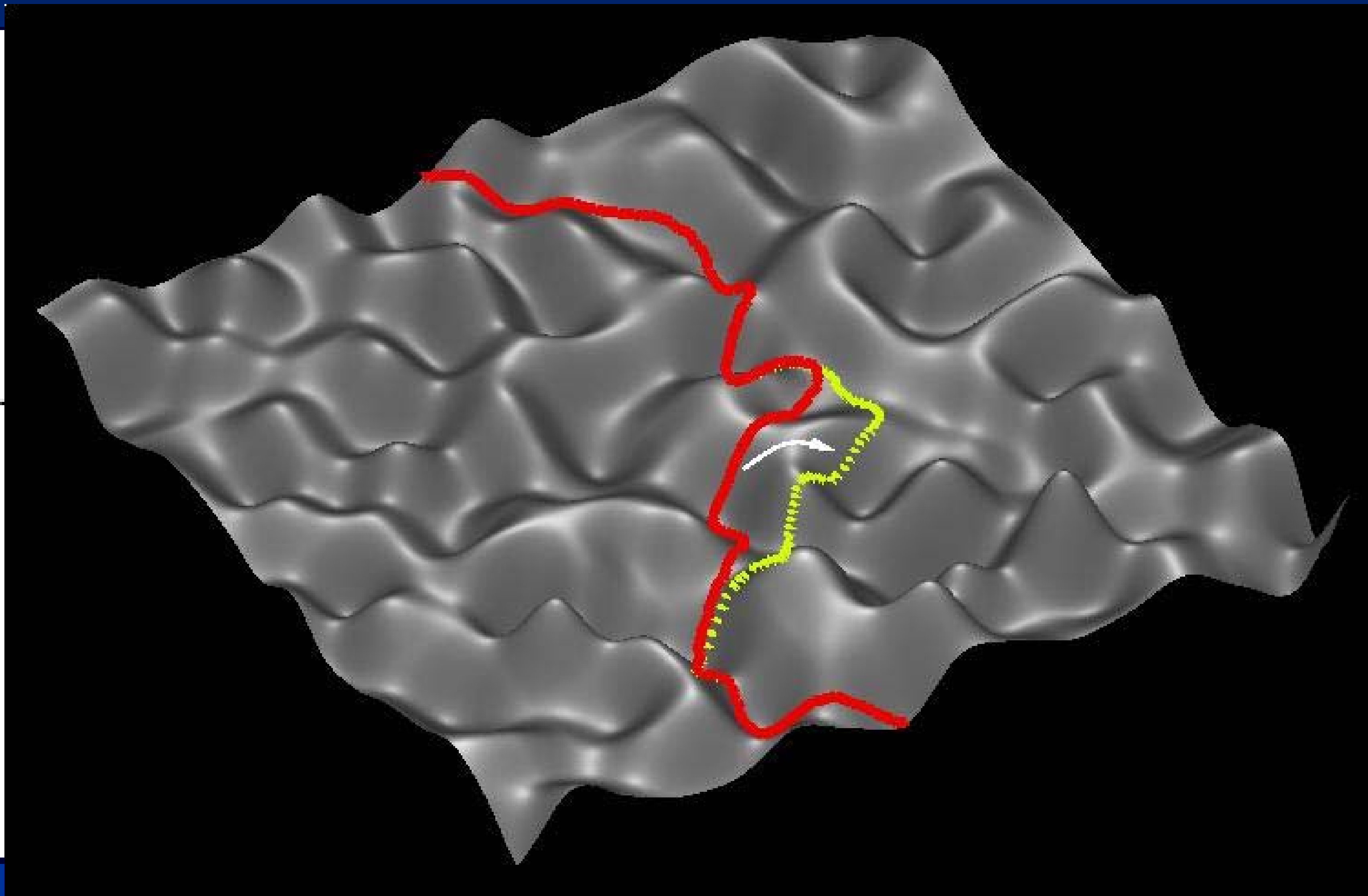
How to find it ?

Enumeration of all « good » moves

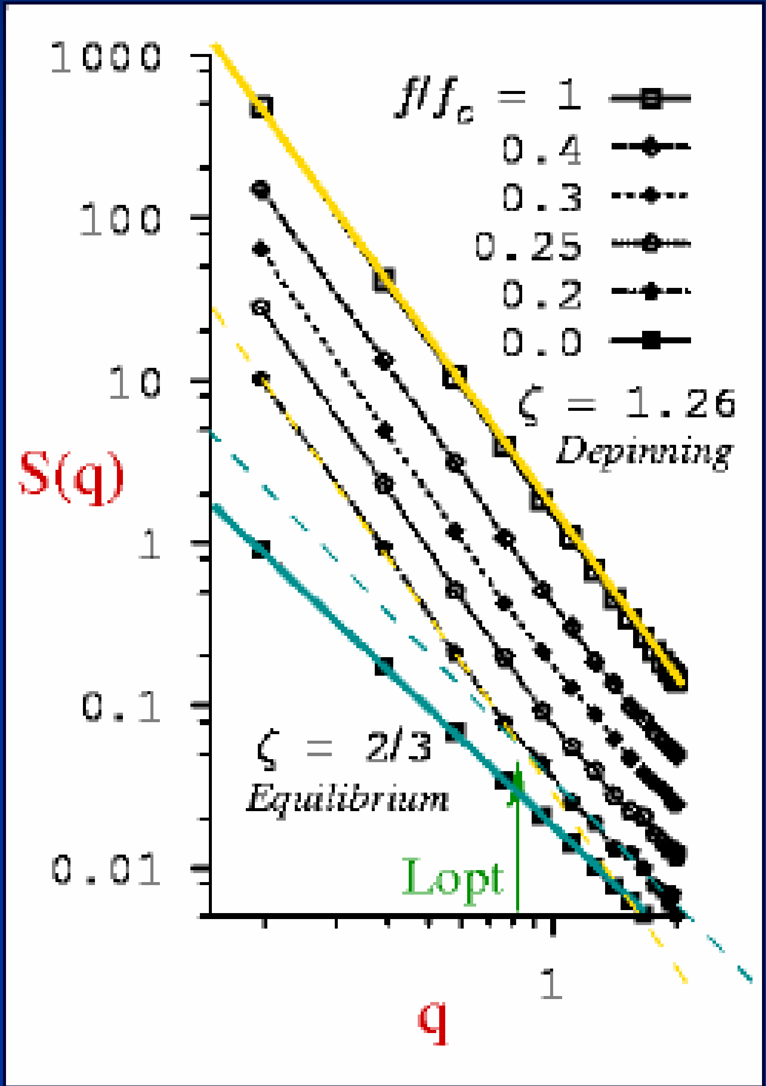


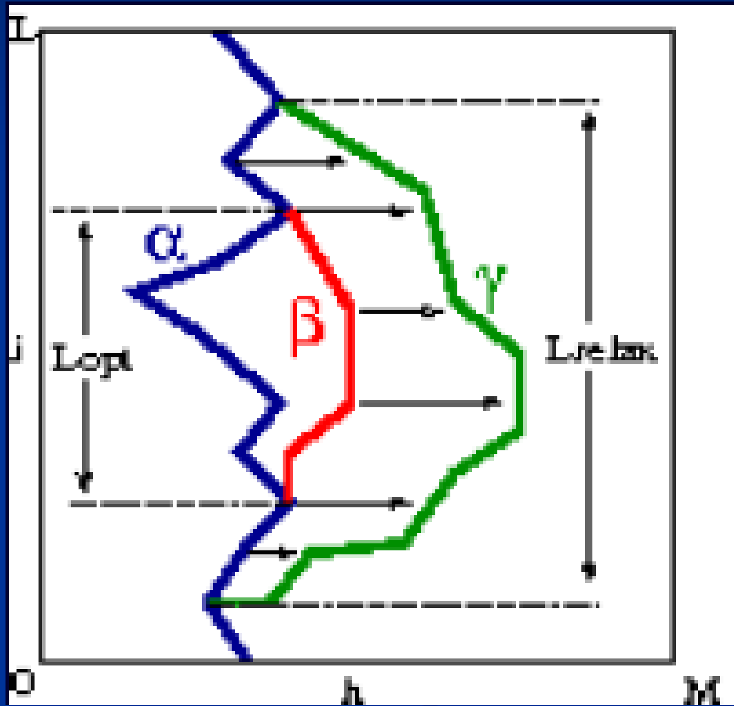
Works well when nucleus size not too big (F ~ Fc)

Dominant configuration F<Fc



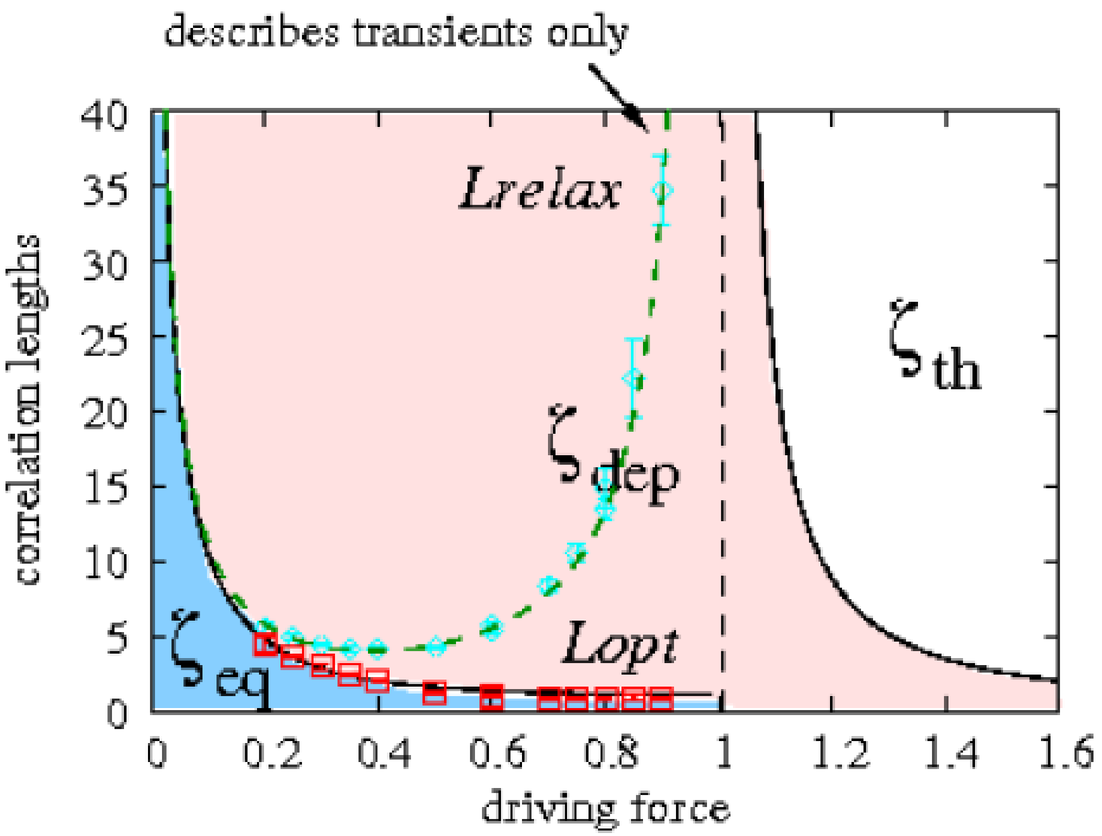
Geometry

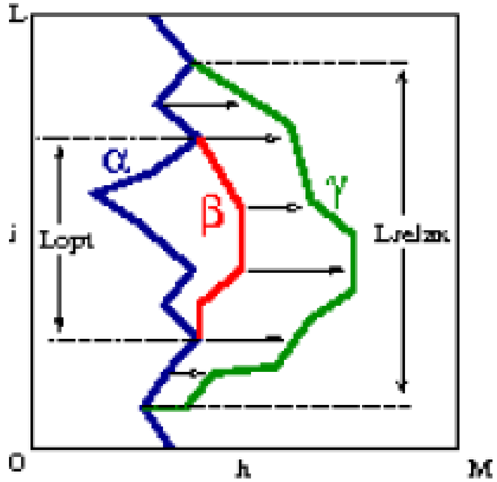


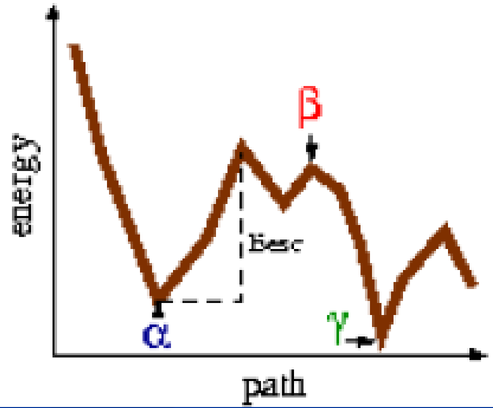


ζ_{eq} at **small** scales

Dynamical phase diagram







Conclusions

- Novel algorithm to tackle the dynamics of a line
- No divergent lengthscale visible in steady state when $F \rightarrow F_c^-$
- Depinning cannot thus be viewed as a « standard » critical phenomena

Perspectives

- Observation of the lengthscales (magnetic domains)
- Determination of other quantities (barriers, etc.)
- Analogies with less conventional critical phenomena ?