

The Saga of
Critical Wetting .

or

when good phase transitions
turn bad.

77 • What is Wetting?

83 • Why interesting?

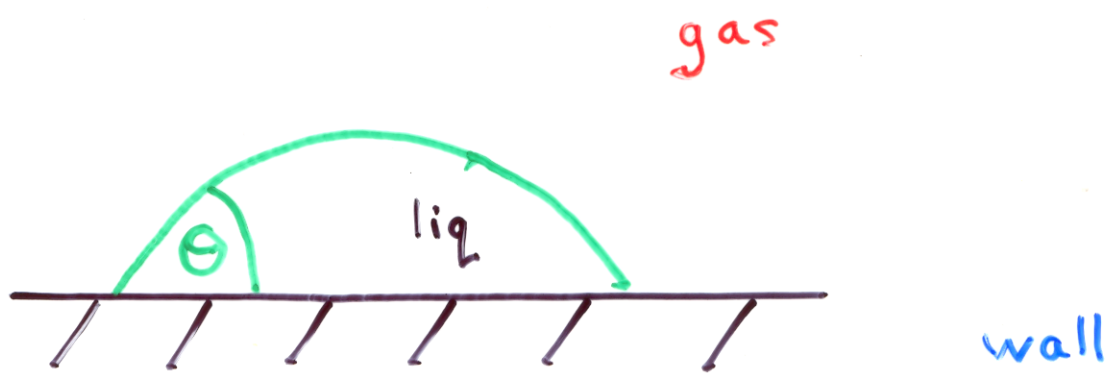
85 • Why controversial?

92 • Why situatⁿ got worse.

06 • Many-body physics to rescue!

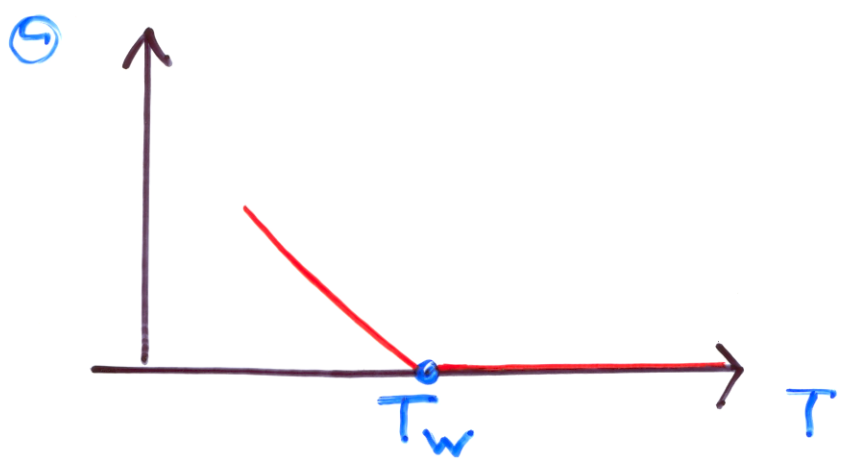
$$W = \text{[Diagram 1]} + \text{[Diagram 2]}$$

The diagram shows the equation $W =$ followed by two Feynman diagrams. The first diagram is a vertical line with two vertices, each having a horizontal line extending from it. The second diagram is a triangle with three vertices, each having a horizontal line extending from it. The two diagrams are separated by a plus sign.

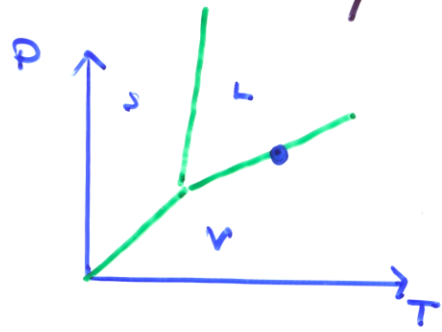


$\theta > 0$ Partial wetting

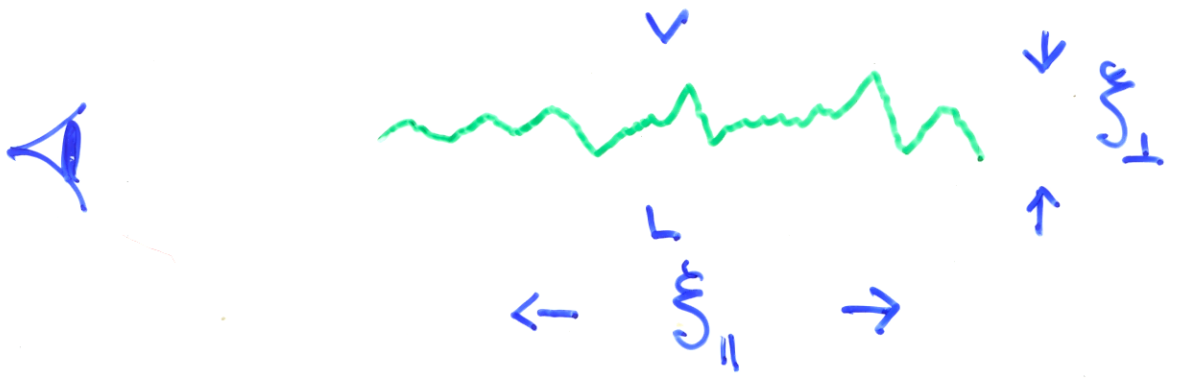
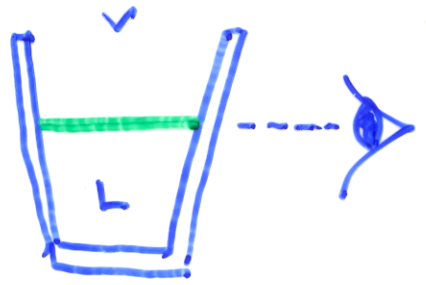
$\theta = 0$ Complete wetting



- Wetting + Filling phase transitions with interface
- Interfaces lead to critical phenomena, scaling, universality etc away from T_c .



Sit at coexistence



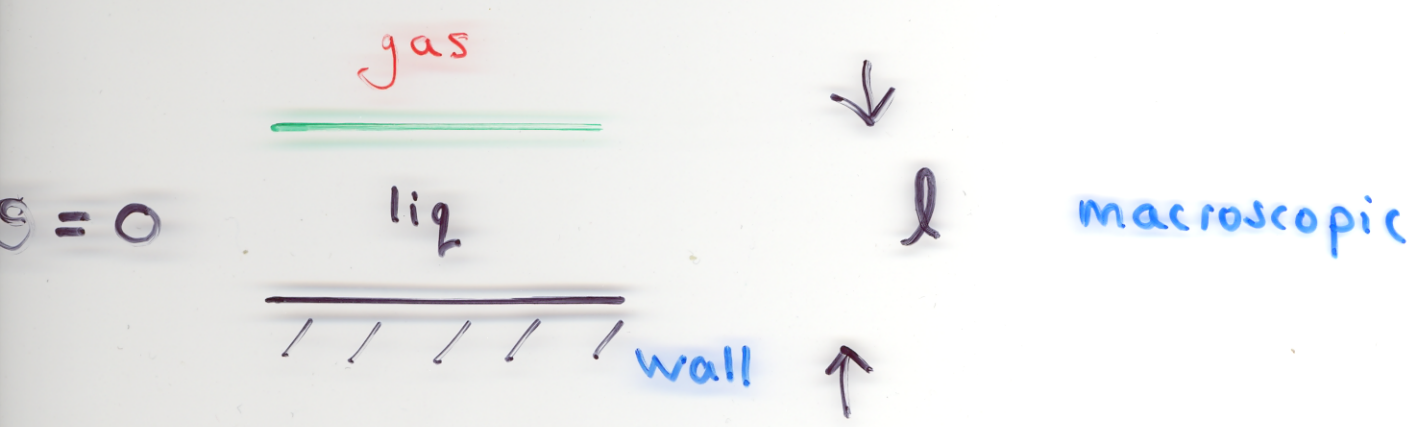
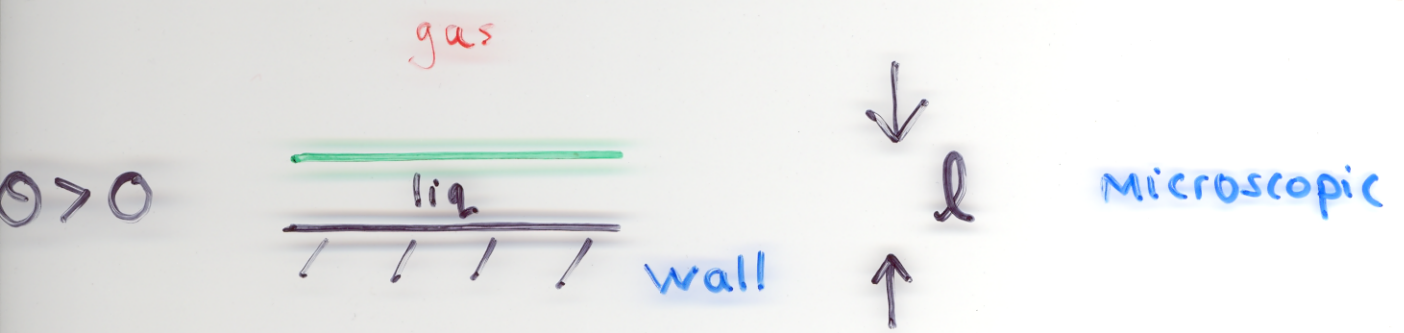
$\xi_{||}$ = parallel or transverse correlⁿ length
 ξ_{\perp} = perpendicular correlⁿ length (roughness)

In absence of pinning fields these are macroscopic

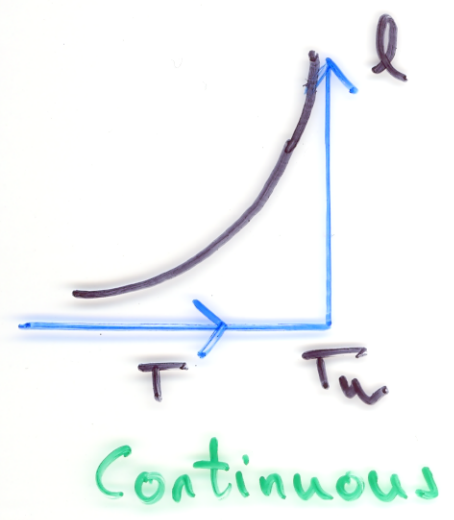
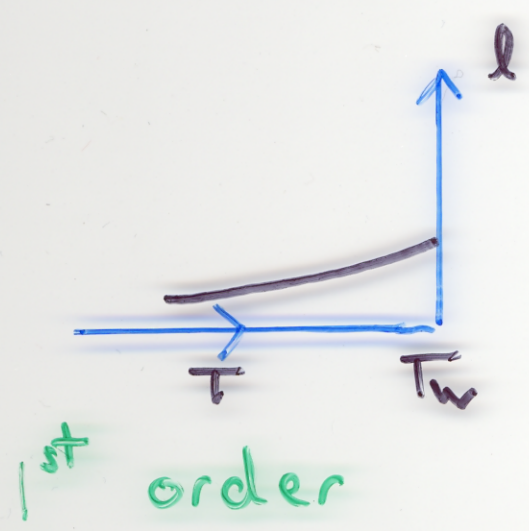
$$\xi_{\perp} = \xi_{||}^{\zeta}$$

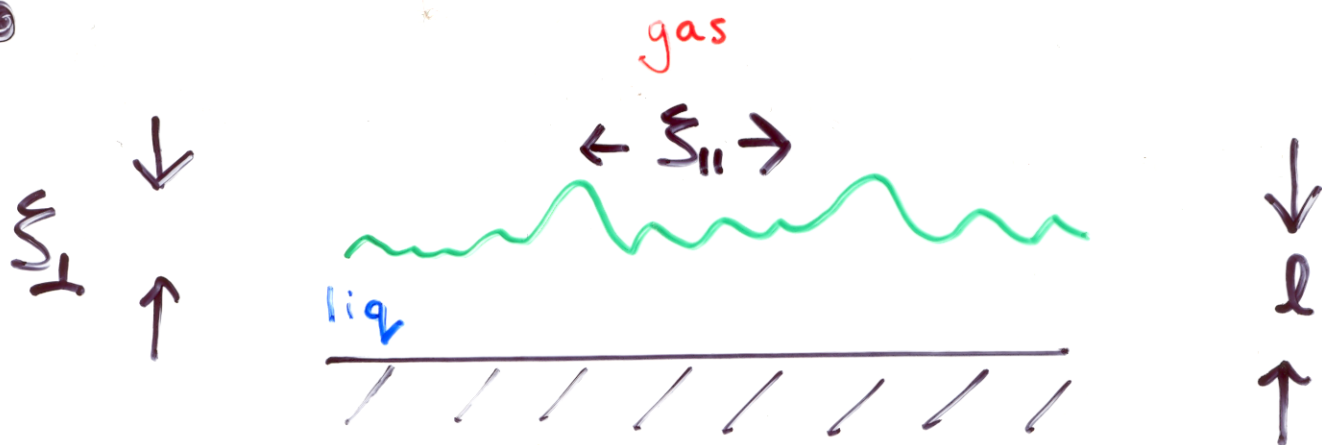
← wandering exponent

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



Two poss. types of wetting transⁿ





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

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

$$\sigma_{wg} - (\sigma_{we} + \sigma_{eg}) \sim (T_w - T)^{2-d_s}$$

$$2 - d_s = 2\nu_{||} - 2\beta_s$$

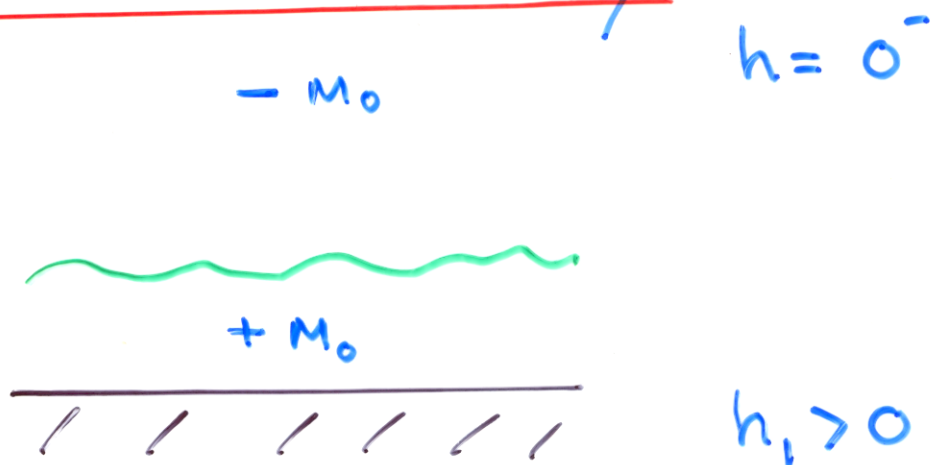
$$2 - d_s = (d-1)\nu_{||}$$

etc....

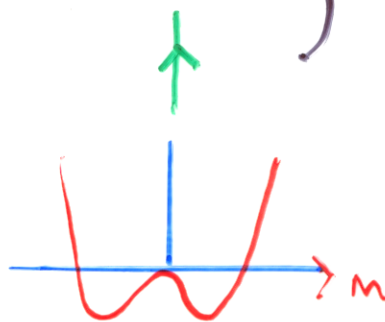
What are they?

Mean-field Theory

Magnetic
language



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



Minimise to get

(NF 82, BHL 83)

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

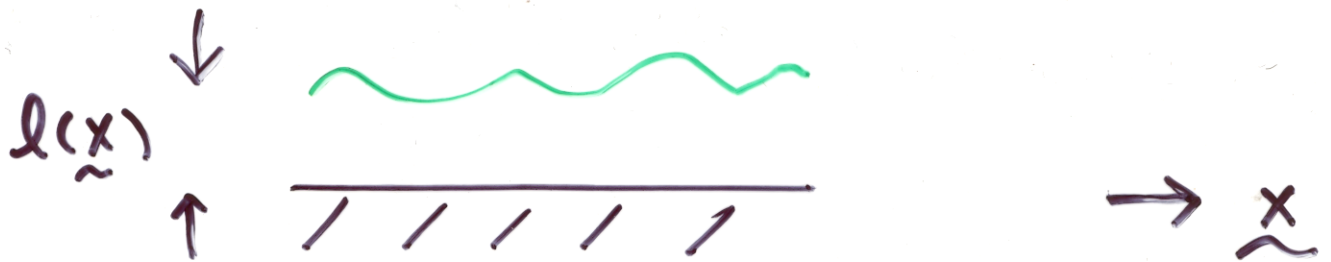
also

$$\alpha_s = 0$$

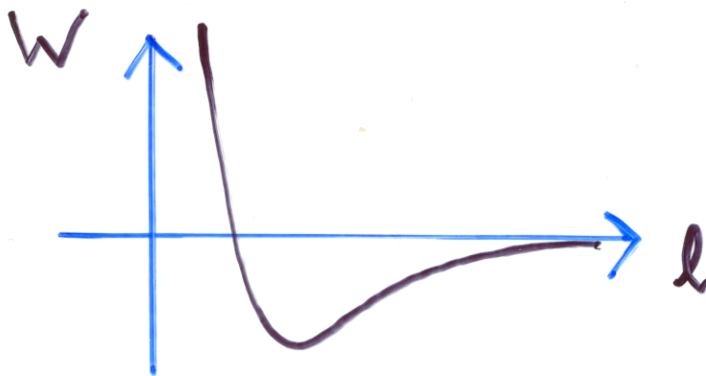
$$v_{11} = 1$$

$$d^* = 3$$

Interfacial Models



$$H_I[l] = \int_{\tilde{x}} dx \left\{ \frac{\sigma_{eg}}{2} (\nabla l)^2 + W(l) \right\}$$



$$W = -a e^{-l} + b e^{-2l} + \dots$$

\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

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

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

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

However Binder et al (1985-)

see NONE of this.

Good news : transition exists

Bad news : $\nu_{||}^{sim} \sim 1$

Mean-field!

Theory of Fisher + Jin

(92)

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

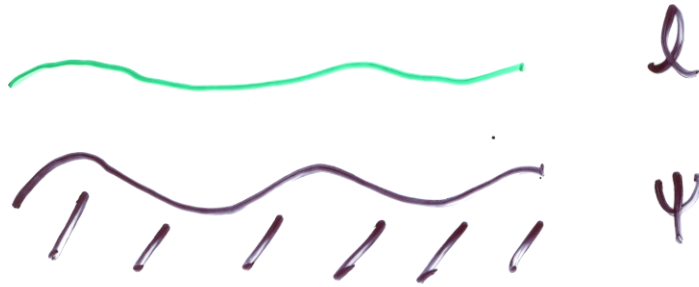
$$H_I[\ell] = \int_{\tilde{x}} dx \left\{ \frac{\sigma(\ell)}{2} (\nabla \ell)^2 + W(\ell) \right\}$$

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

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

- RG of FJ model destroys
transition !

Non-locality



$$H_{NL}[l, \psi] = \sigma_{eg} A + W[l, \psi]$$

$$W = -a \text{ [diagram of two vertices connected by two arcs]} + b \text{ [diagram of two vertices connected by three arcs]} + \dots \dots \dots \text{zig-zags}$$

e.g.

$$\text{[diagram of two vertices connected by two arcs]} \equiv \int ds_\psi \int ds_e K(r)$$

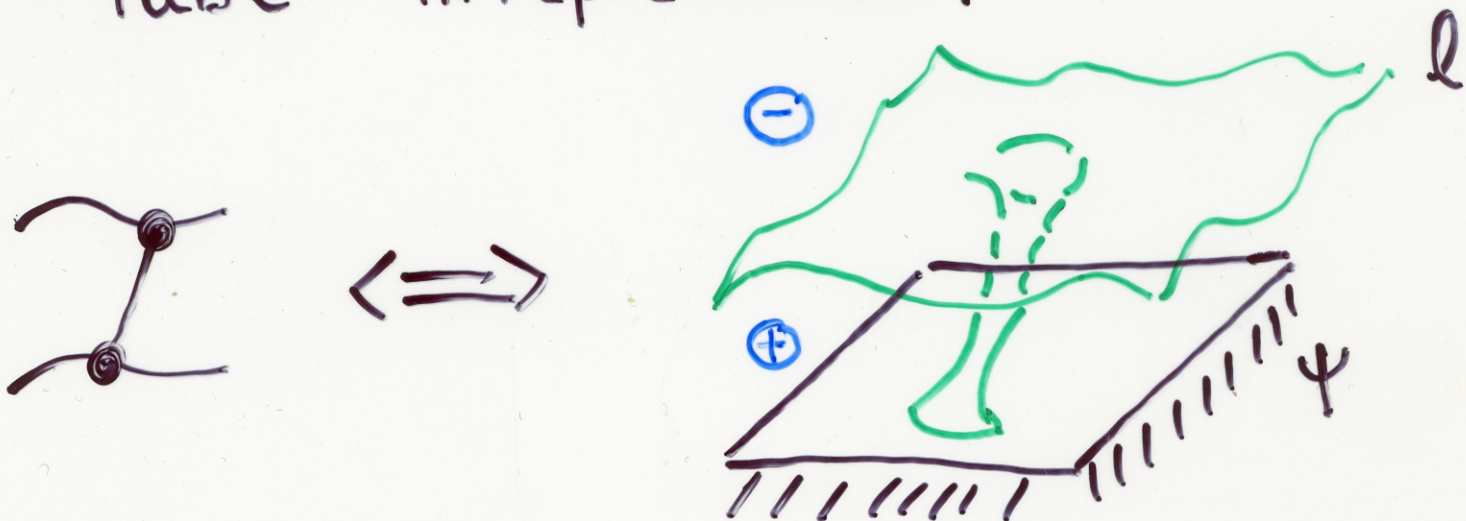
$$\uparrow$$

$$\frac{e^{-r}}{2\pi r}$$

11

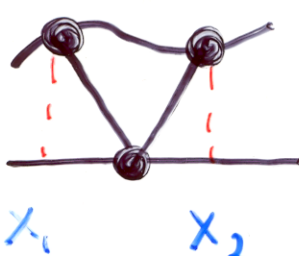
$$\begin{aligned} &= \text{Area } e^{-l} \\ &= \text{Area } e^{-2l} \end{aligned} \left. \vphantom{\begin{aligned} &= \text{Area } e^{-l} \\ &= \text{Area } e^{-2l} \end{aligned}} \right\} \checkmark W(l)$$

"Tube" interpretation.



Hidden symmetries, exact sum-rules \checkmark

RG of wetting revisited




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

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

2-body interaction

"Long-ranged" \sqrt{l}

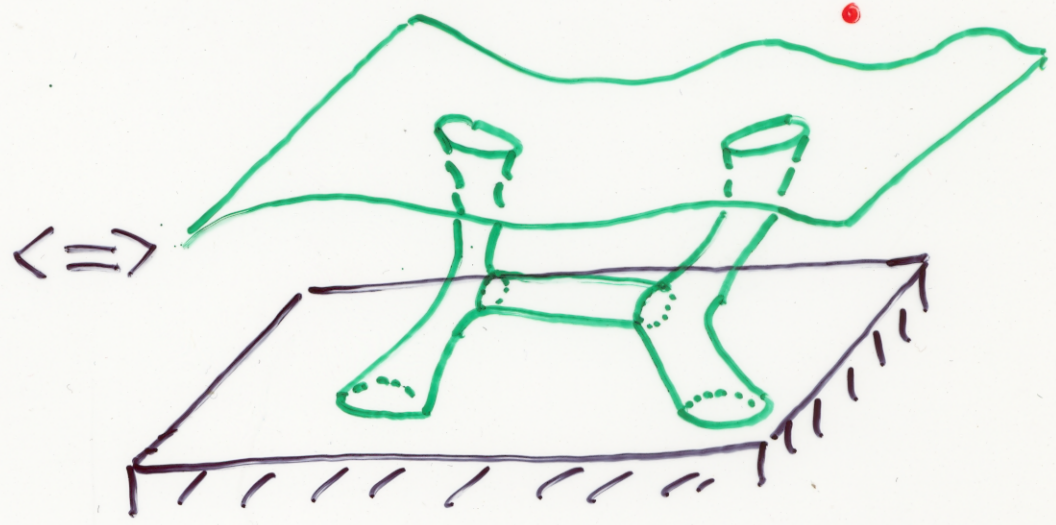
- 1) Phase transition not destroyed
- 2) Asymptotic singularities non-universal
- 3) Huge decrease in critical regime

$$G(1,2) = \int_{z_1, z_2}^z$$


Other diagrams

• $W_{FJ}(l) = -ae^{-l} + be^{-2l} + a^2le^{-2l} + \dots$

?



• Tricritical wetting ($a=b=0$)



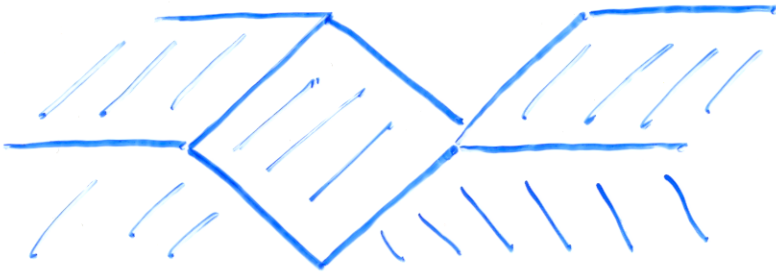
$$= \iiint dx_1 dx_2 dx_3 e^{-l(1)} \cdot e^{-l(2)} \cdot e^{-l(3)} S_3$$

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

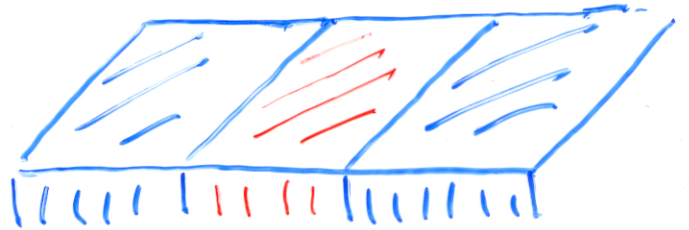
3-body interaction.

Future

- Structured, non-planar geometries



wedge



chemical stripes

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

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