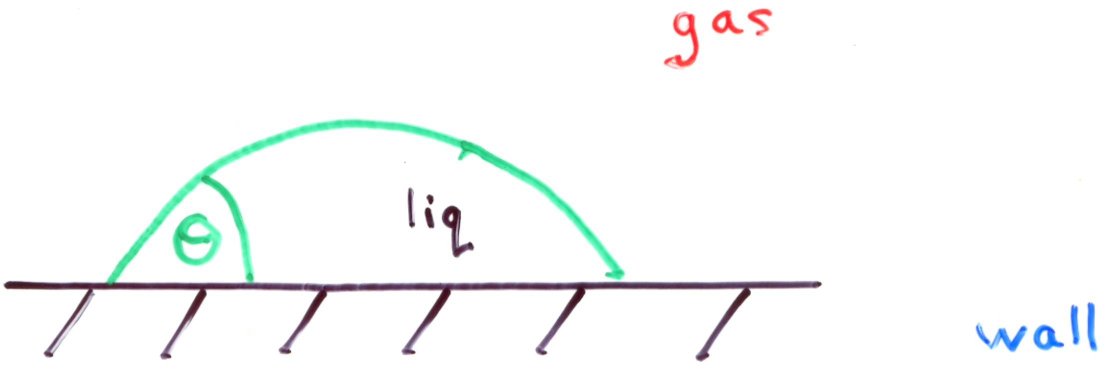
The Saga of Critical Wetting.

or

when good phase transitions turn bad.

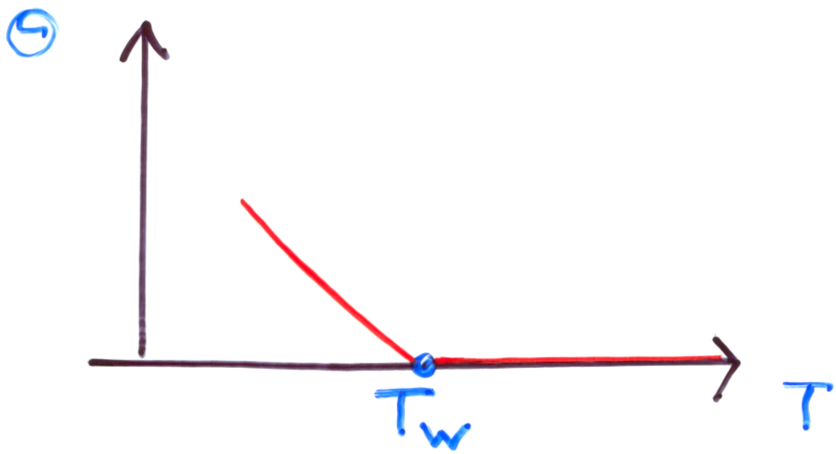
- 77 • What is Wetting?
- 83 • Why interesting?
- 85 • Why controversial?
- 92 • Why situat^n got worse.
- 06 • Many-body physics to rescue!

W = 



$\Theta > 0$ Partial wetting

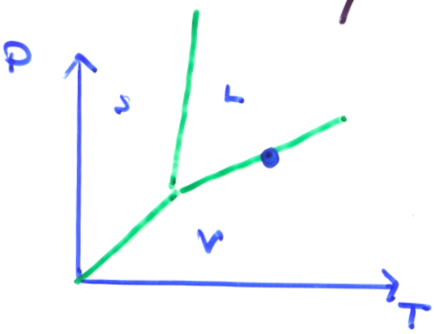
$\Theta = 0$ Complete wetting



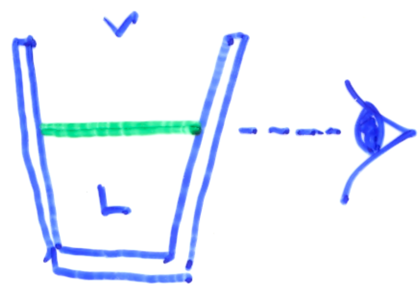
Cahn 77

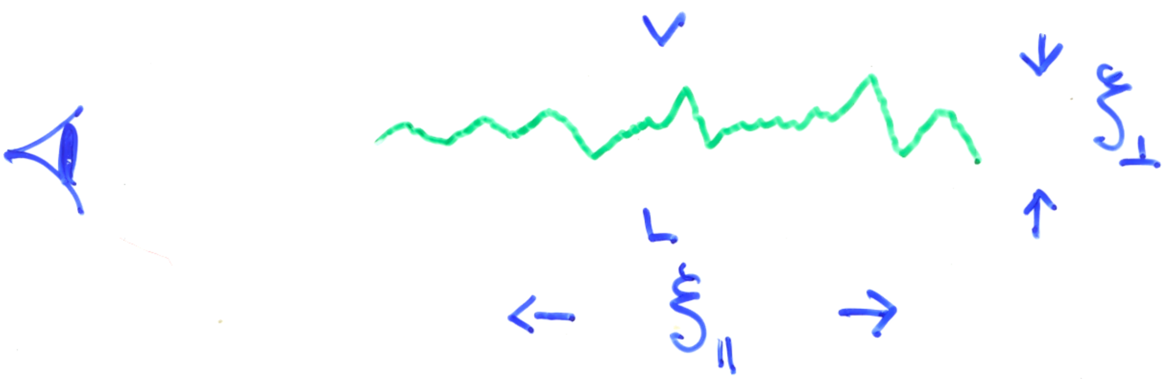
- Wetting + Filling phase transitions with interfaces

- Interfaces lead to critical phenomena, scaling, universality etc away from T_c.



Sit at coexistence





$\xi_\parallel$ = parallel or transverse correl^n length

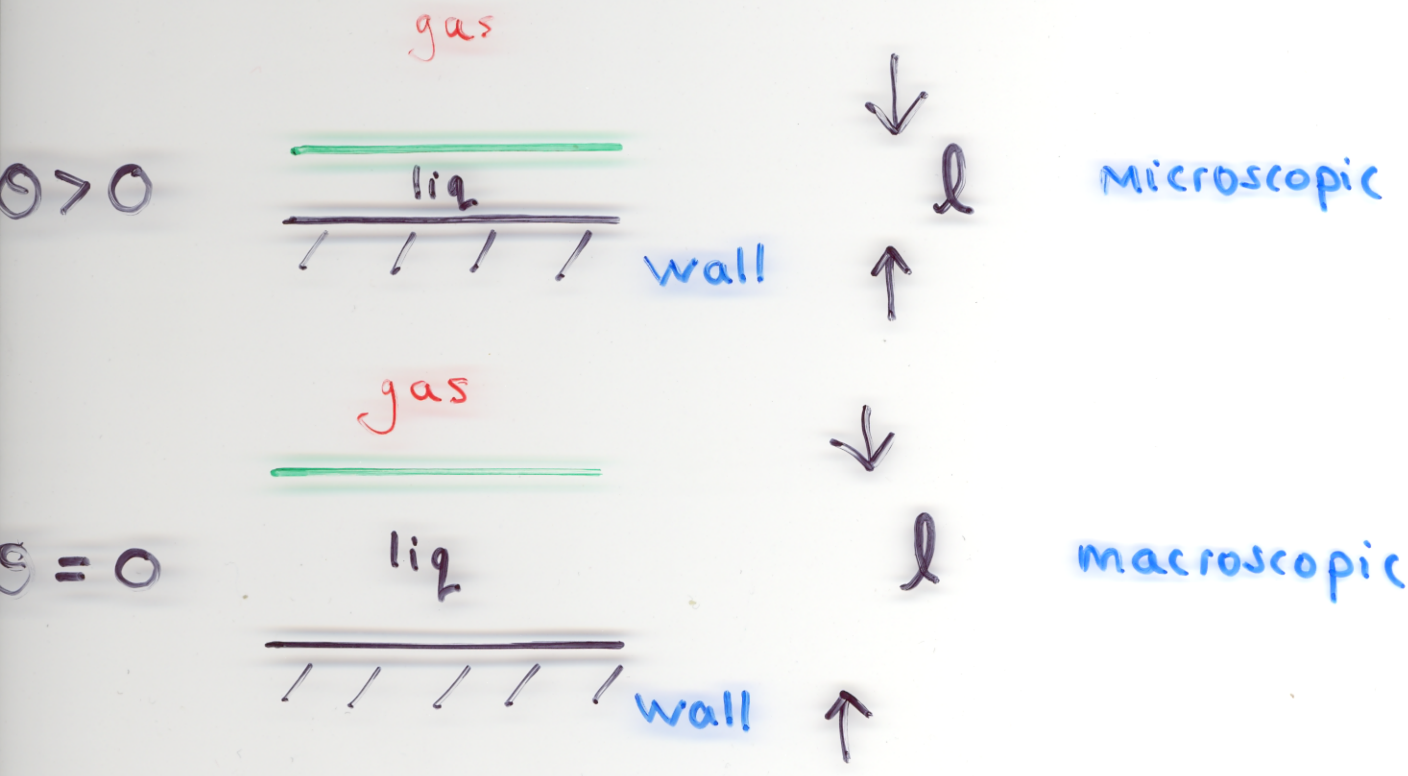
$\xi_\perp$ = perpendicular correl^n length (roughness)

In absence of pinning fields these are macroscopic

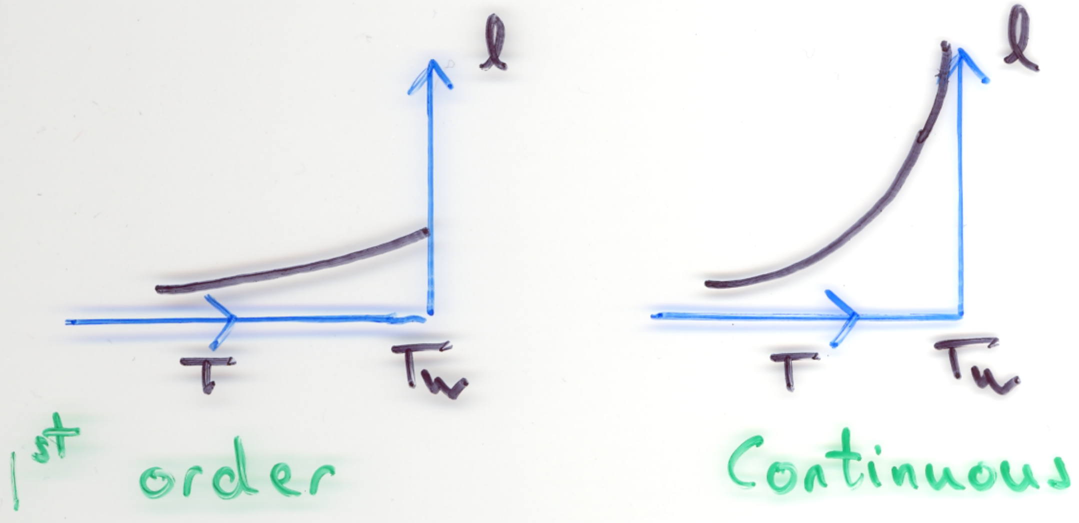
$$\xi_\perp = \xi_\parallel^{\,\zeta}$$

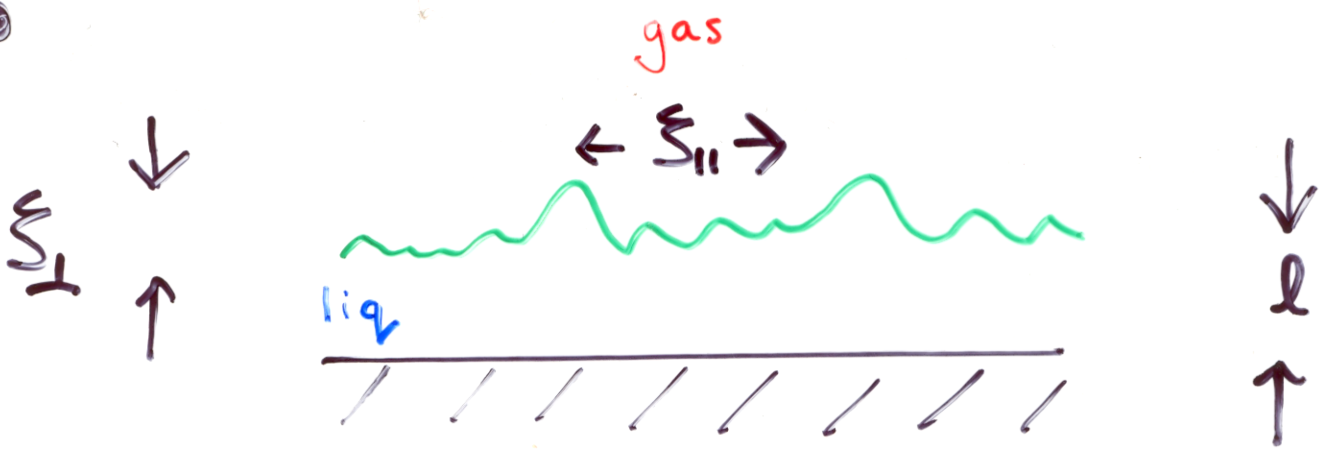
ζ ← wandering exponent

ζ depends on d, type of disorder (+ also geometry)



Two poss. types of wetting trans^n





$$l \sim (T_w - T)^{-\beta_s}$$

$$\xi_{\parallel} \sim (T_w - T)^{-\nu_{\parallel}}$$

$$\sigma_{wg} - (\sigma_{wl} + \sigma_{lg}) \sim (T_w - T)^{2-\alpha_s}$$

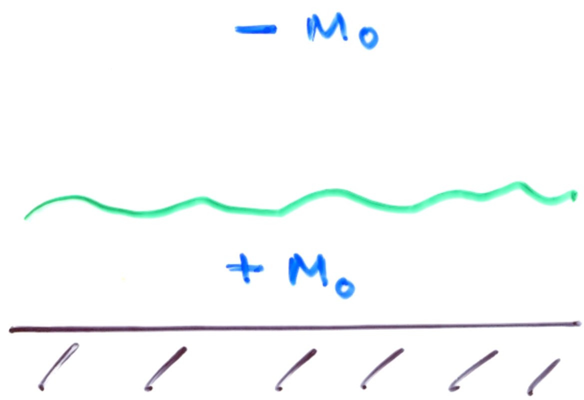
$$2 - \alpha_s = 2\nu_{\parallel} - 2\beta_s$$

$$2 - \alpha_s = (d-1)\nu_{\parallel}$$ etc....

What are they ?

Mean-field Theory

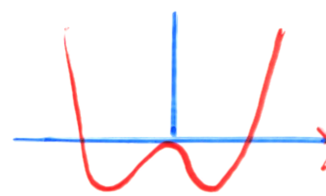
Magnetic language



$h = 0^-$

$h_1 > 0$

$$H_{LGW}[m] = \int d\underset{\sim}{r} \left\{ \frac{(\nabla m)^2}{2} + \phi(m) \right\} + \phi_1$$



(NF 82, BHL 83)

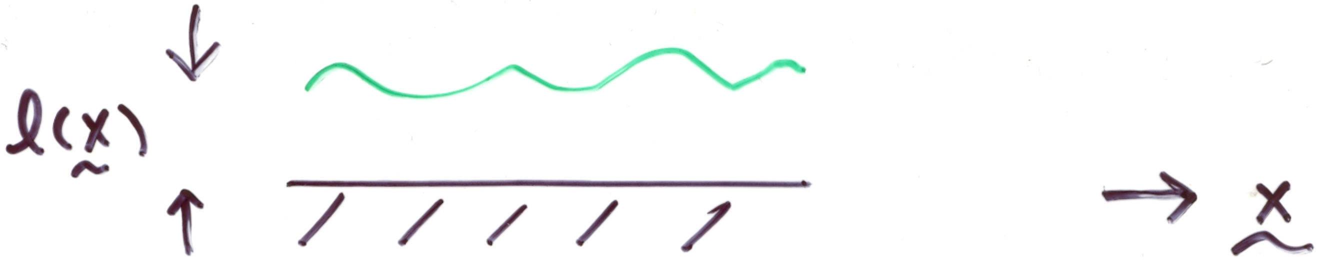
Minimise to get

$$\ell \sim -\ln(T_w - T)$$

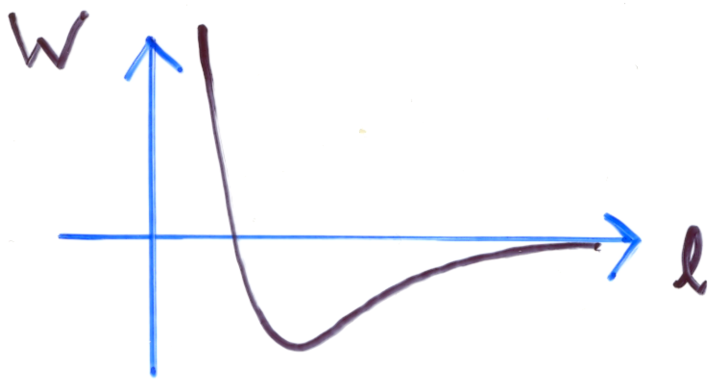
also $\alpha_s = 0$, $\nu_{\parallel} = 1$

$$\boxed{d^* = 3}$$

Interfacial Models



- $$H_I[\ell] = \int d\underset{\sim}{x} \left\{ \frac{\sigma_{\ell g}}{2} (\nabla \ell)^2 + W(\ell) \right\}$$

- 

$$W = -a e^{-\ell} + b e^{-2\ell} + \cdots$$

$a \uparrow (T_w - T)$

- $d > 3$ mean-field ✓

  $d = 2$ Exact Ising ✓

RG predictions in $d=3$

(BHL 83, FH 85)

Non-Universality!

dependent on

$$\omega = \frac{k_B T_w \kappa^2}{4\pi \sigma_{eg}}$$

e.g. $\nu_{\parallel} = (\sqrt{2} - \sqrt{\omega})^{-2}$; $\frac{1}{2} < \omega < 2$

- For Ising model $\omega \sim 0.8 \Rightarrow \nu_{\parallel}^{RG} \sim 4$

- However Binder et al (1985–)

see **NONE** of this.

Good news : transition exists

Bad news : $\nu_{\parallel}^{sim} \sim 1$ Mean-field !

Theory of Fisher + Jin (92)

- Derive $H_I[\ell]$ from $H_{LGW}[m]$

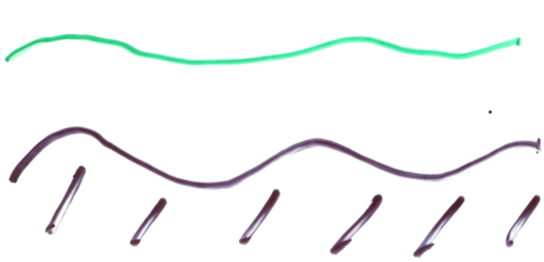
$$H_I[\ell] = \int d\underset{\sim}{x} \left\{ \frac{\sigma(\ell)}{2} (\nabla \ell)^2 + W(\ell) \right\}$$

$$-ae^{-\ell} + be^{-2\ell} \checkmark$$

$$\Delta\sigma = -ae^{-\ell} - 2b\ell e^{-2\ell}$$

- RG of FJ model destroys transition!

Non-locality



$$H_{NL}[\ell,\psi] = \sigma_{\ell g} A + W[\ell,\psi]$$

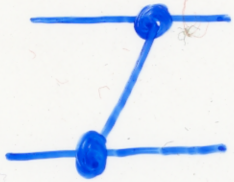
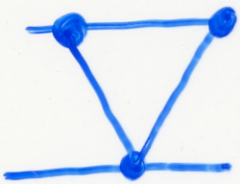
$W = -a$  $+ \, b$  $+ \cdots\cdots$

zig-zags

e.g.

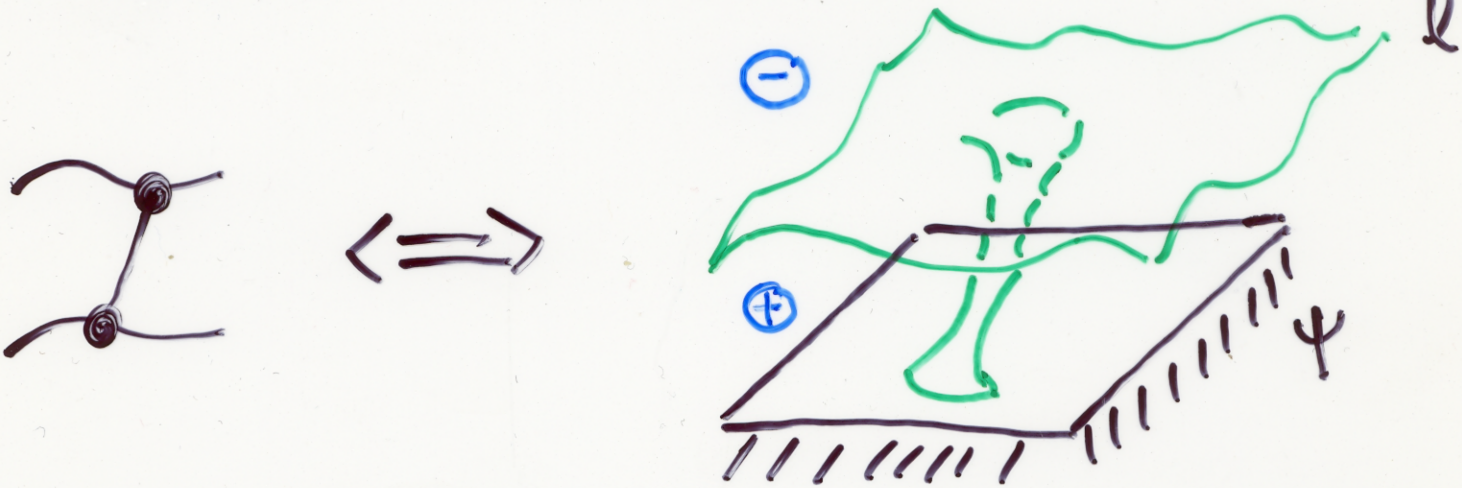
 $\equiv \int ds_\psi \int ds_\ell \; K(r)$

$$K(r) = \frac{e^{-r}}{2\pi r}$$

-  $= \text{Area } e^{-\ell}$
-  $= \text{Area } e^{-2\ell}$

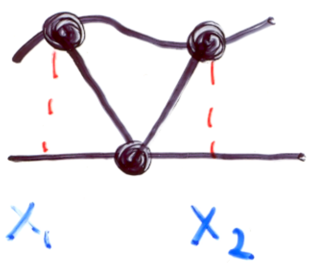
$\Big\}$ ✓ $W(\ell)$

- "Tube" intepretation.



- Hidden symmetries, exact sum-rules ✓

• RG of wetting revisited



$$= \iint dx_1\, dx_2\, e^{-\ell(x_1)}\, S(x_{12})\, e^{-\ell(x_2)}$$

$$S(x_{12}) \propto e^{-x_{12}^2/\ell}$$

2-body interaction

"Long-ranged" $\sqrt{\ell}$

1) Phase transition not destroyed

2) Asymptotic singularities non-universal

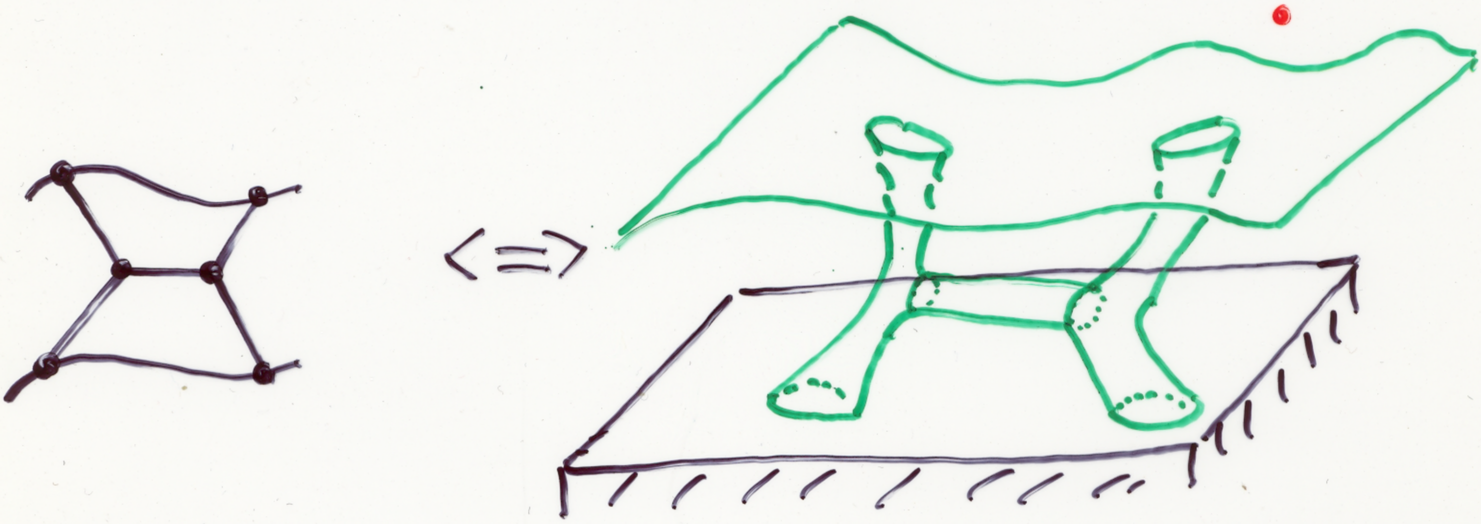
3) Huge decrease in critical regime

$$G(1,2) = \partial^2_{z_1 z_2}$$

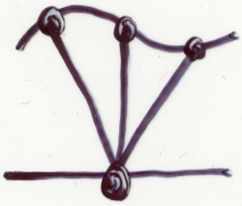
Other diagrams

- $W_{FJ}(\ell) = -a e^{-\ell} + b e^{-2\ell} + a^2 \ell e^{-2\ell} + \dots$

  ?



- Tricritical wetting (a=b=0)



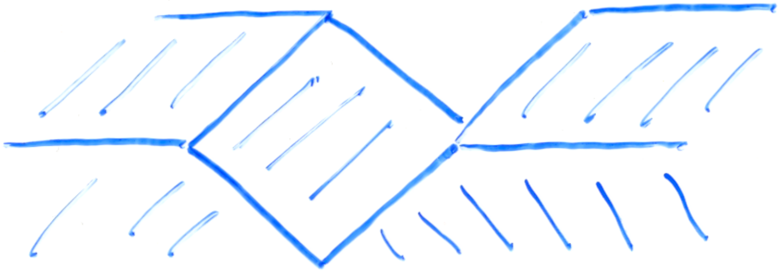
$$= \iiint dx_1 dx_2 dx_3 \, e^{-\ell(1)} \cdot e^{-\ell(2)} \cdot e^{-\ell(3)} \, S_3$$

$$S_3 \equiv S(x_{12}, x_{23}, x_{13})$$

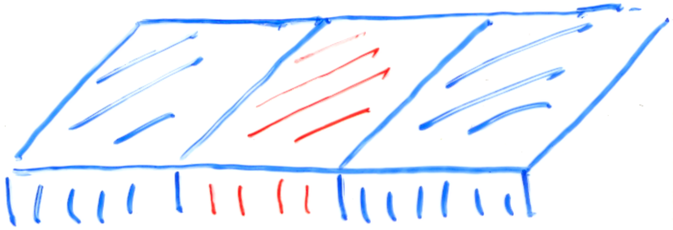
3-body interaction.

Future

- Structured, non-planar geometries



wedge



chemical stripes

Papers: PRL 04, J Phys Cond Matt 06,07

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