Metastability in Gauge Mediation

work done in coll. with Emilian Dudas
and Stephane Lavignac

J. Parmentier GDR Terascale- Saclay 29/03/2010

(A few words about...)

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A few words on gauge mediation

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MSSM

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$$X = X_0 + \theta^2 F_X$$

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+ messengers $\phi\tilde{\phi}$

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Introduction — A few words on gauge mediation

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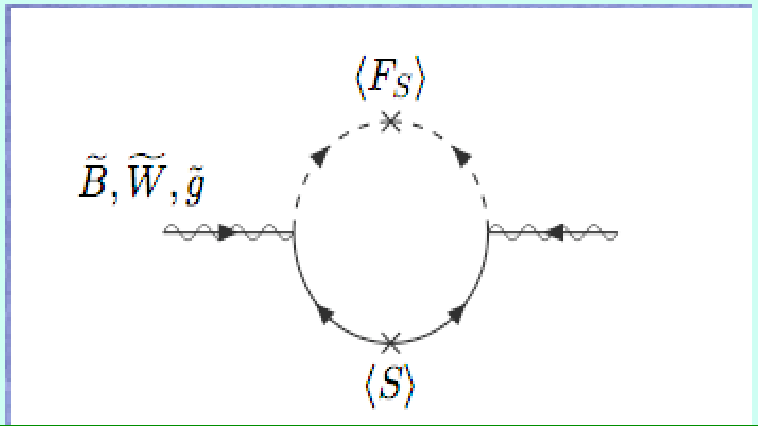
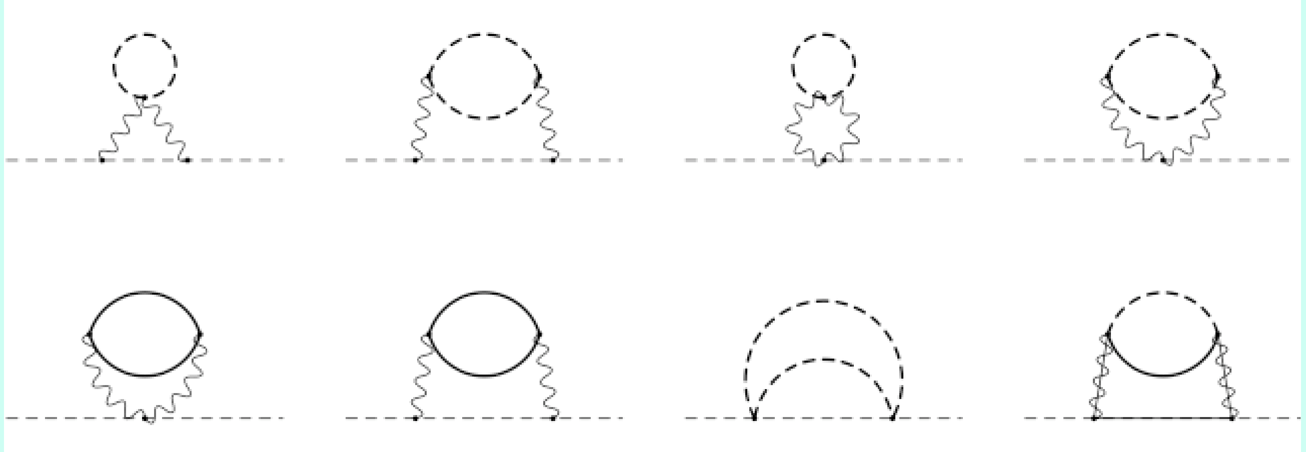
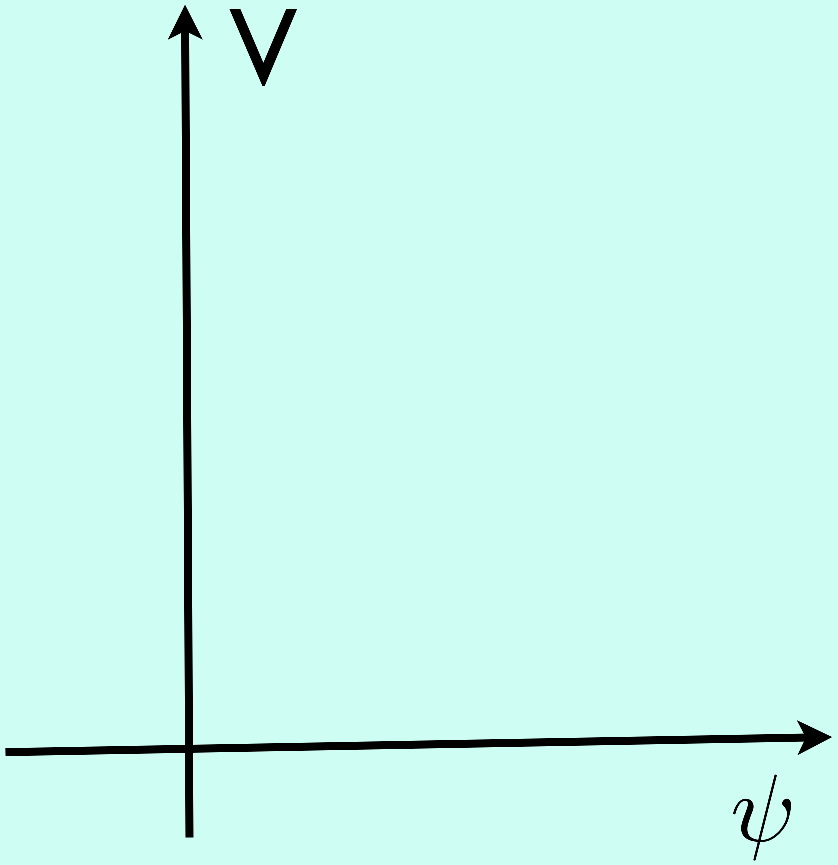


$$M_a(\mu) \;=\; \frac{\alpha_a(\mu)}{4\pi} N_m \sum_i 2T_a(R_i)\,\frac{F}{M}$$



$$m_\chi^2 \;=\; 2\,N_m \sum_a C_\chi^a \left(\frac{\alpha_a}{4\pi}\right)^2 \sum_i 2T_a(R_i) \left|\frac{F}{M}\right|^2$$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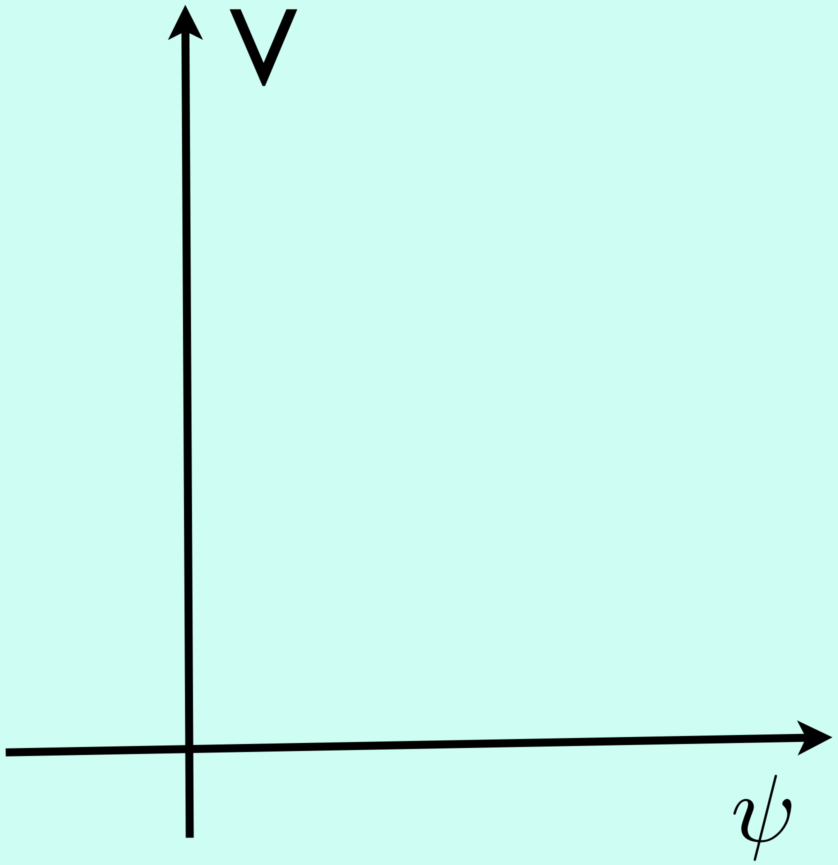
Stability and Gauge Mediation



$$V = \sum |F_\psi|^2$$

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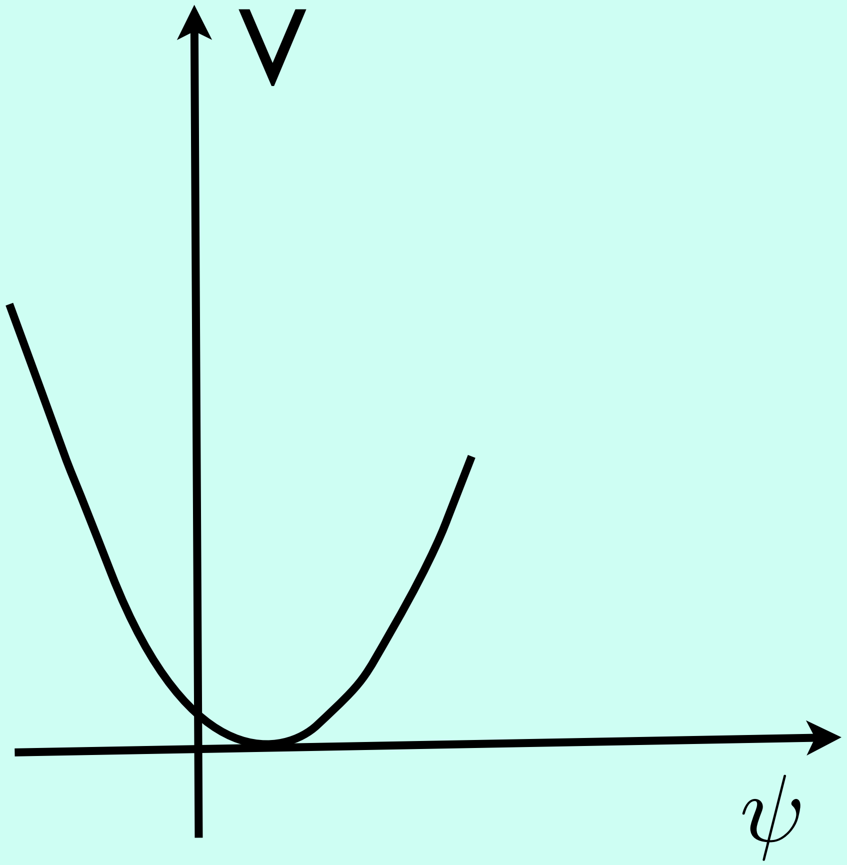

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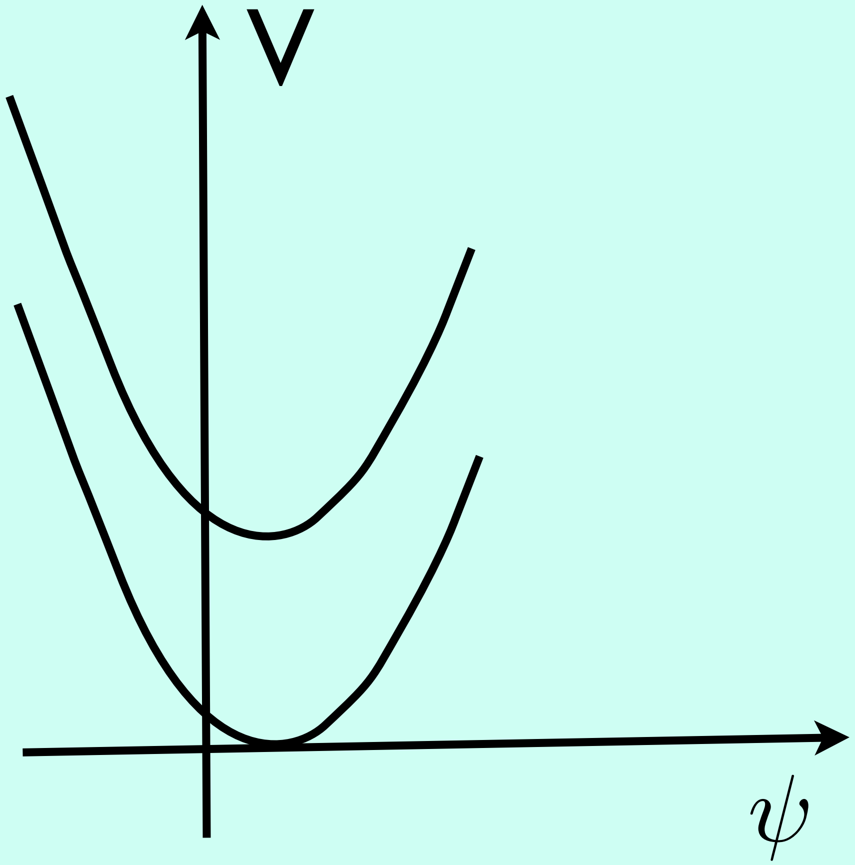
SUSY

Stability and Gauge Mediation



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$$V = \sum |F_\psi|^2$$

$$\frac{\partial W}{\partial \psi_a} \neq 0$$

$$X = X_0 + \theta^2 F_X$$

constraints
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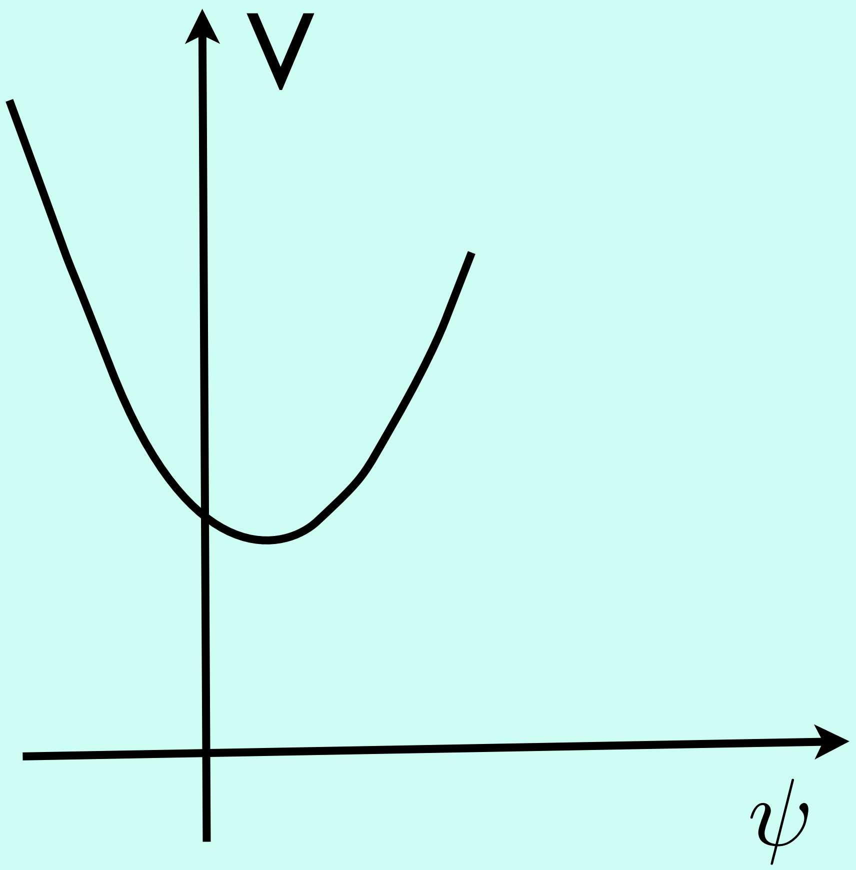

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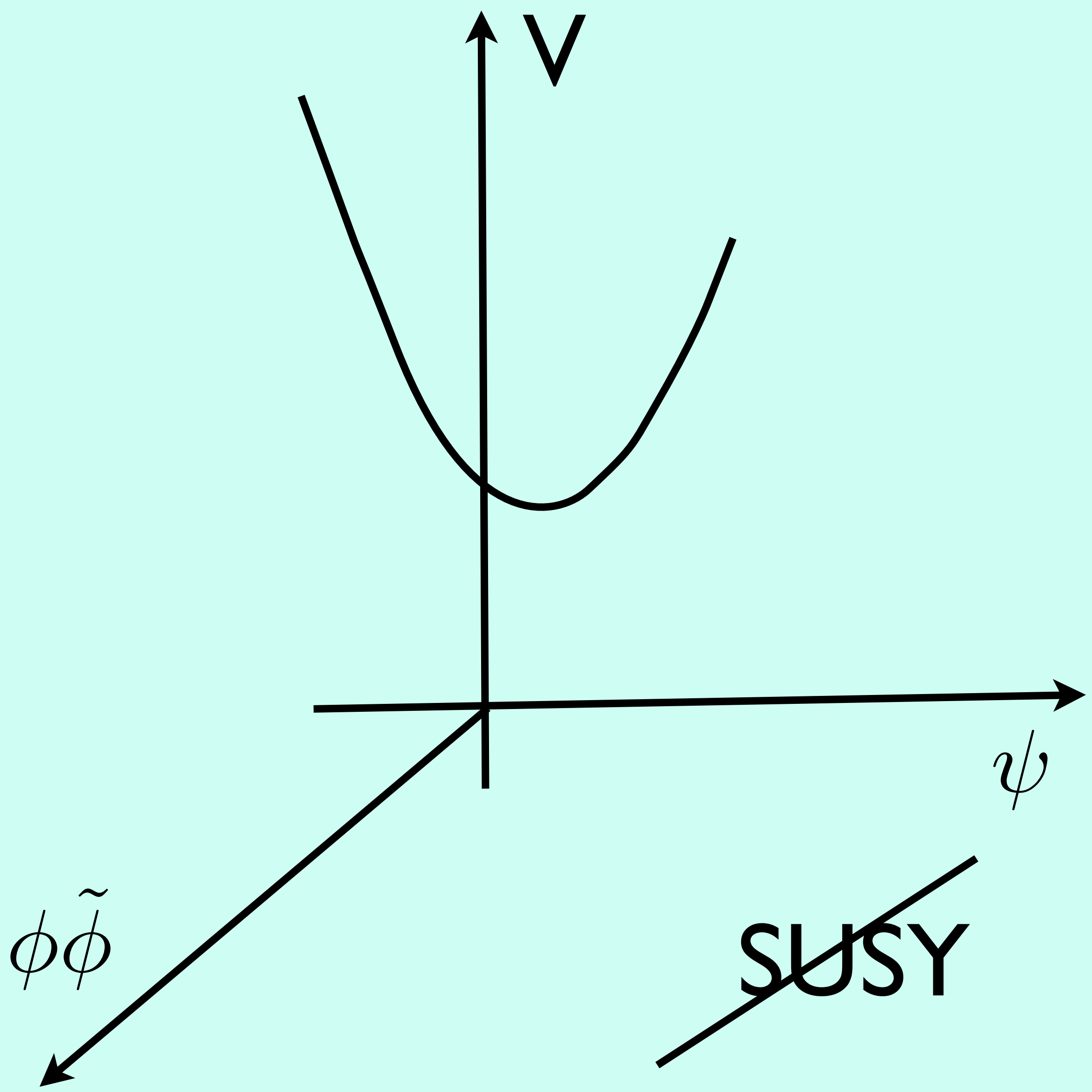

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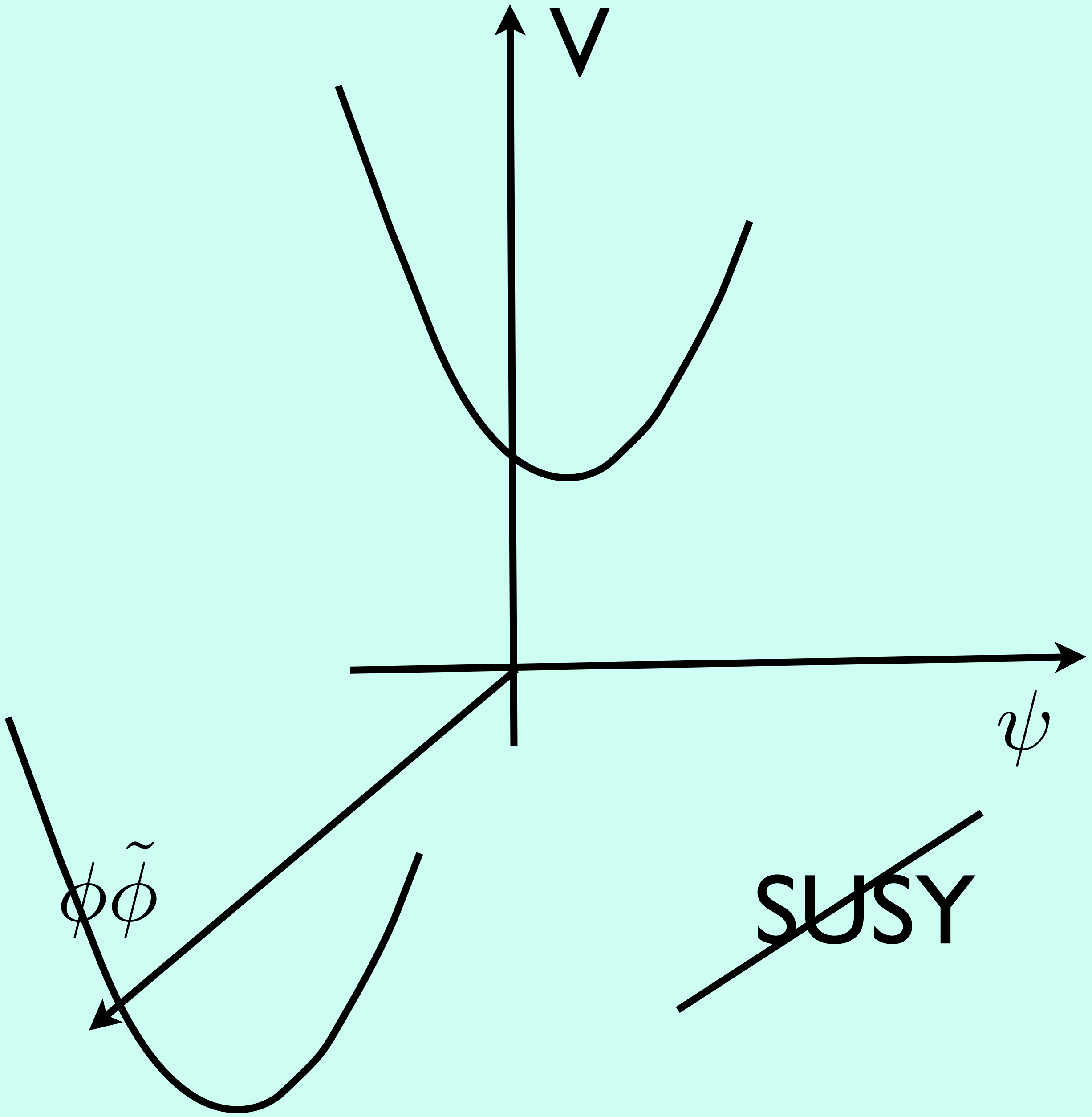

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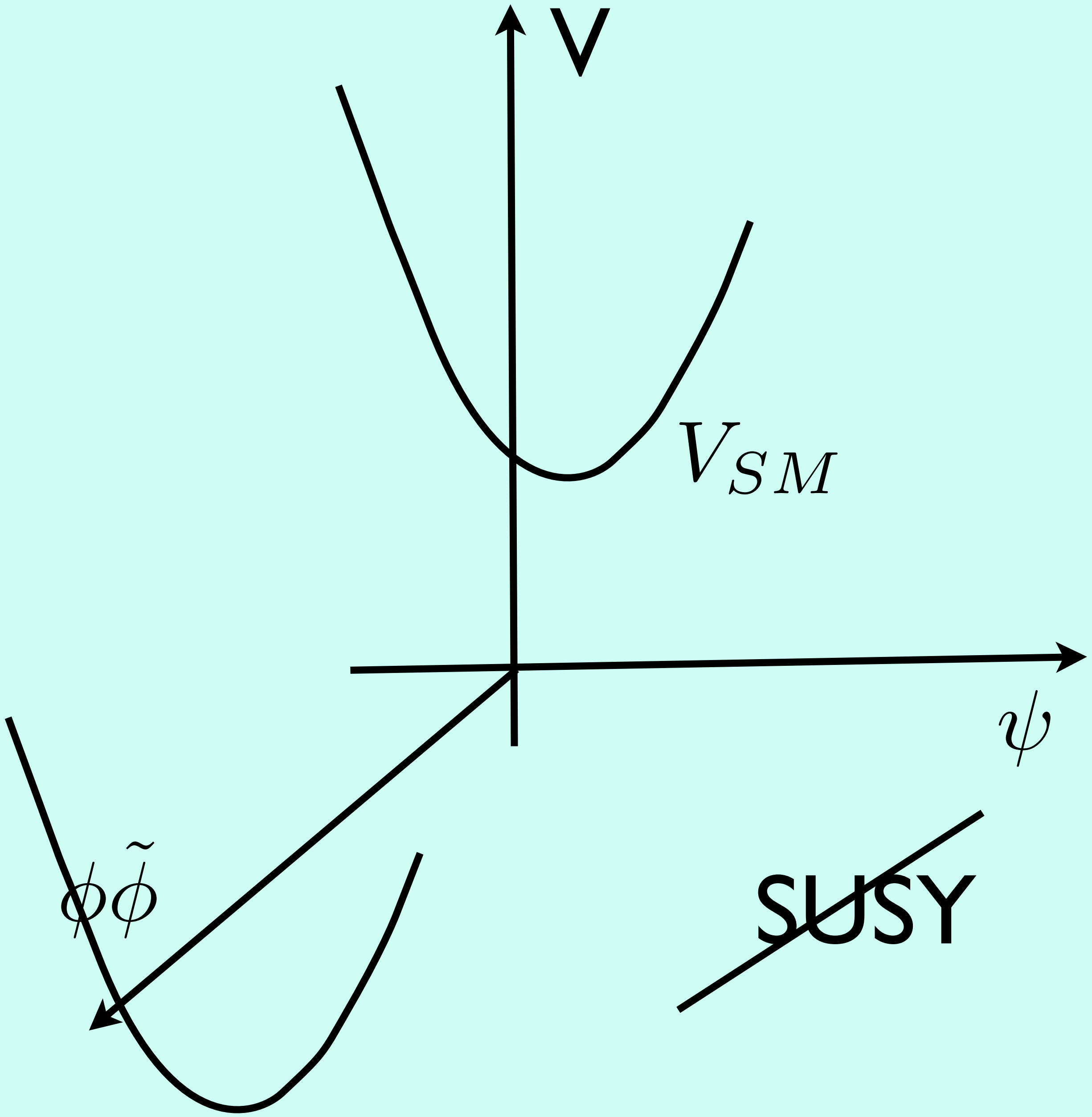

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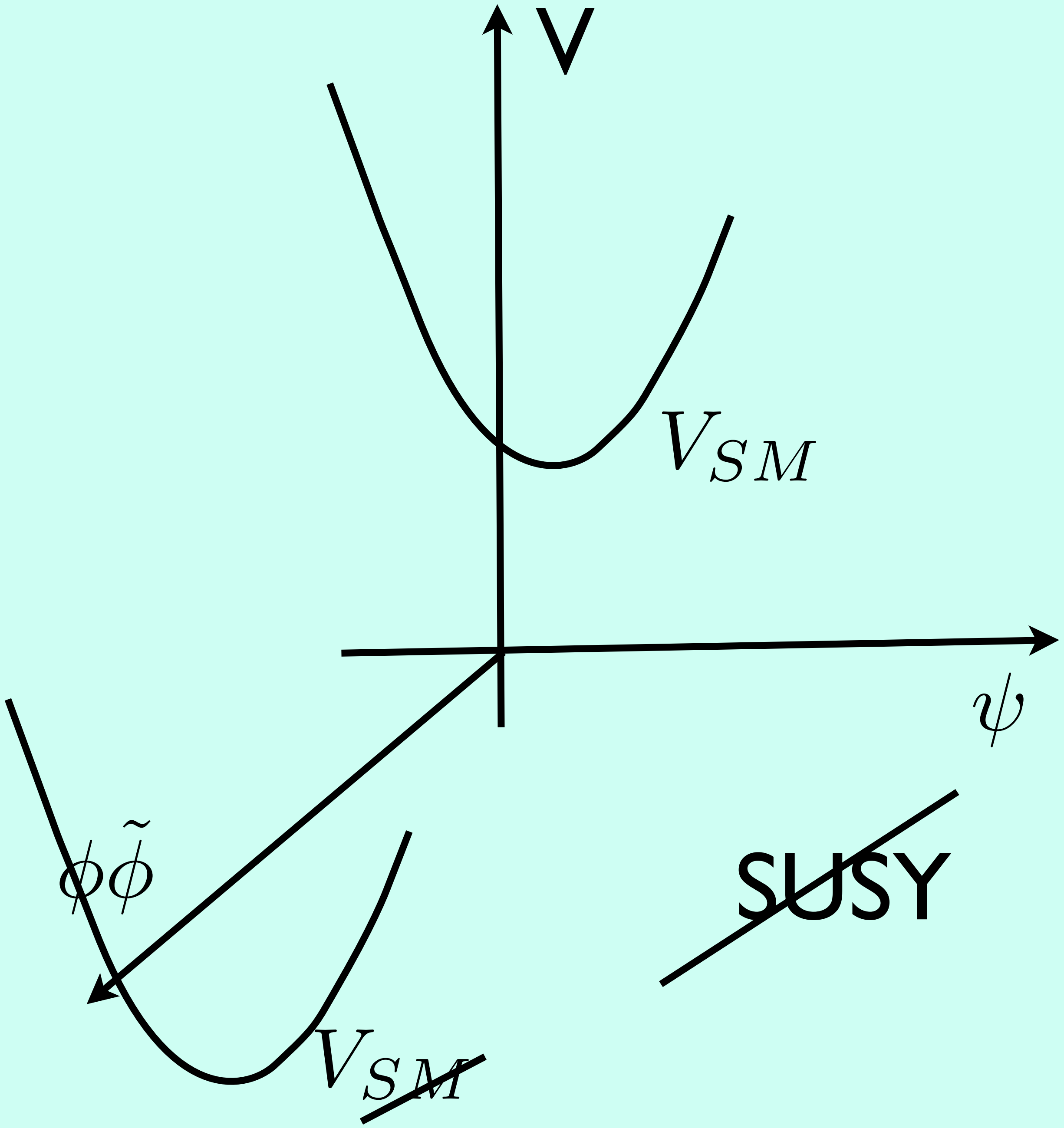

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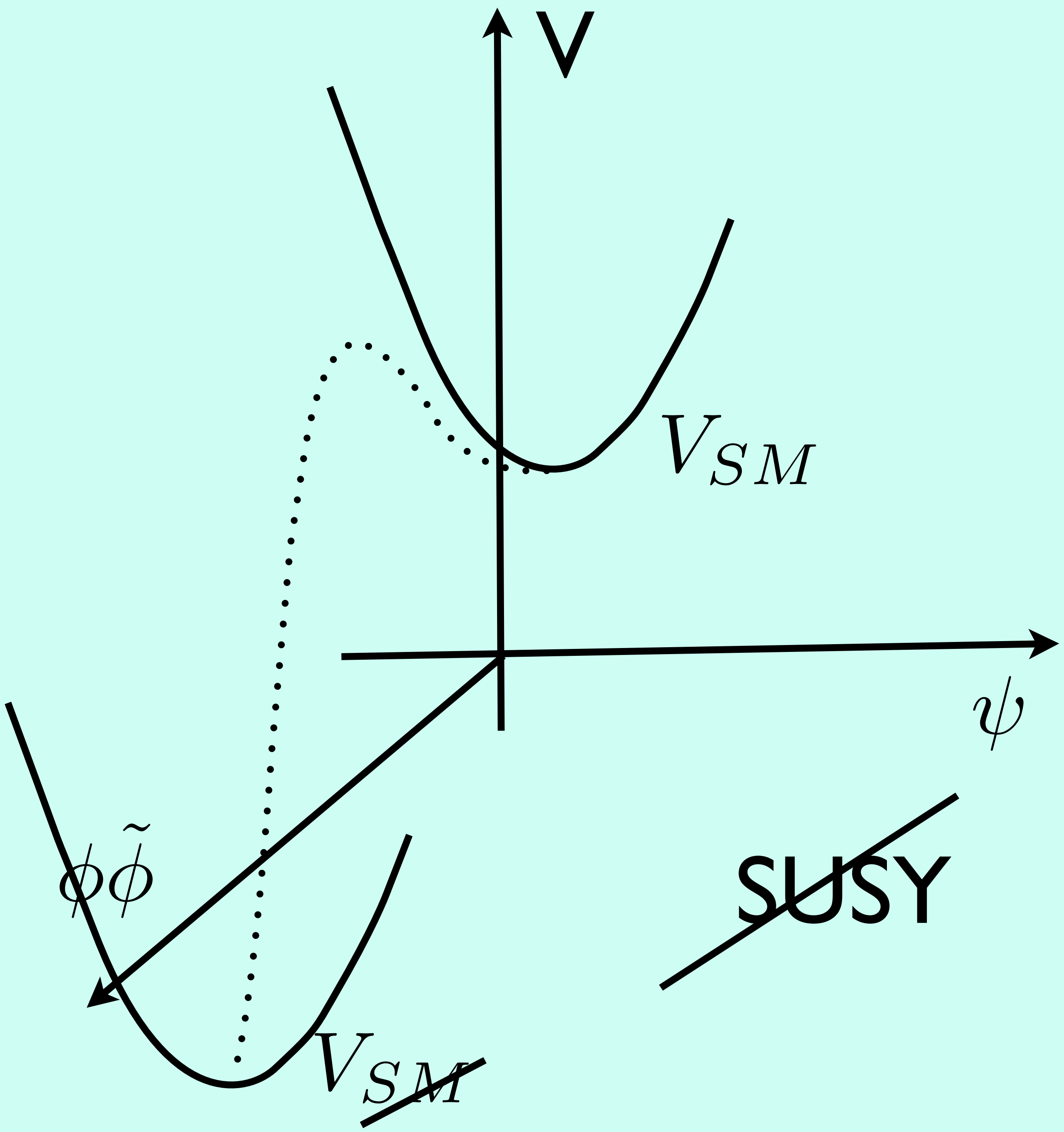

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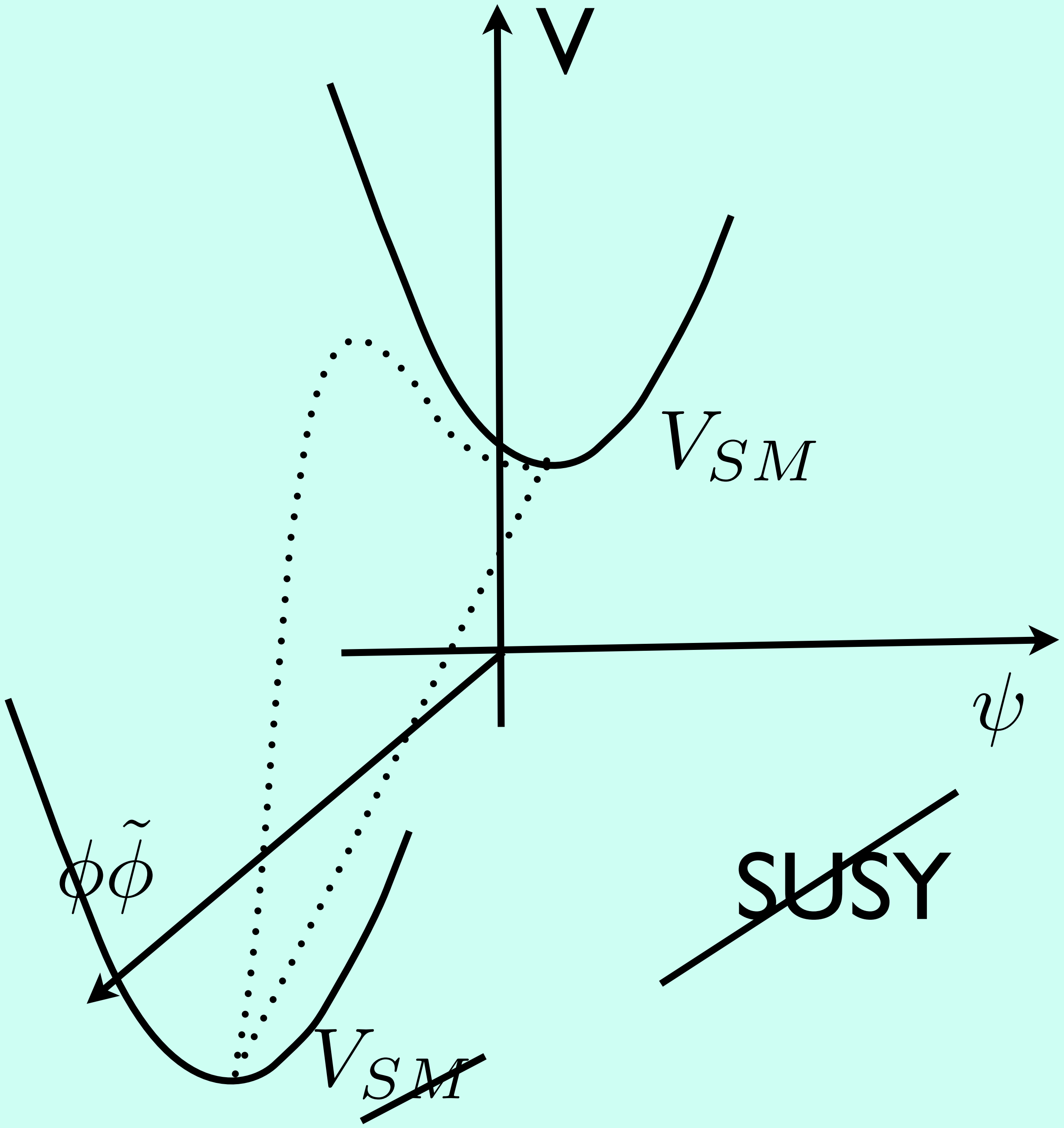

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O’R and Gauge Mediation

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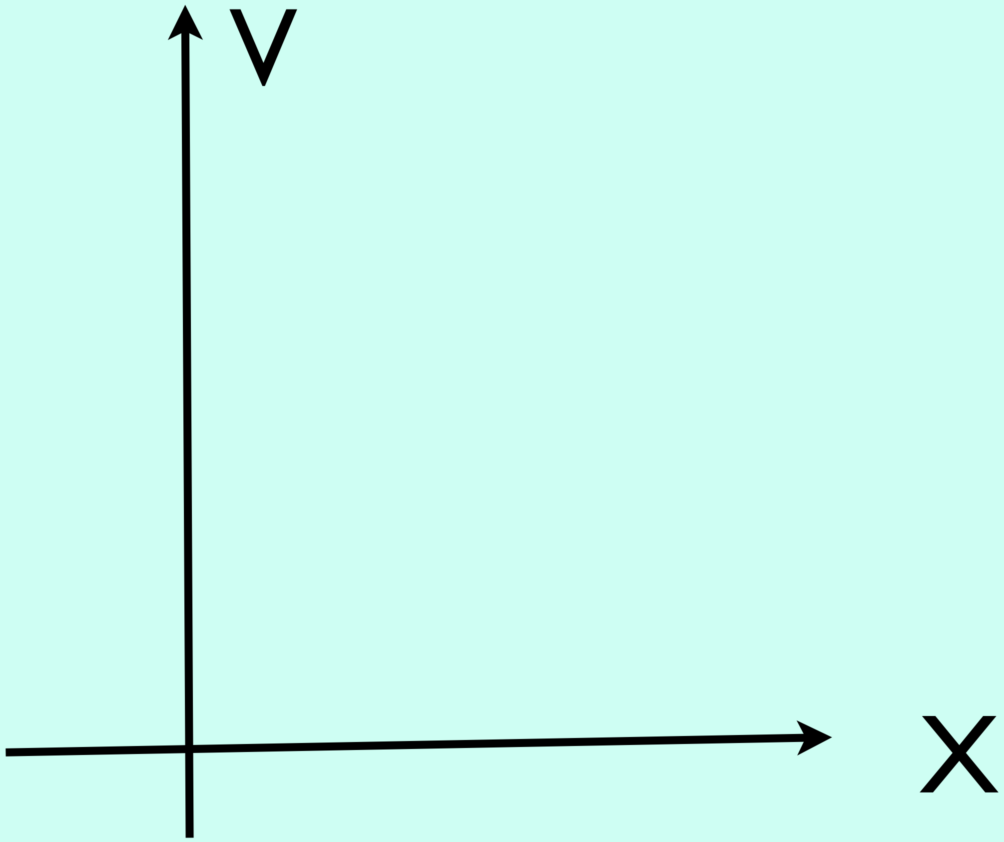

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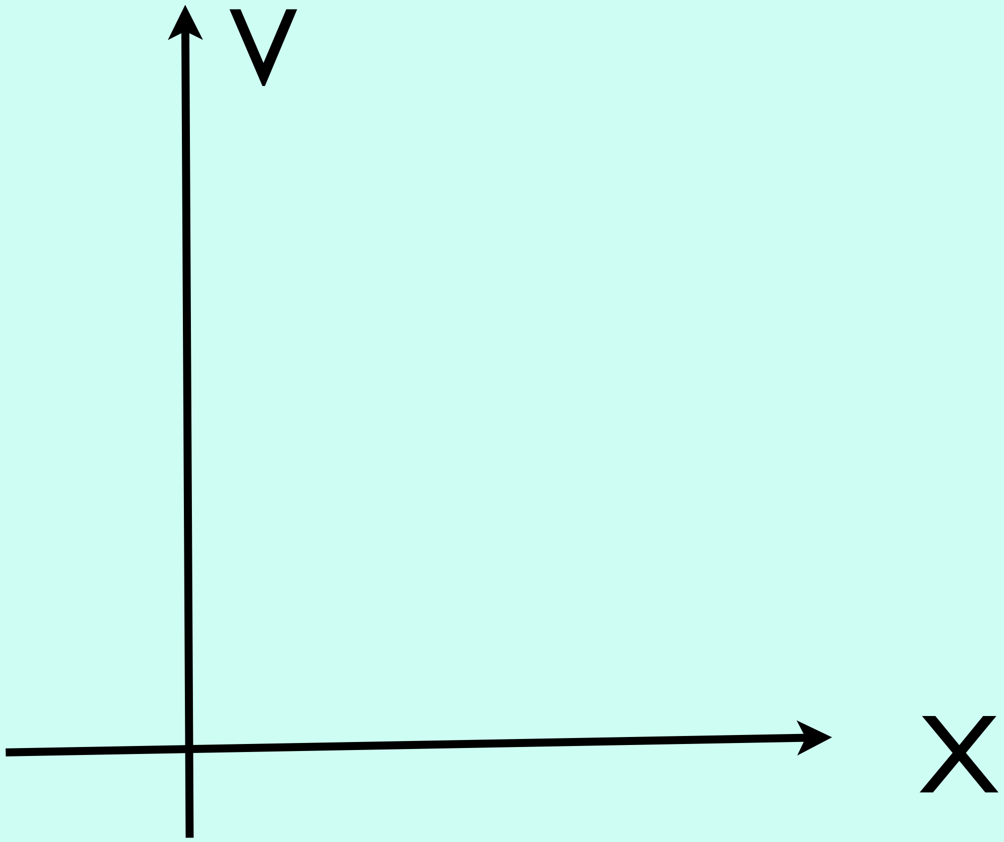

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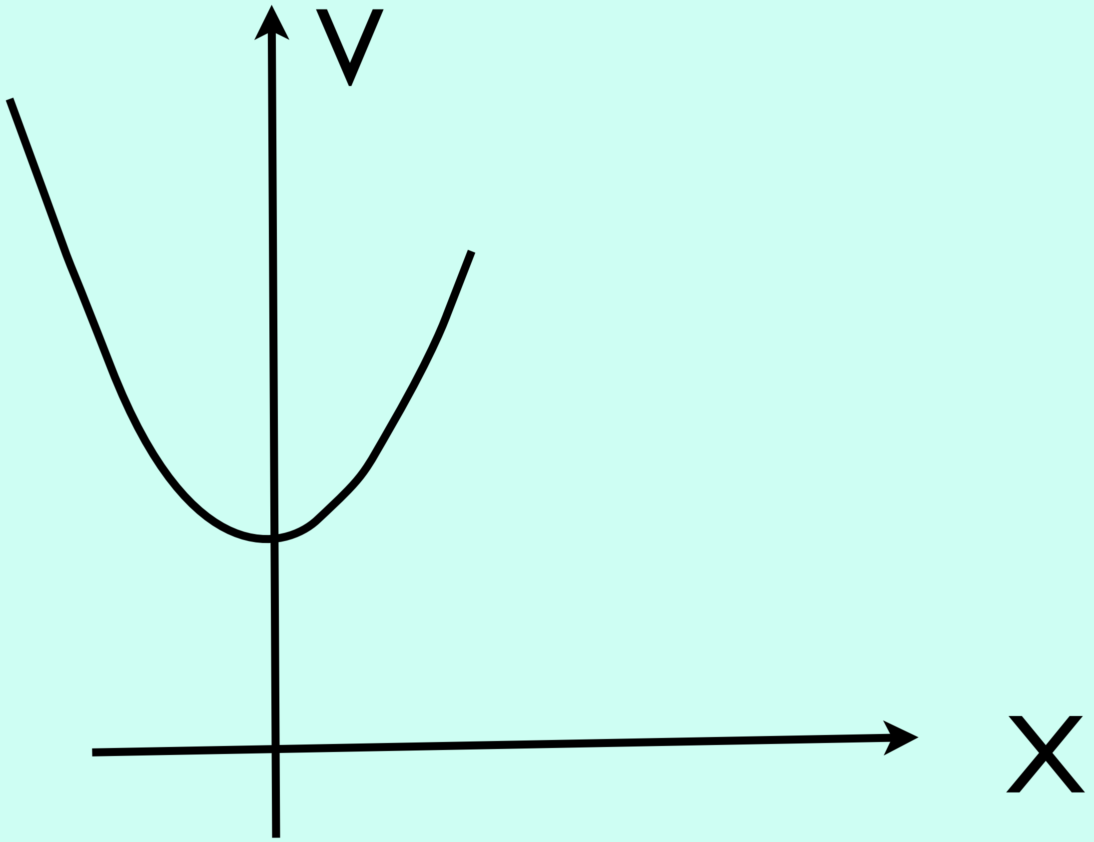

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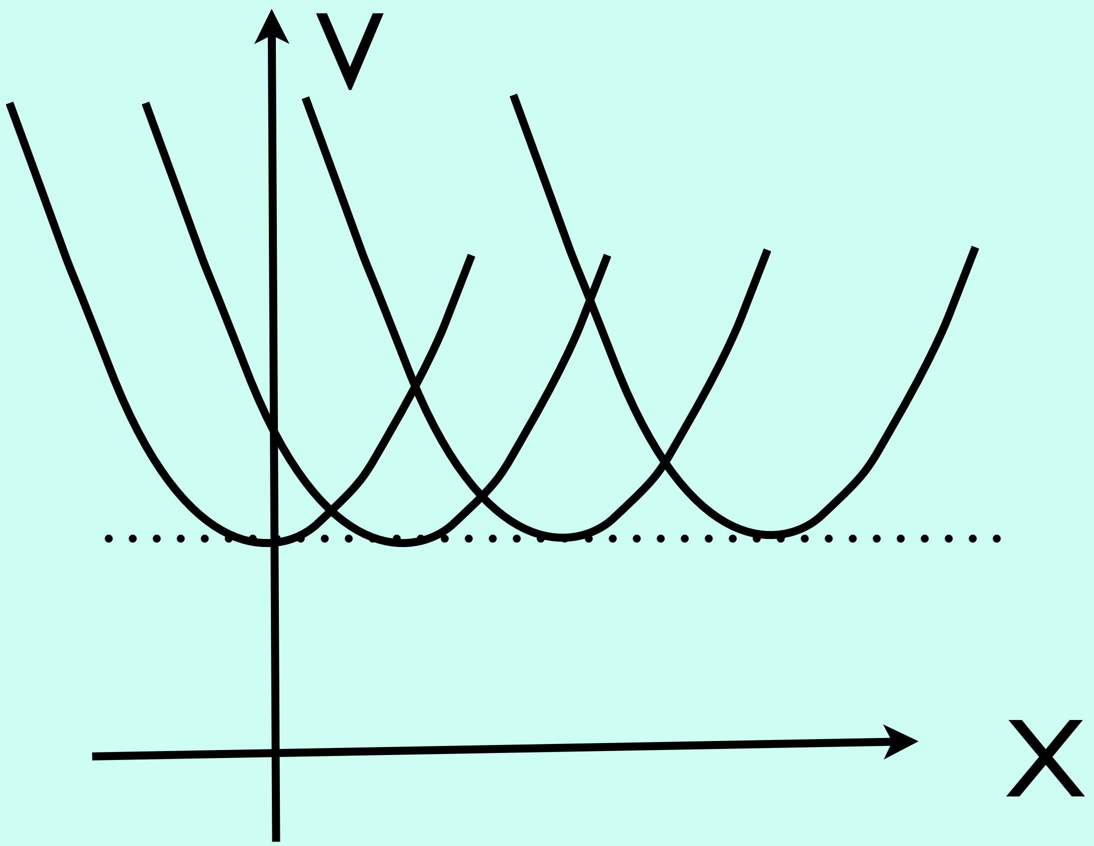

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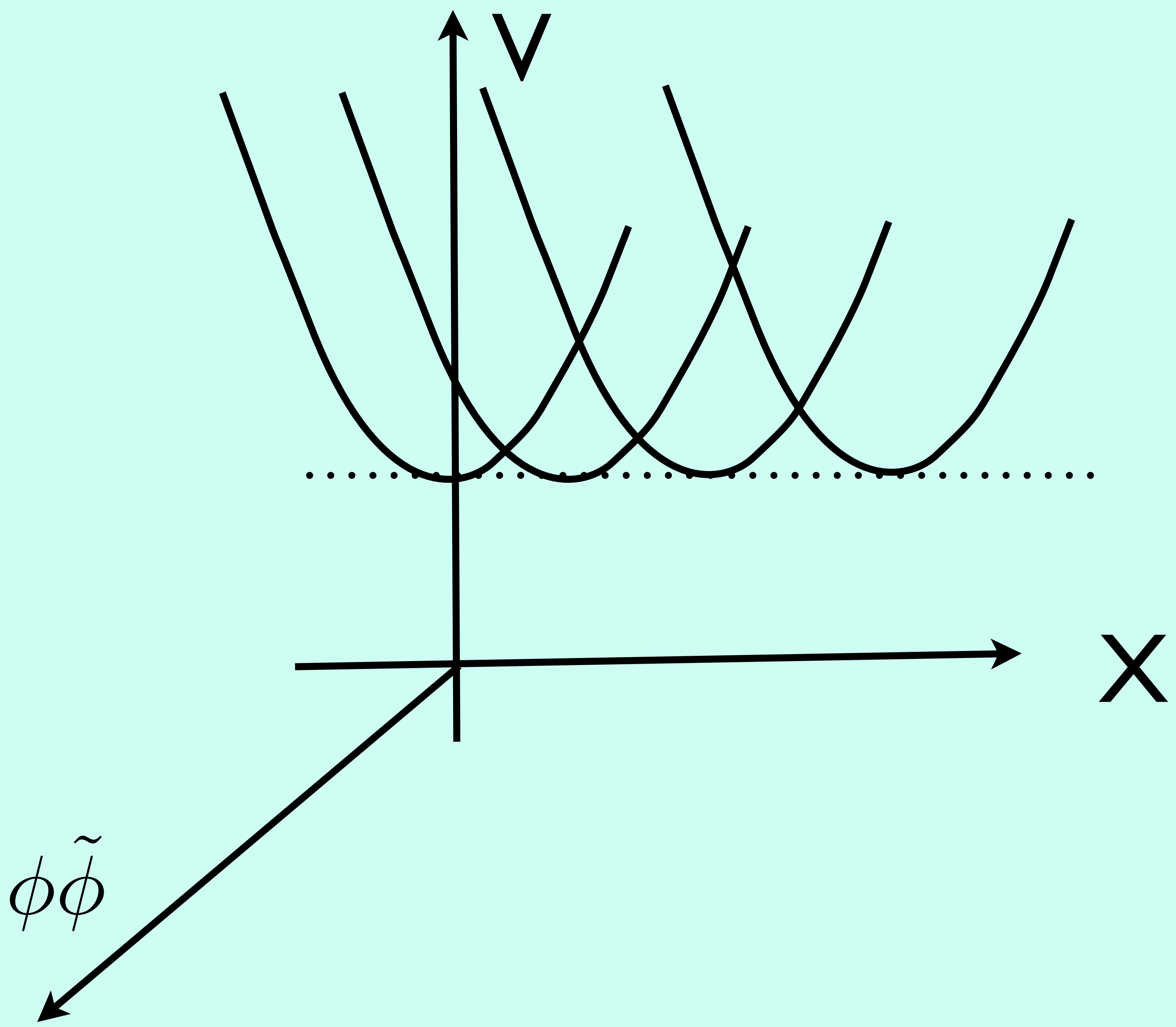

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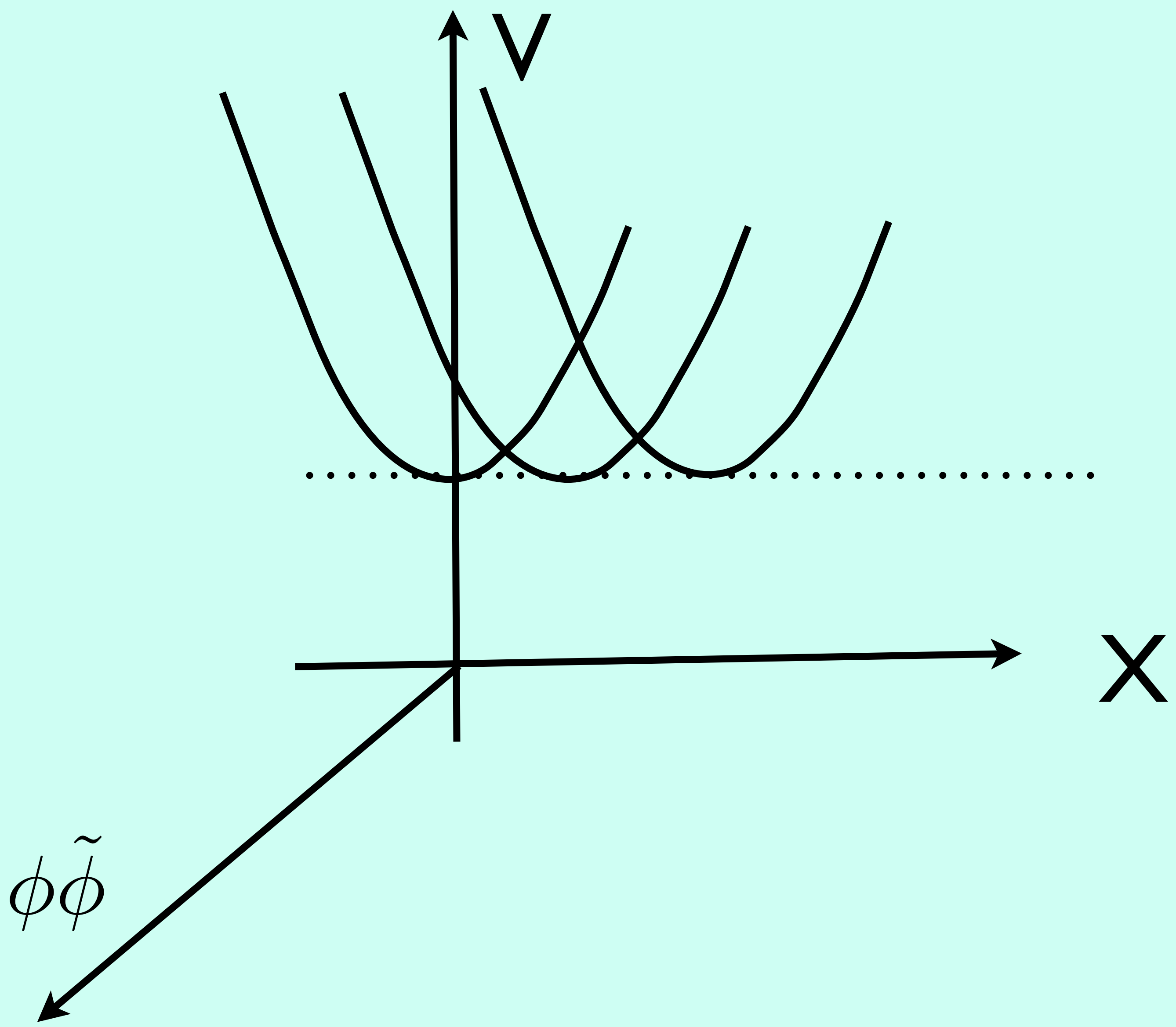

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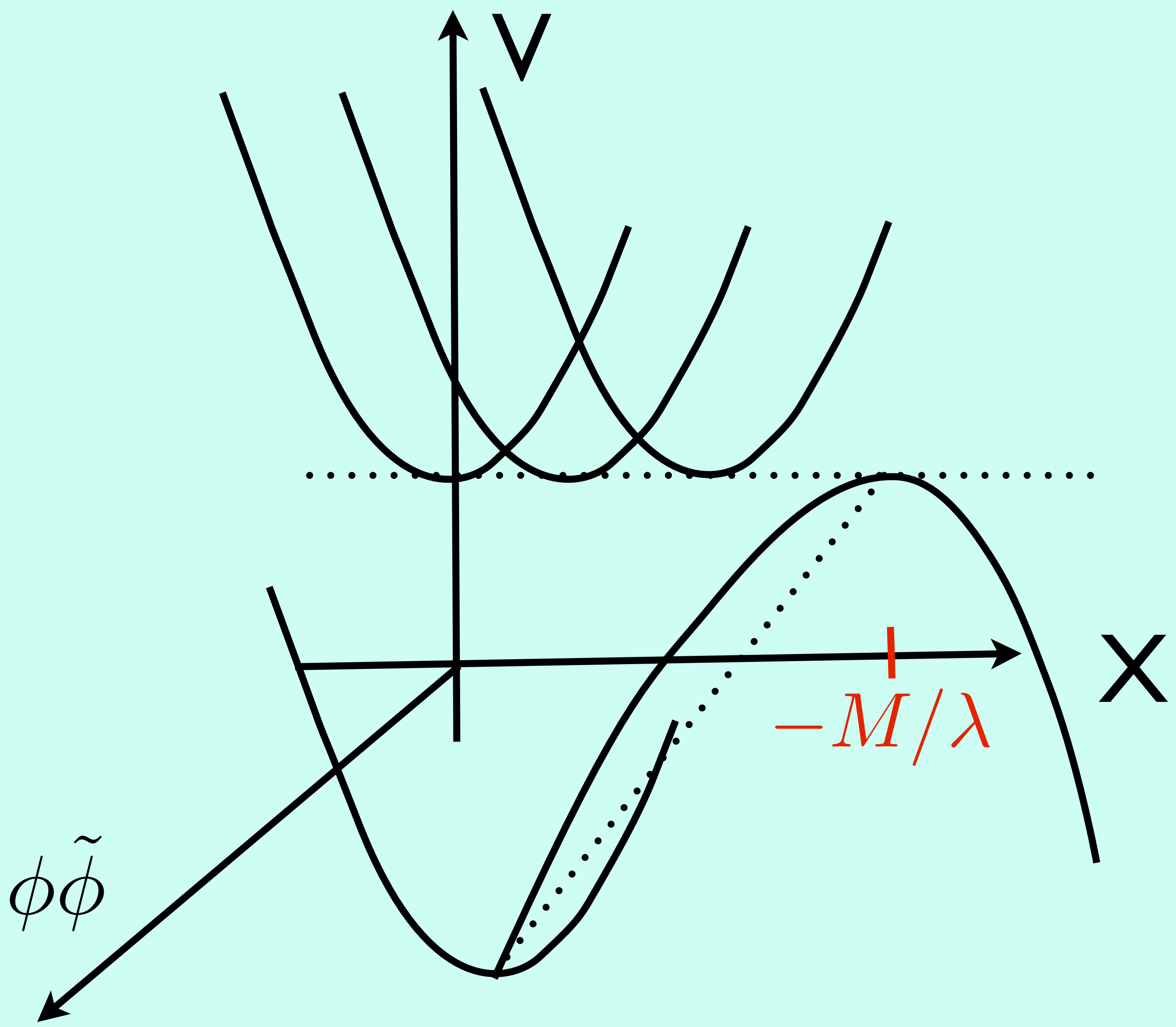

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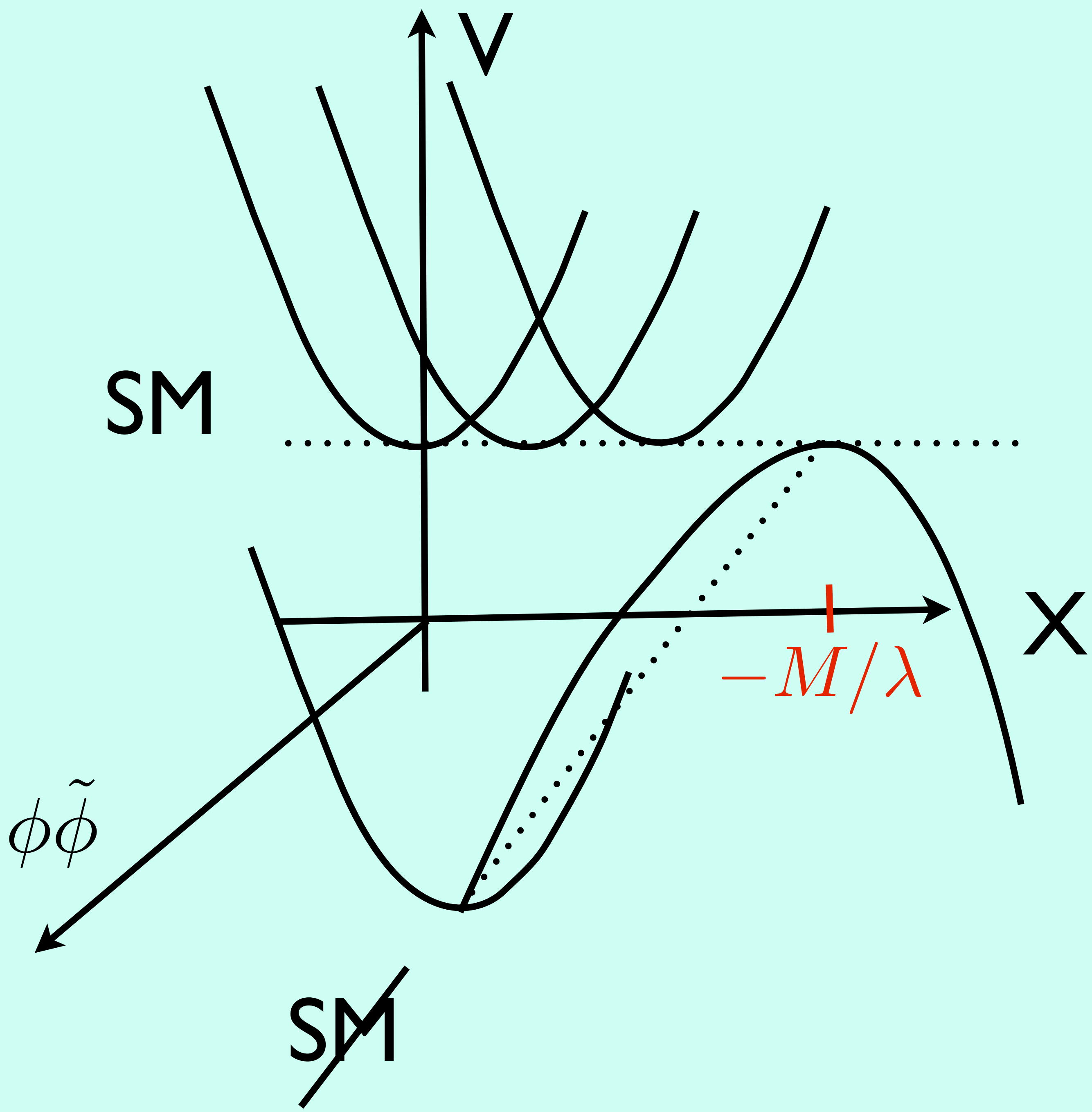

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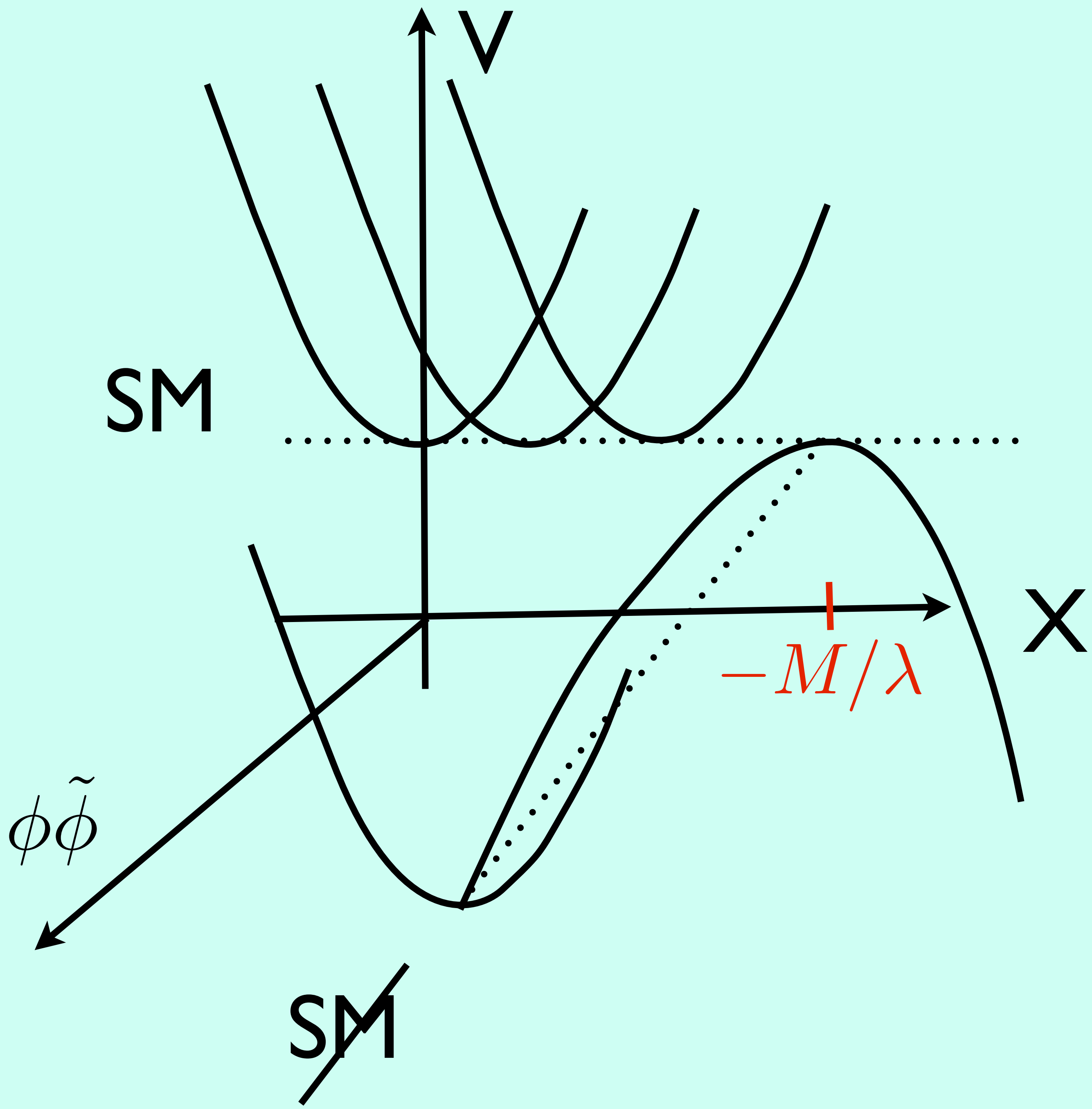

Tree level :
flat directions
+ instability

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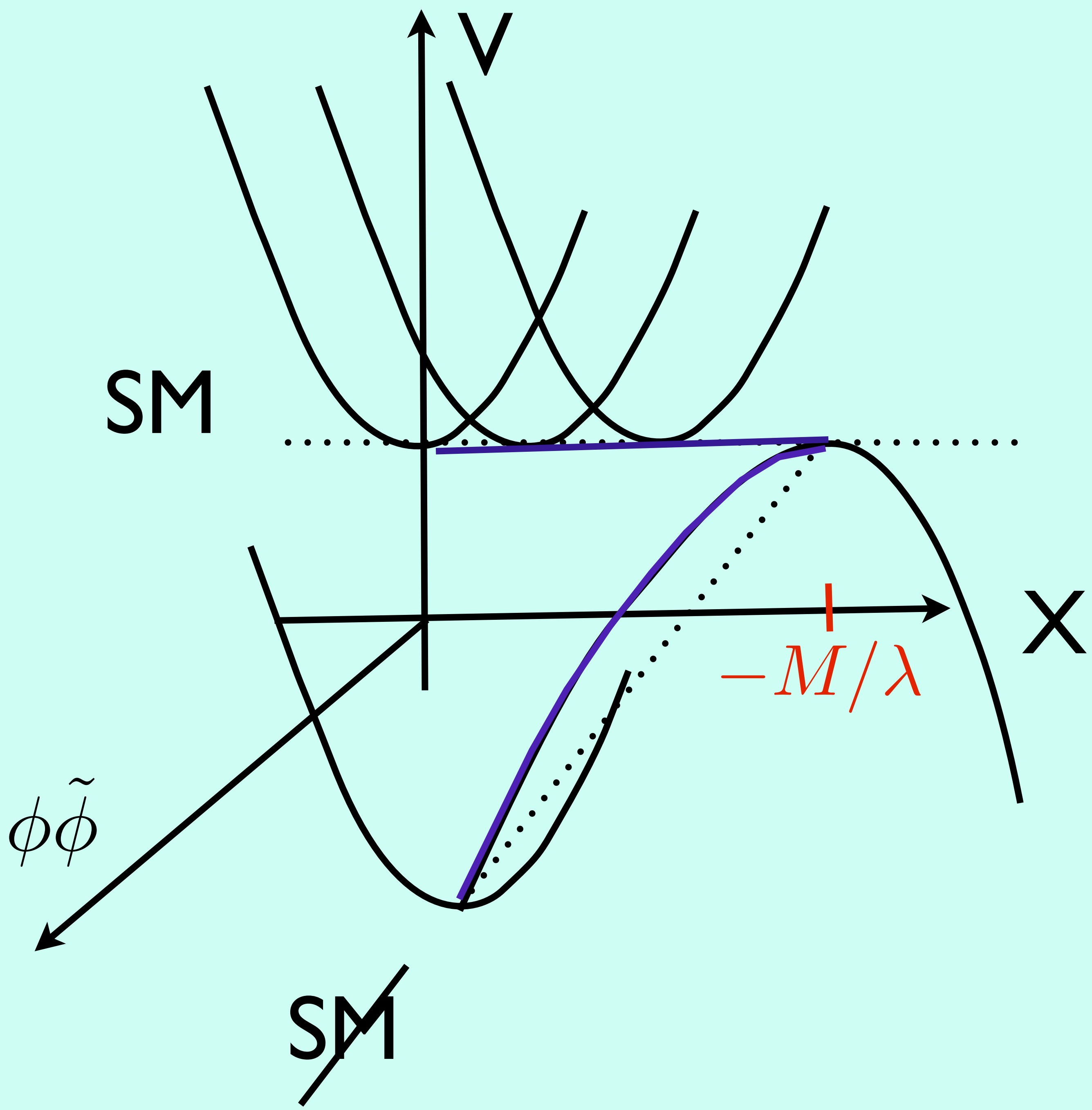

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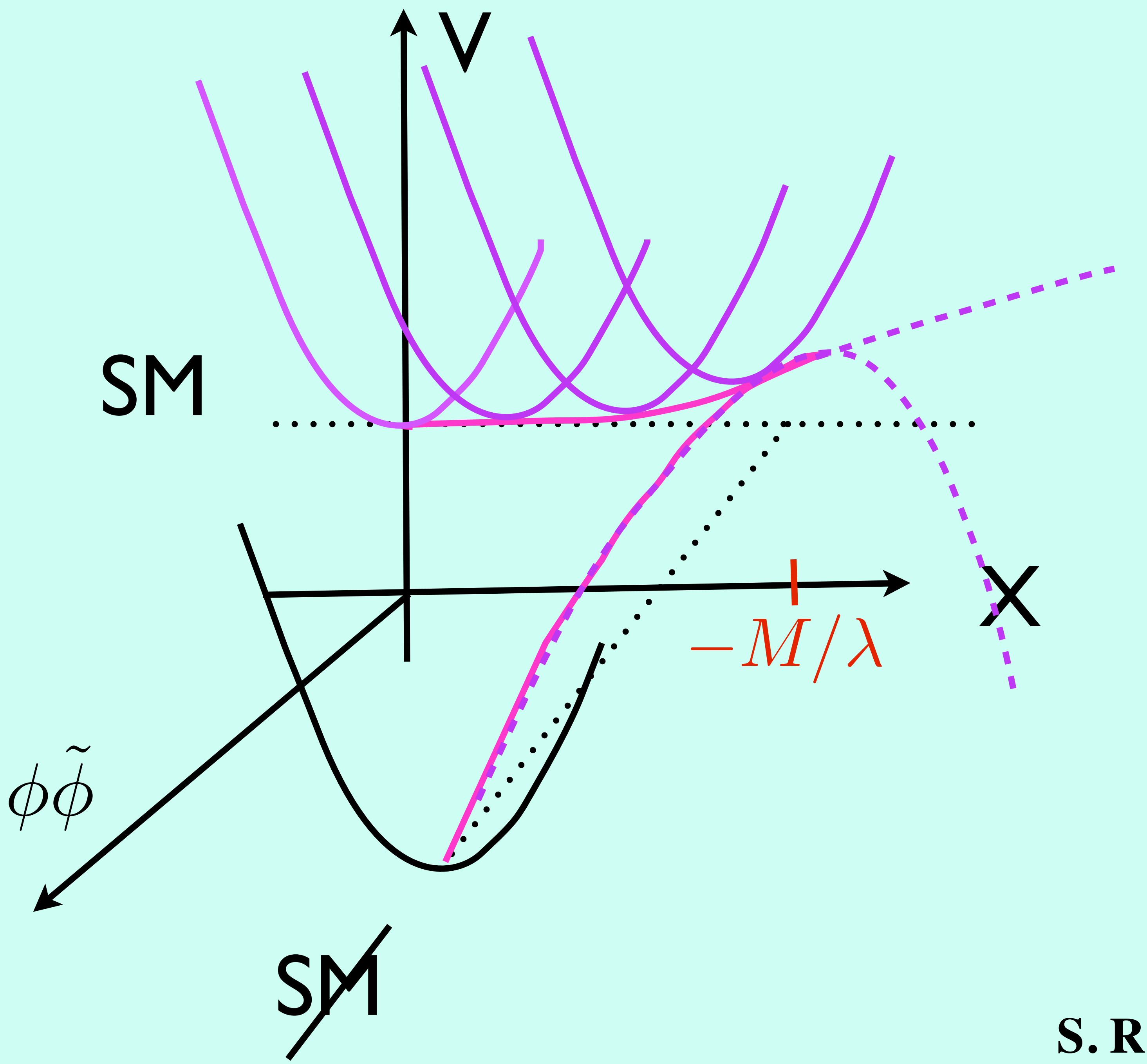

Tree level :
flat directions
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Quantum corrections:
metastability?

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Flat directions in O'R : tree level

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$$W_{OR} = X_i f_i(\psi_k) + g(\psi_k)$$ i = 1.. N, k = 1..M **N>M**

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→ N-M flat directions

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Tree level : $\psi_k, k = 1..M$ fixed,

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$X_i, i = M + 1..N$ flat directions

Flat directions and quantum corrections

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V = V (   )

Instability — Flat directions and quantum corrections

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V = V ($\{\psi_k, k = 1..M\}$,$\{X_i, i = 1..M\}$)

Instability

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fixed at tree level

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Flat directions and quantum corrections

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fixed at tree level

fixed by quantum corrections

Instability   Flat directions and quantum corrections

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fixed at tree level

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M constraints on the N-M flat directions

Instability

Flat directions and quantum corrections

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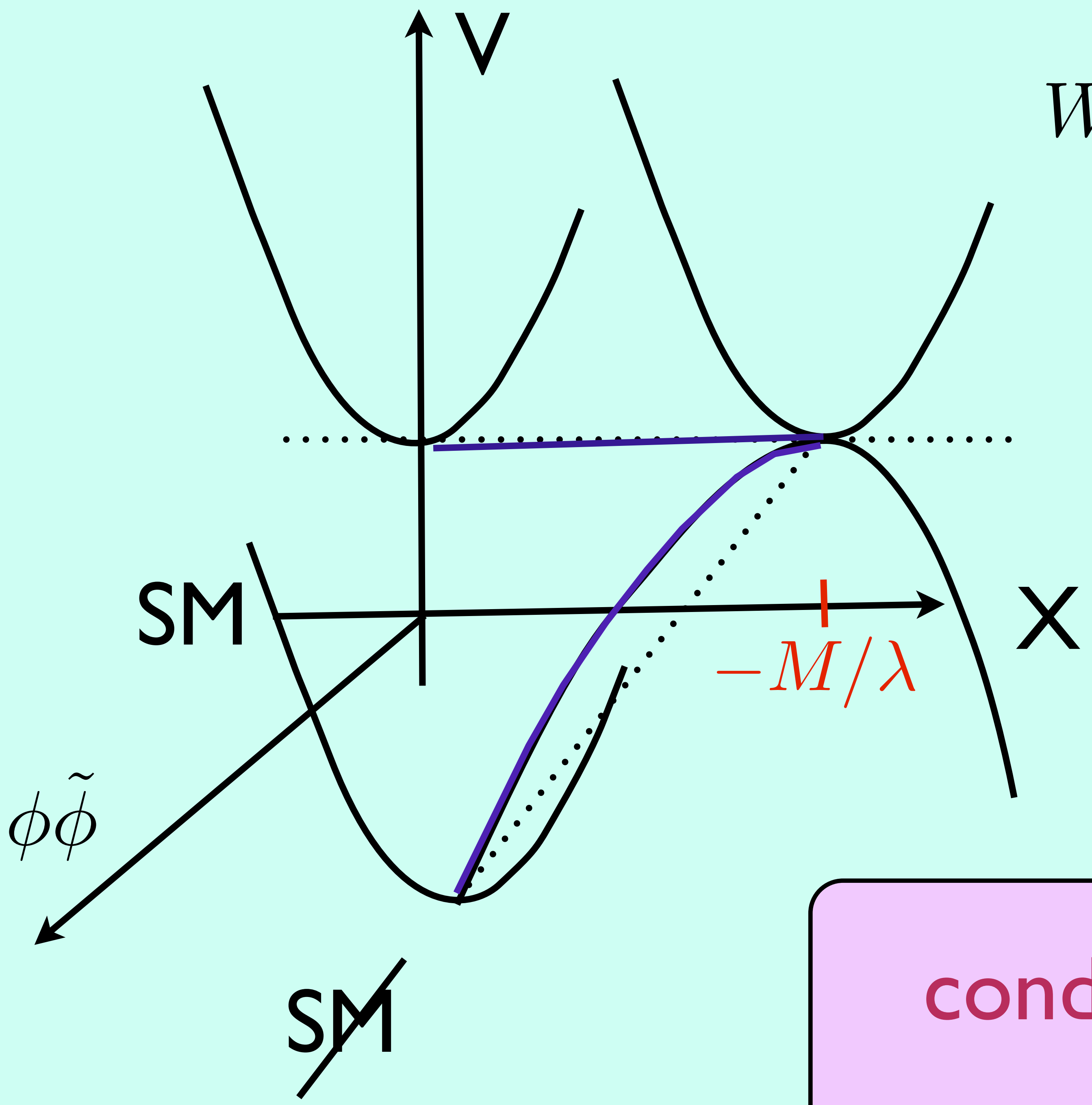
fixed at tree level

fixed by quantum corrections

M constraints on the N-M flat directions

If N > 2M, some flat directions are left

Avoiding instability in O'R



$$W_{OR} = X_i f_i(\psi_k) + g(\psi_k)$$

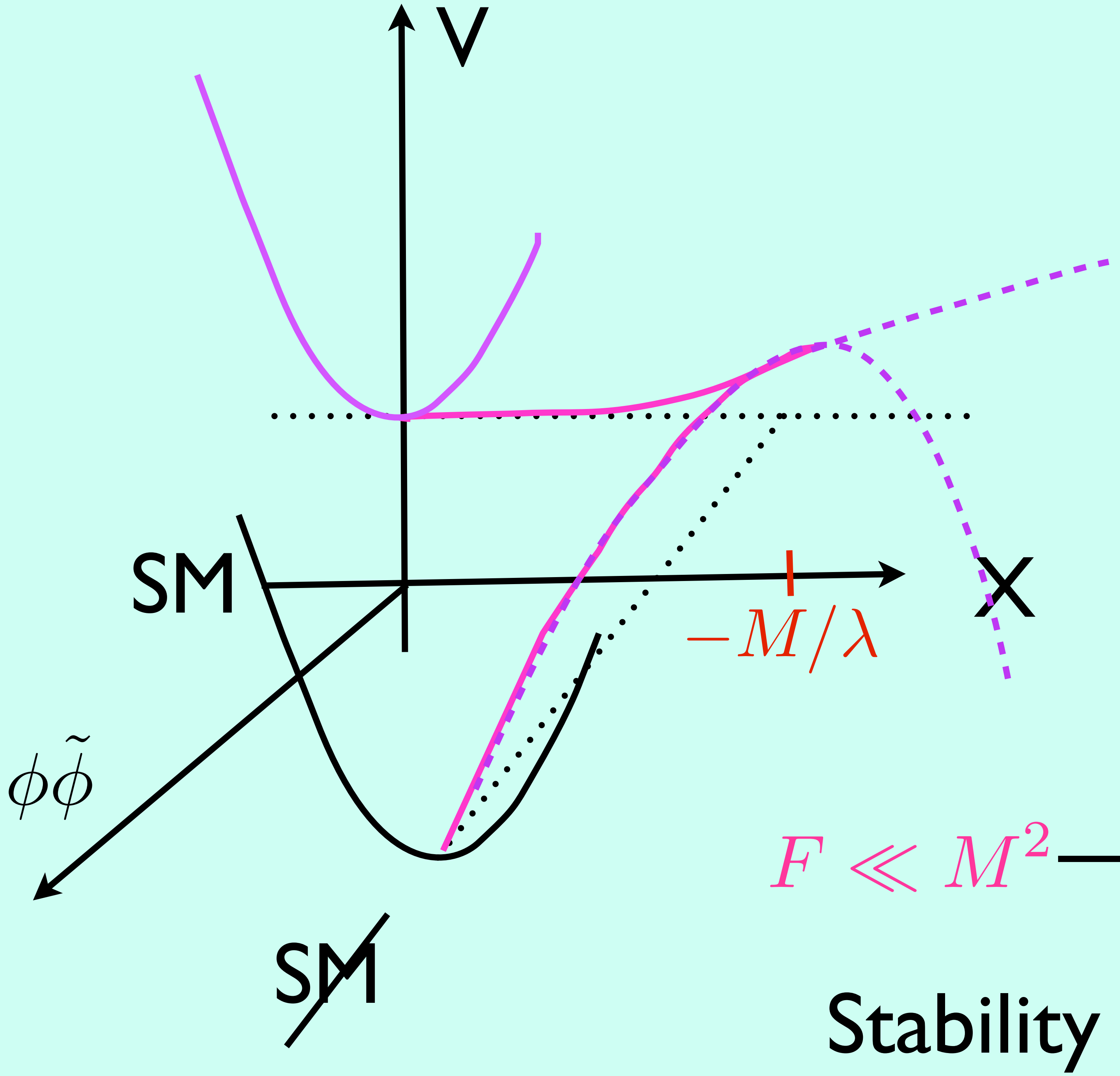
i = 1.. N, k = 1..M

if N> 2M,
quantum corrections
can't lift all
flat directions

condition for (meta)stability:

$$N \leq 2M$$

Tunneling and Lifetime



$$\Delta X = M/\lambda$$

$$\Delta\phi\tilde{\phi} = -\frac{\sum \lambda_i^* F_i}{\sum |\lambda_i|^2}$$

$$\Delta V = \frac{|\sum \lambda_i^* F_i|^2}{\sum |\lambda_i|^2}$$

Lifetime : $e^{(\Delta\psi)^4/\Delta V}$

$F \ll M^2$ ⟶ Long lived vacuum

Stability ⟶ $M_\lambda = 0$

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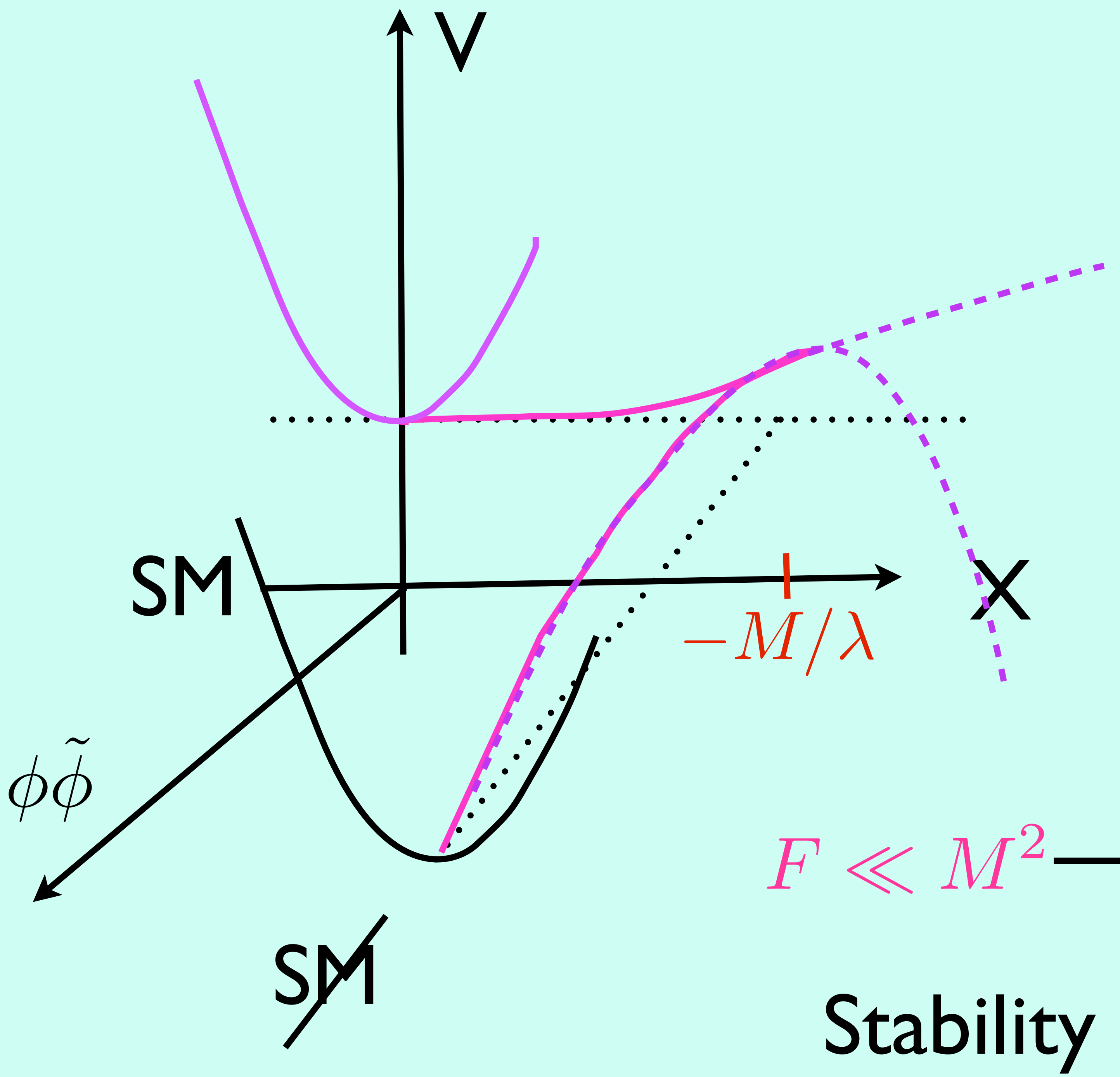

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Building a model

$$W_{OR} = X_i f_i(\psi_k) + g(\psi_k)$$ i = 1.. N, k = 1..M

SUSY Breaking : N > M

SUSY Breaking with messengers : N > M+1

No flat directions : $N \leq 2M$

Window: $M + 1 < N \leq 2M$

minimal:
M=2, N=4

$$W = mX_1\chi_1 + X_2(m_2\chi_2 + h_2\chi_2^2) + X_3(f_3 + h_2'\chi_2^2 + h_3\chi_1^2)$$
$$+X_4(f_4 + h_4\chi_1^2) + (\lambda_i X^i + M)\phi\tilde{\phi}$$

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$$\begin{aligned} F_{X_1} &= m_1\chi_1 + \lambda_1\phi\tilde{\phi} \\ F_{X_2} &= m_2\chi_2 + h_2\chi_2^2 + \lambda_2\phi\tilde{\phi} \\ F_{X_3} &= f_3 + h_3\chi_1^2 + h_2'\chi_2^2 + \lambda_3\phi\tilde{\phi} \\ F_{X_4} &= f_4 + h_4\chi_1^2 + \lambda_4\phi\tilde{\phi} \end{aligned}$$

$$\begin{aligned} F_{\chi_1} &= m_1X_1 + 2(h_3X_3 + h_4X_4)\chi_1 \\ F_{\chi_2} &= m_2X_2 + (2h_2X_2 + 2h_2'X_3)\chi_2 \end{aligned}$$

Building a model

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M=2 + 1 variables

N=4 equations

⟶ ~~SUSY~~

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$$\chi_1 = \chi_2 = X_1 = X_2 = 0$$
$$2h_2X_2 + 2h_2'X_3$$
$$2h_3X_3 + 2h_4X_4$$

N-M = 2 flat directions

Building a model

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$$V = \frac{1}{64\pi^2}\mathrm{Str}M^4\ln(\frac{M^2}{\Lambda^2}) \sim \frac{1}{64\pi^2}\mathrm{Str}M^4\ln(\frac{1\mathrm{TeV}}{\Lambda^2})$$

$V_{\cancel{SM}} - V_{SM} > 0$ $\quad h \sim \lambda \sim 1$ $\quad \boxed{\sum \lambda_i^* F_i < F_i}$

small fine tuning

$\longrightarrow$ $\boxed{\text{small gaugino masses}}$

Final comments

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Our work is consistent with these results although it does not rely on R symmetry arguments

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instability	check that all flat directions are lifted by quantum corrections
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Next : cosmological history of the vacua

Conclusions