

Stability in Gauge Mediation

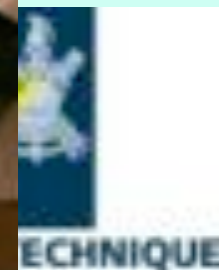


work in progress, done in coll.
with Emilian Dudas and Stephane Lavignac





cea



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

MSSM

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

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$$(\lambda X + M)\phi\tilde{\phi}$$

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$$(\lambda X + M)\phi\tilde{\phi}$$

charged under
 $SU(3) \times SU(2) \times U(1)$



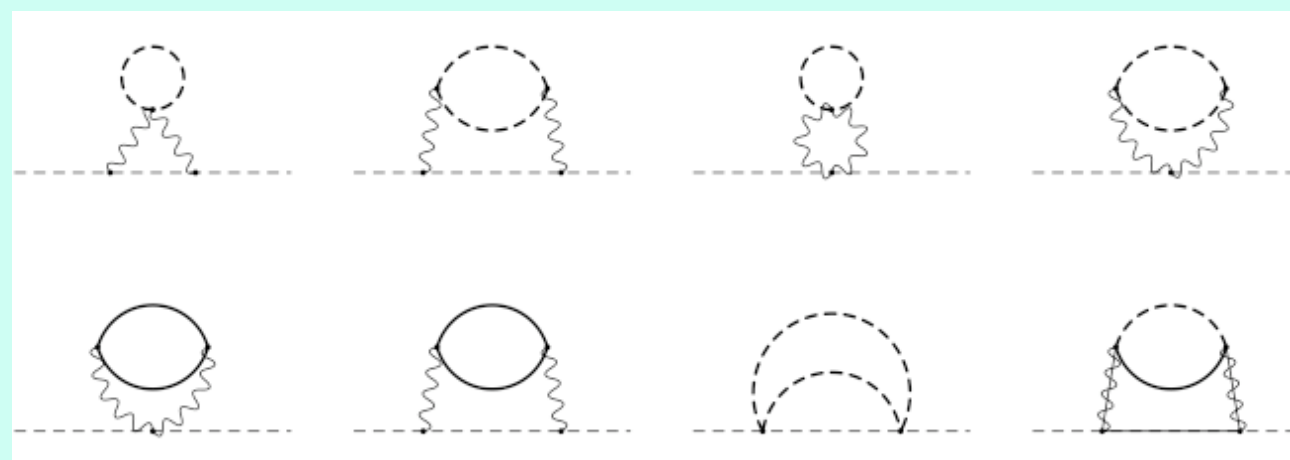
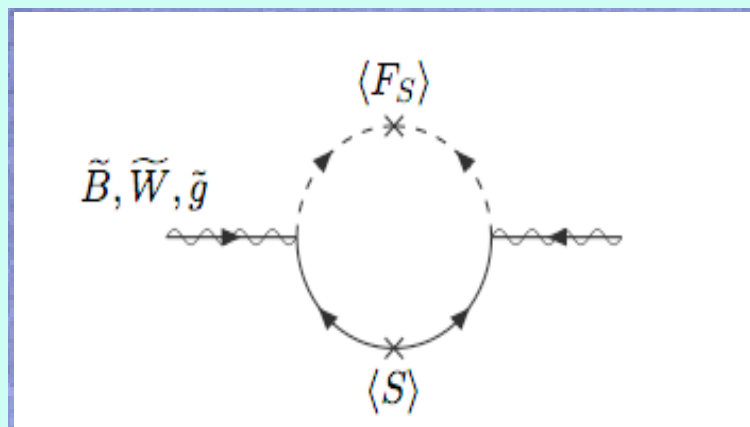
$$X = X_0 + \theta^2 F_X$$

MSSM

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

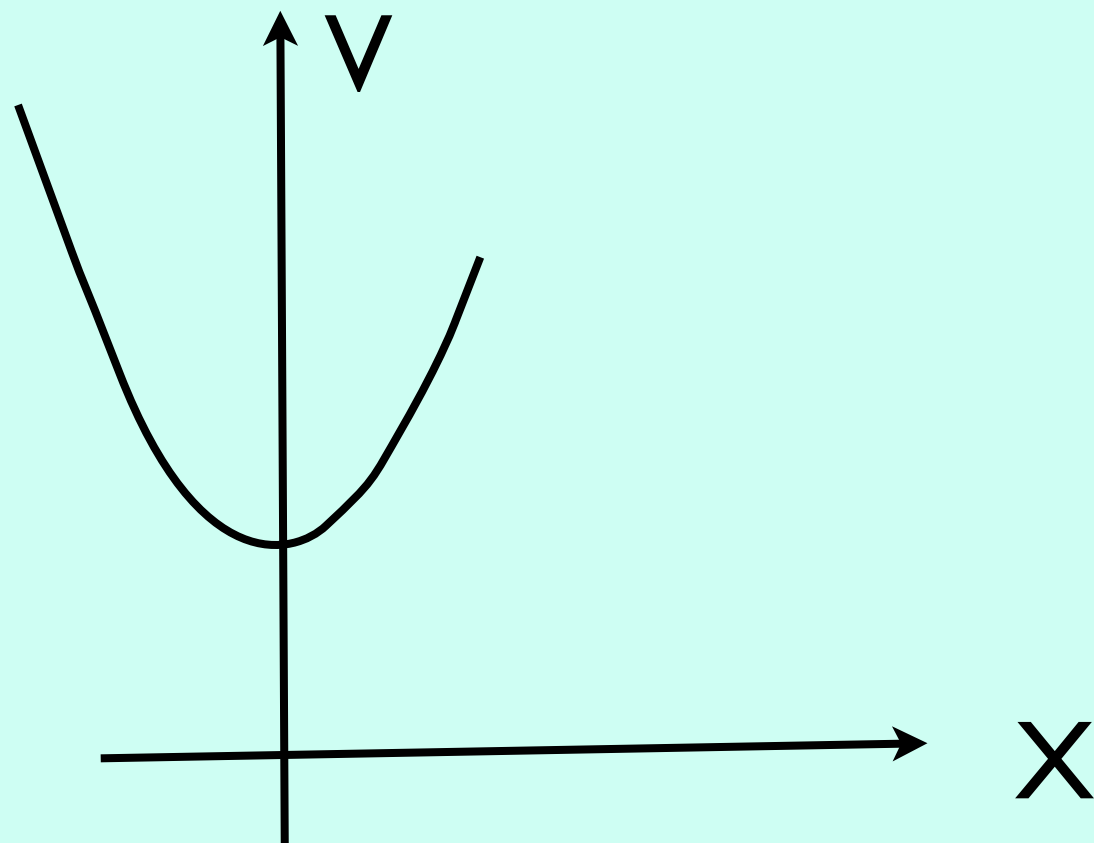
$$(\lambda X + M)\phi\tilde{\phi}$$

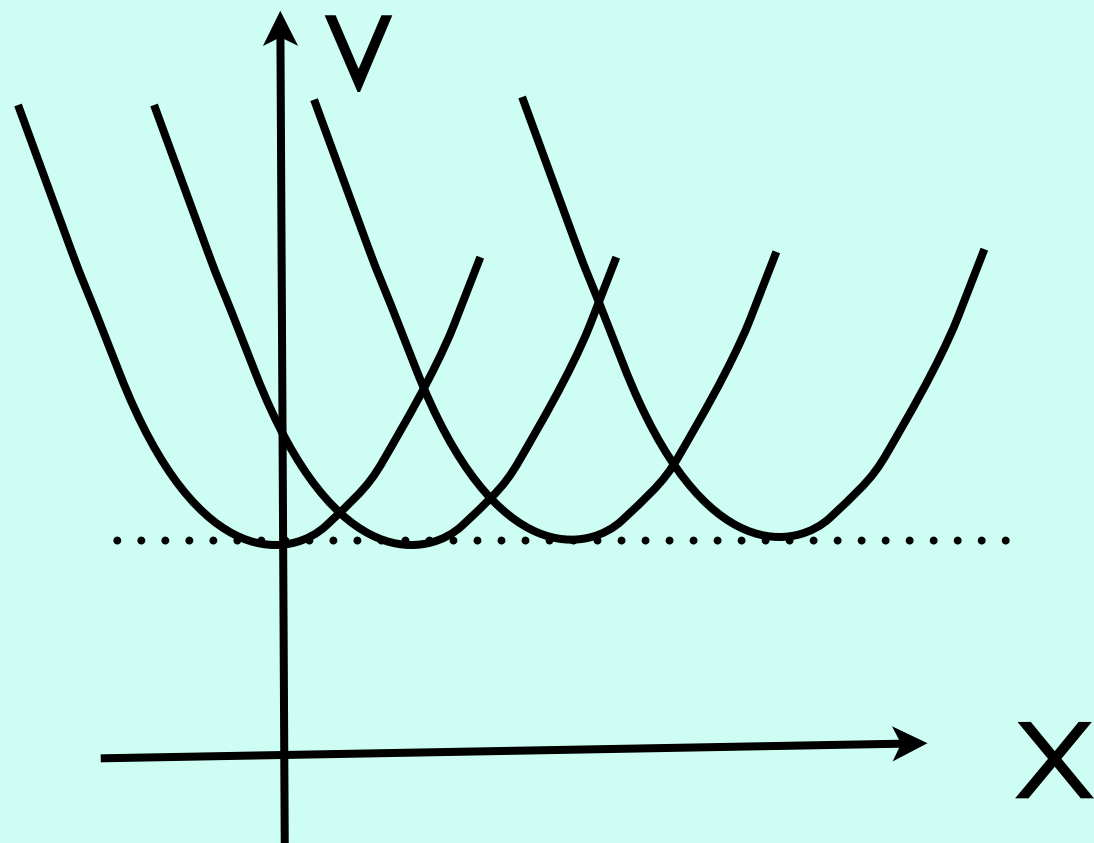
charged under
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$$M_a(\mu) = \frac{\alpha_a(\mu)}{4\pi} N_m \sum_i 2T_a(R_i) \frac{F}{M}$$

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

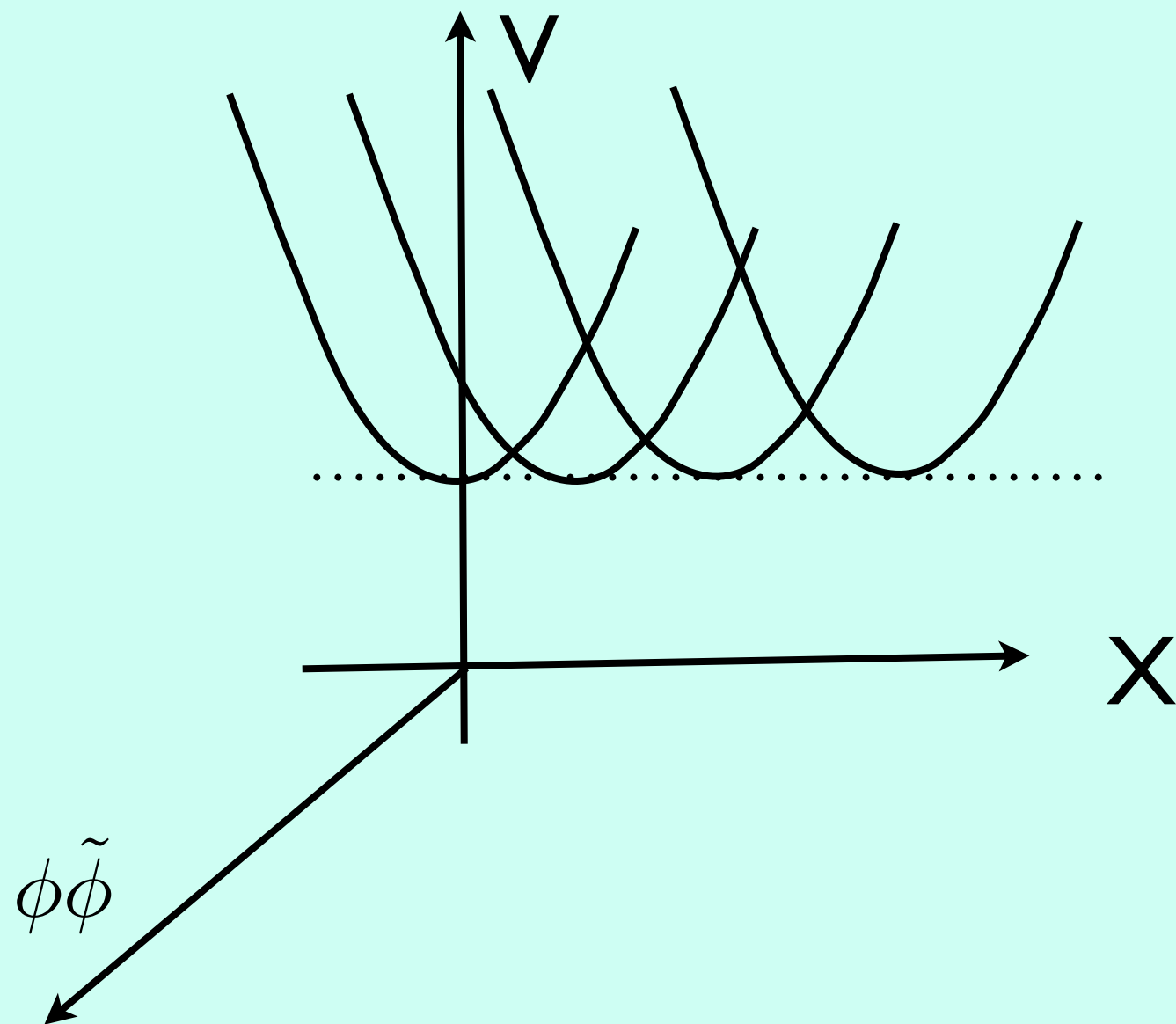




$$W_{OR} = X_i f_i(\psi_k) + g(\psi_k)$$

S. Ray hep-th/0708.2200

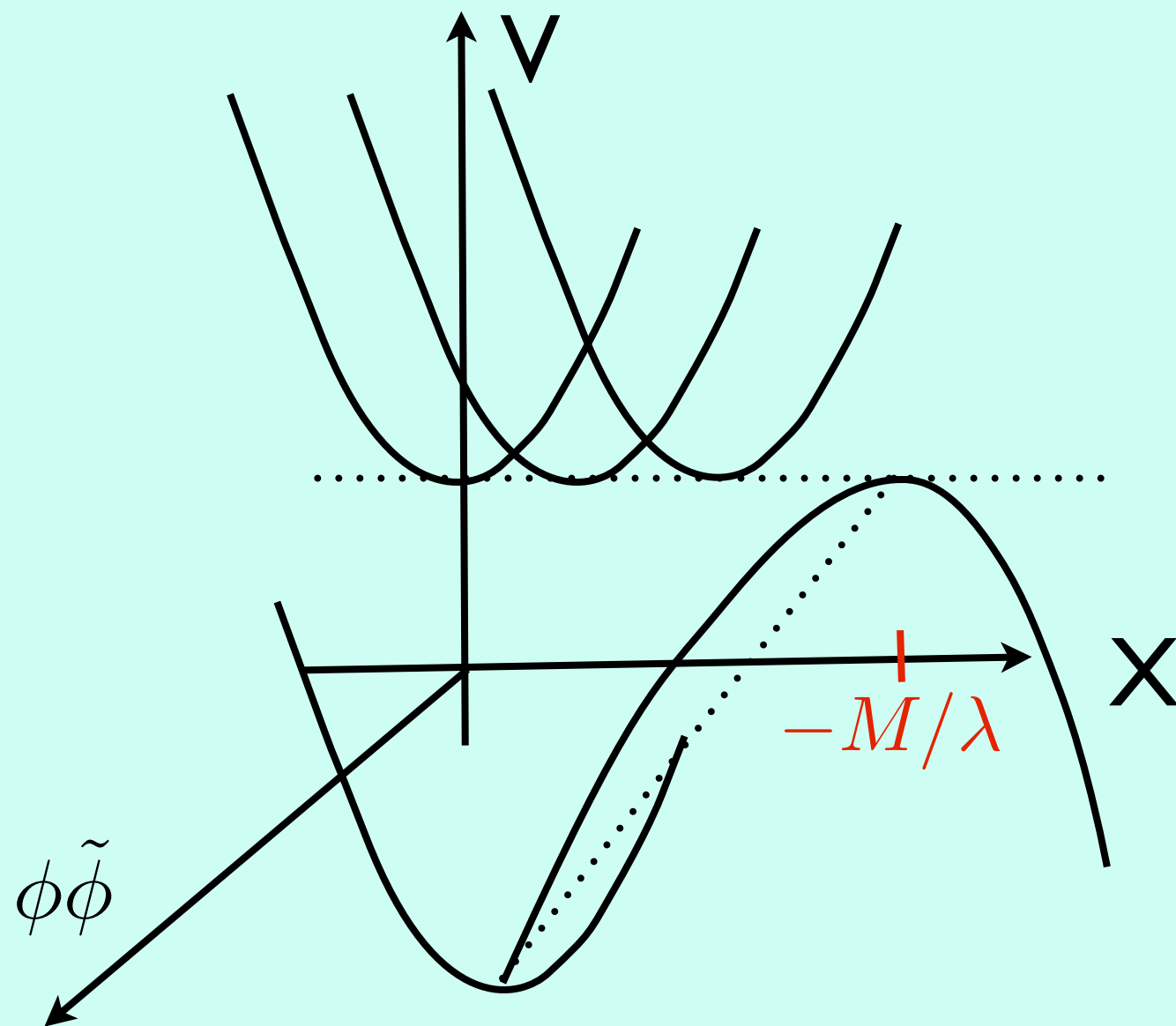
Z. Komargodski, D. Shih hep-th/0902.0030



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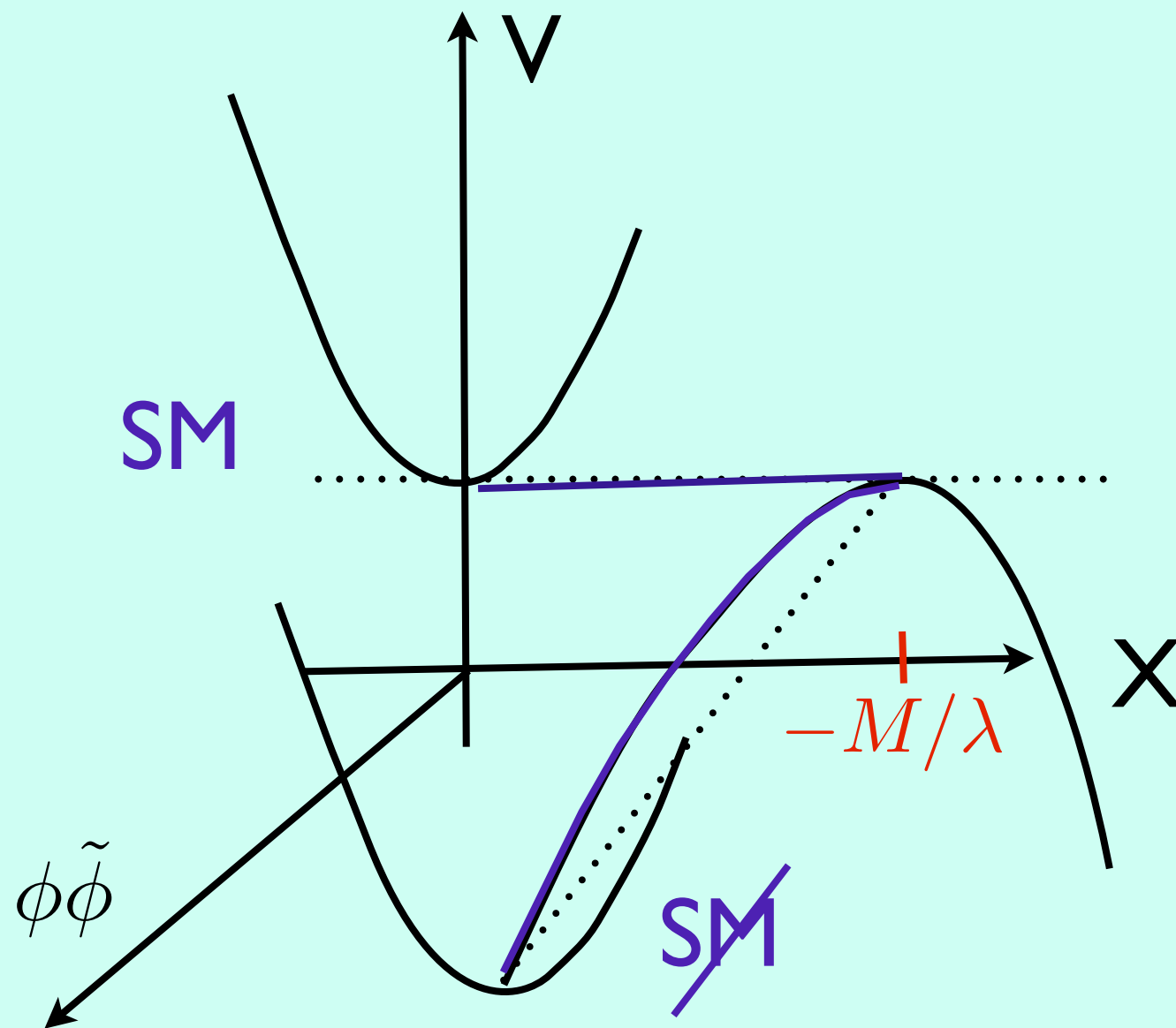
$$\cancel{V_{SM}} = V_{SM} + \frac{|\sum \lambda_i^* F_i|^2}{\sum |\lambda_i|^2}$$

$$\cancel{V_{SM}} = V_{SM}$$

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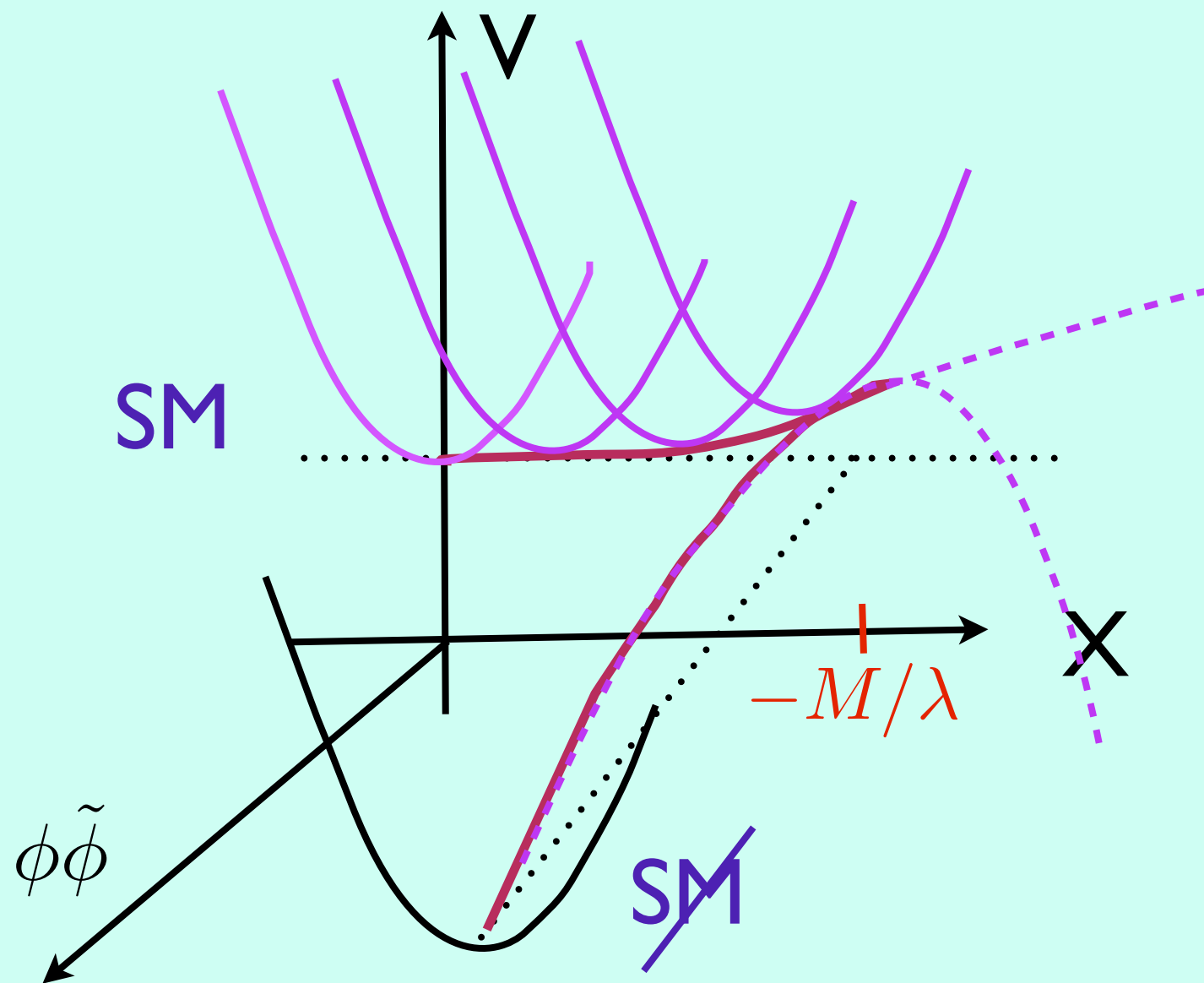
$$\cancel{V_{SM}} = V_{SM}$$

Classical : Instability

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

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$$\cancel{V_{SM}} = V_{SM} + \frac{|\sum \lambda_i^* F_i|^2}{\sum |\lambda_i|^2}$$

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Classical : Instability

Quantum corrections:
metastability?

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

S. Ray hep-th/0708.2200

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

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$$F_{X_i} = f_i(\psi_k) = 0 \quad N \text{ equations, } M \text{ variables}$$

→ ~~SUSY~~

$$F_{\psi_k} = X_i \frac{\partial f_i}{\partial \psi_k} + \frac{\partial g}{\partial \psi_k} = 0 \quad M \text{ equations, } N \text{ variables}$$

→ N-M flat directions

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

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Tree level :

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

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

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—————→ N-M flat directions

Tree level : $\psi_k, k = 1..M$ fixed,
 $X_i, i = 1..M$ fixed,
 $X_i, i = M + 1..N$ flat directions

$$V = V (\quad)$$

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

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

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fixed at tree level

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fixed at tree level

fixed by quantum corrections

$$F_{X_i} = f_i(\psi_k)$$

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Flat directions and quantum corrections

$$F_{X_i} = f_i(\psi_k)$$

$$F_{\psi_k} = X_i \frac{\partial f_i}{\partial \psi_k} + \frac{\partial g}{\partial \psi_k}$$

$$\mathbf{V} = \mathbf{V} \left(\{\psi_k, k = 1..M\}, \{X_i, i = 1..M\} \{X_i, i = M + 1..N\} \right)$$

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Flat directions and quantum corrections

$$F_{X_i} = f_i(\psi_k)$$

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$$F_{\psi_k} = \sum_1^M X_i \frac{\partial f_i}{\partial \psi_k} + Y_k + \frac{\partial g}{\partial \psi_k} \quad Y_k = \sum_{M+1}^N X_i \frac{\partial f_i}{\partial \psi_k} \quad k = 1..M$$

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M constraints on the N-M flat directions

Flat directions and quantum corrections

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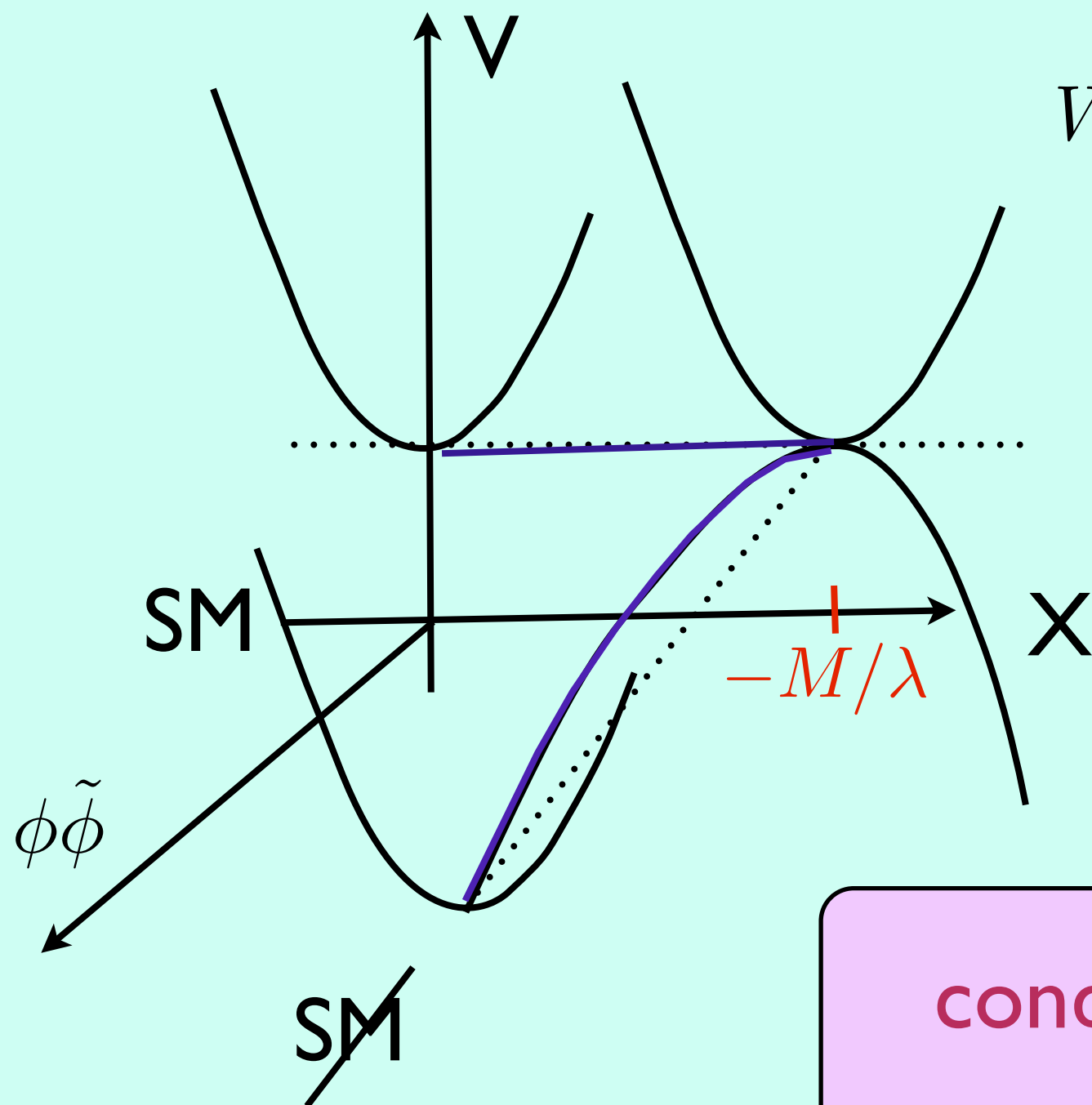
fixed at tree level

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



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

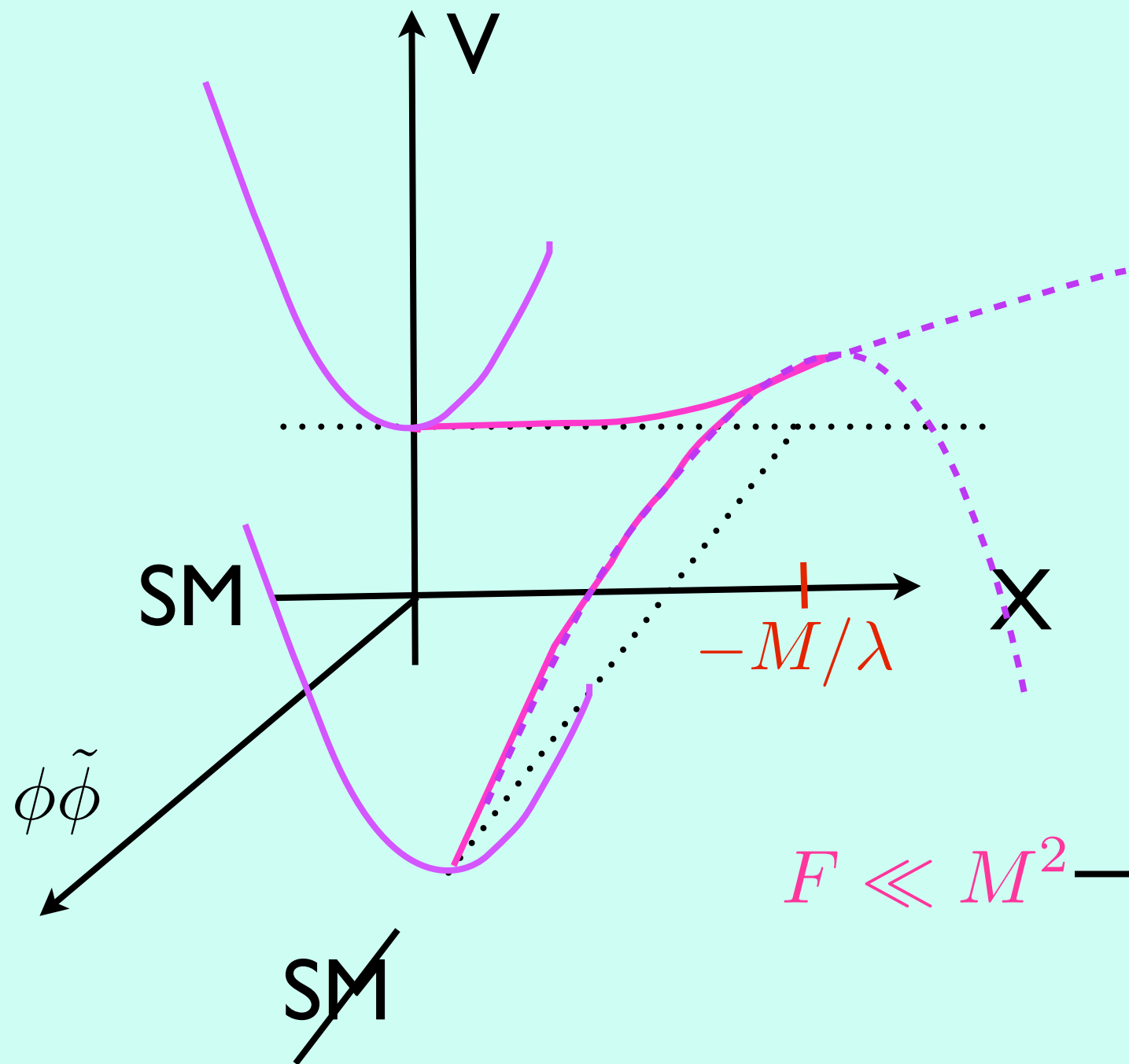
$$i = 1..N, k = 1..M$$

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

condition for (meta)stability:

$$N \leq 2M$$

I Tunneling and Lifetime



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

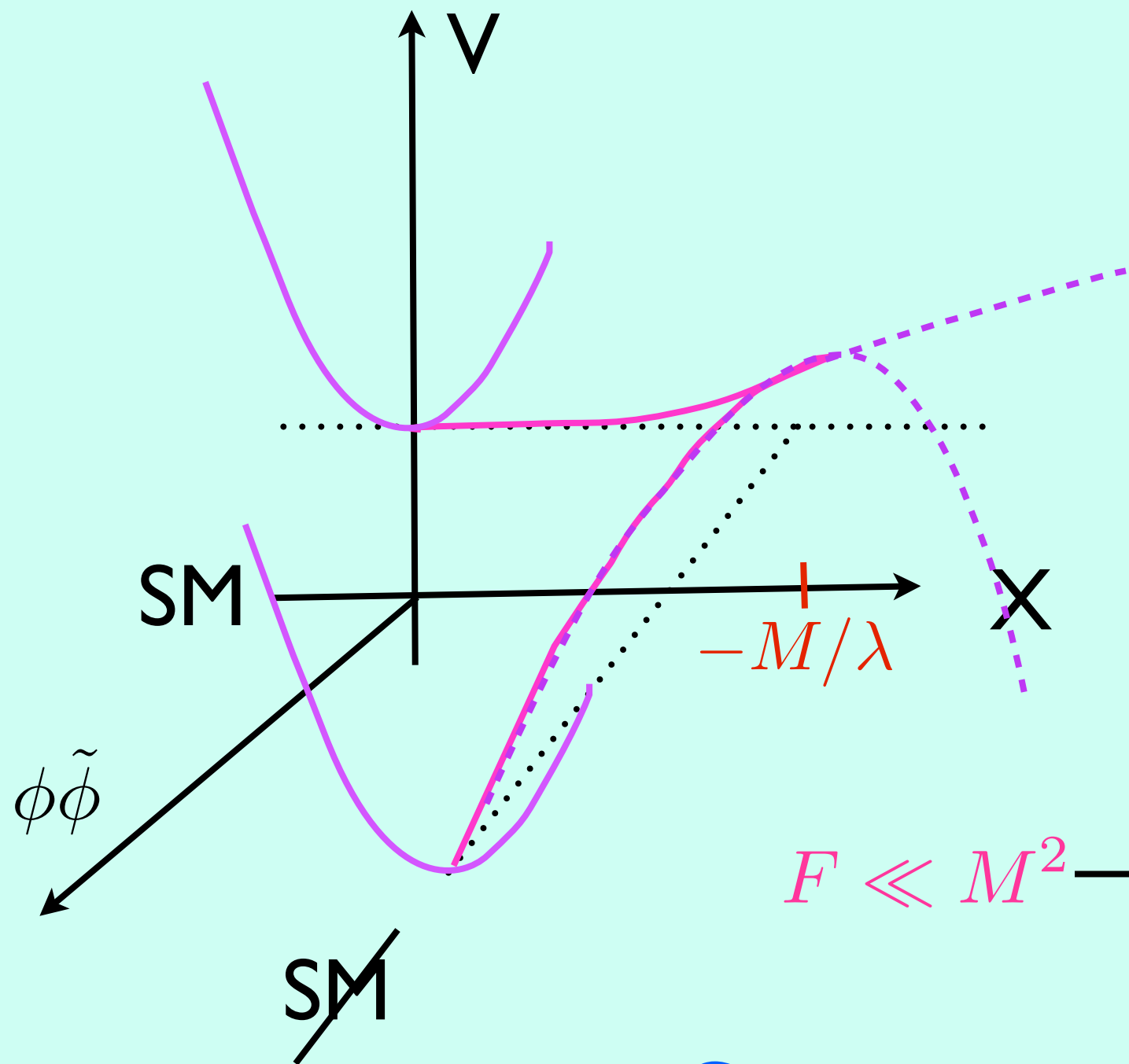
$$\Delta\phi\tilde{\phi} = -\frac{\sum \lambda_i^* F_i}{\sum |\lambda_i|^2}$$

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

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

$F \ll M^2 \longrightarrow$ Long lived vacuum

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

$F \ll M^2 \longrightarrow$ Long lived vacuum

Can we avoid metastability?

$$W = X_i (f_i + m_i^a \psi_a + h_i^{a,b} \psi_a \psi_b) + (\lambda_i X^i + M) \phi \tilde{\phi}$$

X is neutral

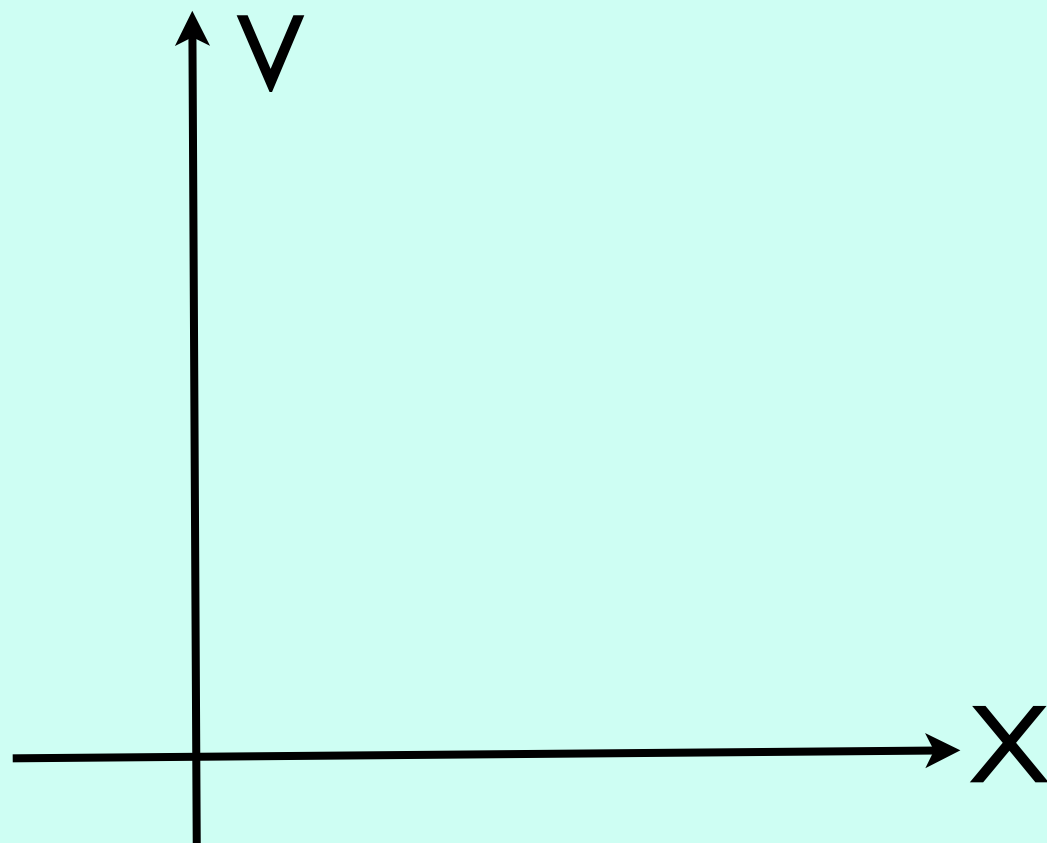
$\phi \tilde{\phi}$ is gauge invariant

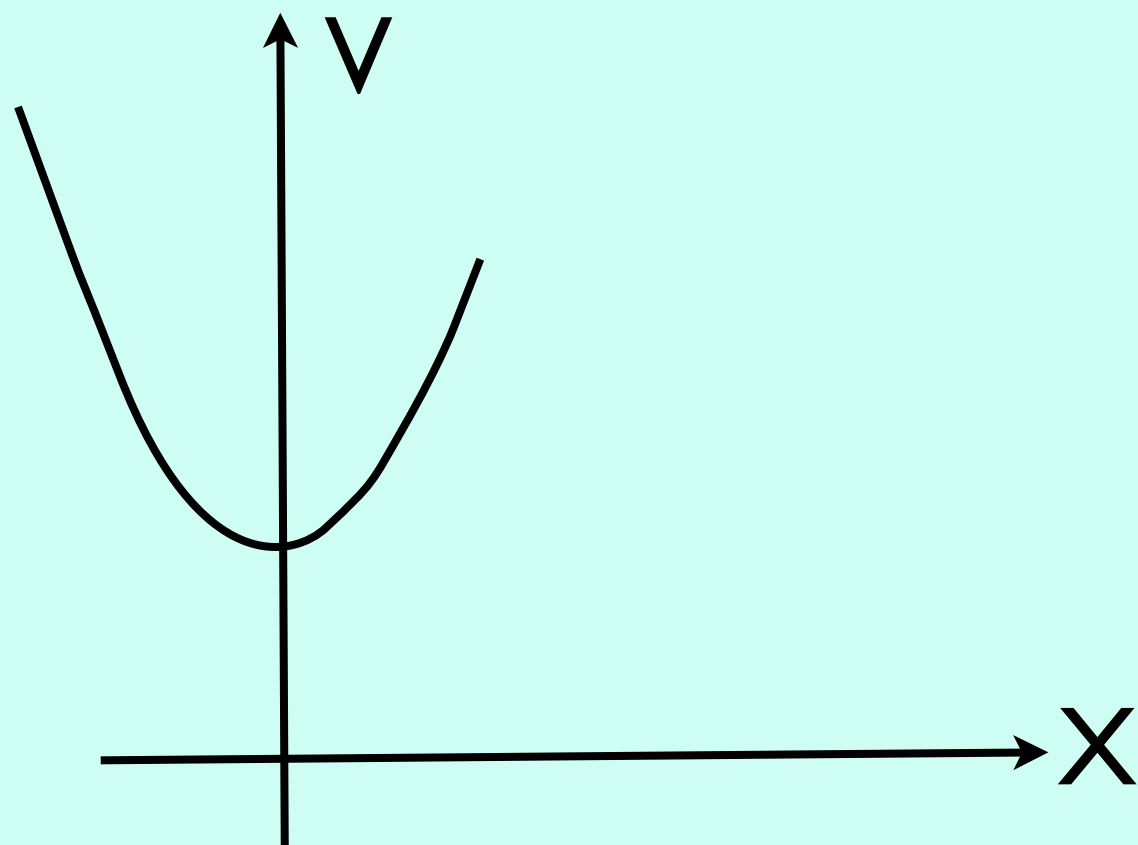
→ **flat direction**

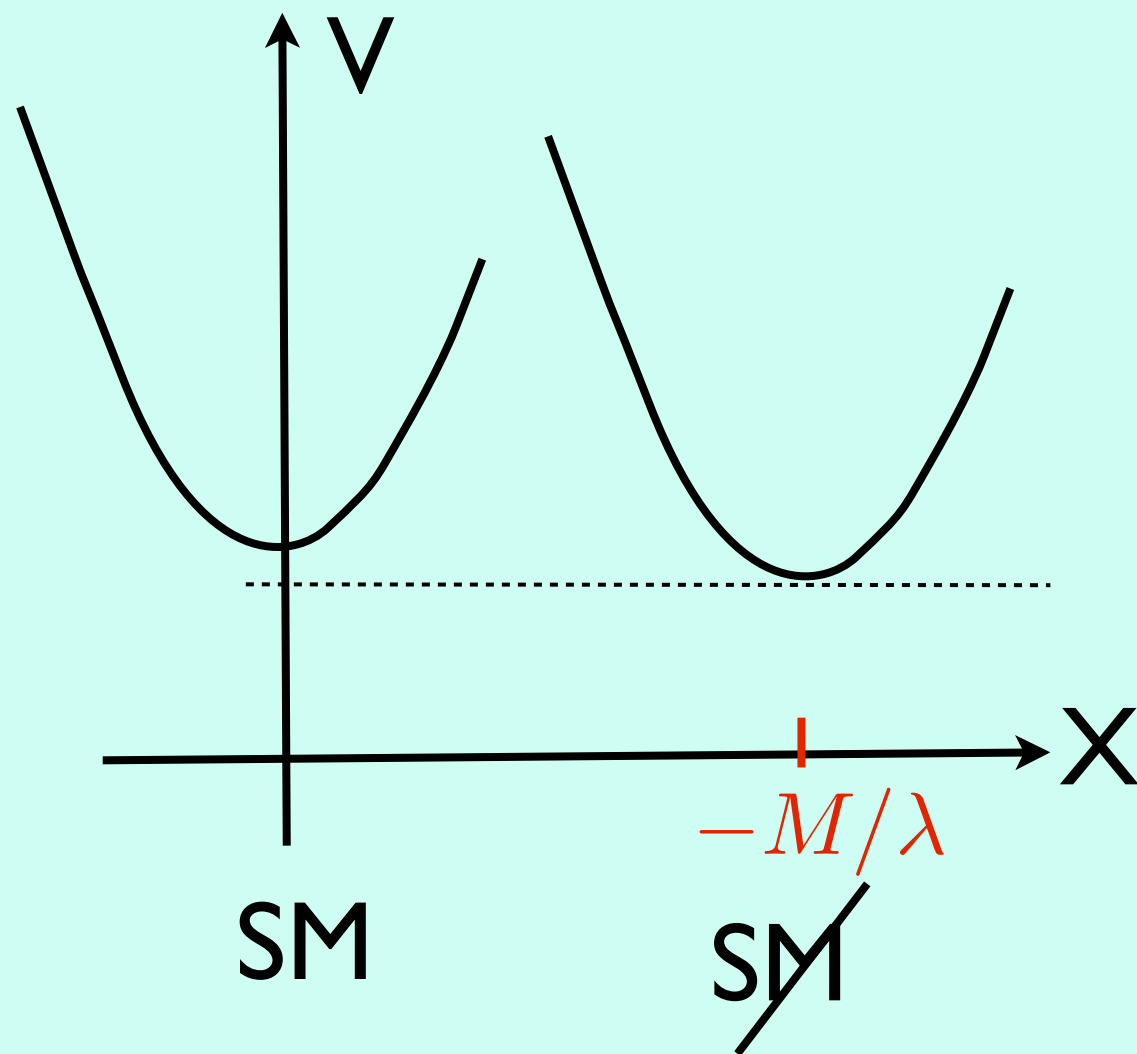
→ **D = 0**

Patterns of Symmetry Breaking in
Supersymmetric Gauge Theories

Phys.Lett.B115:375,1982



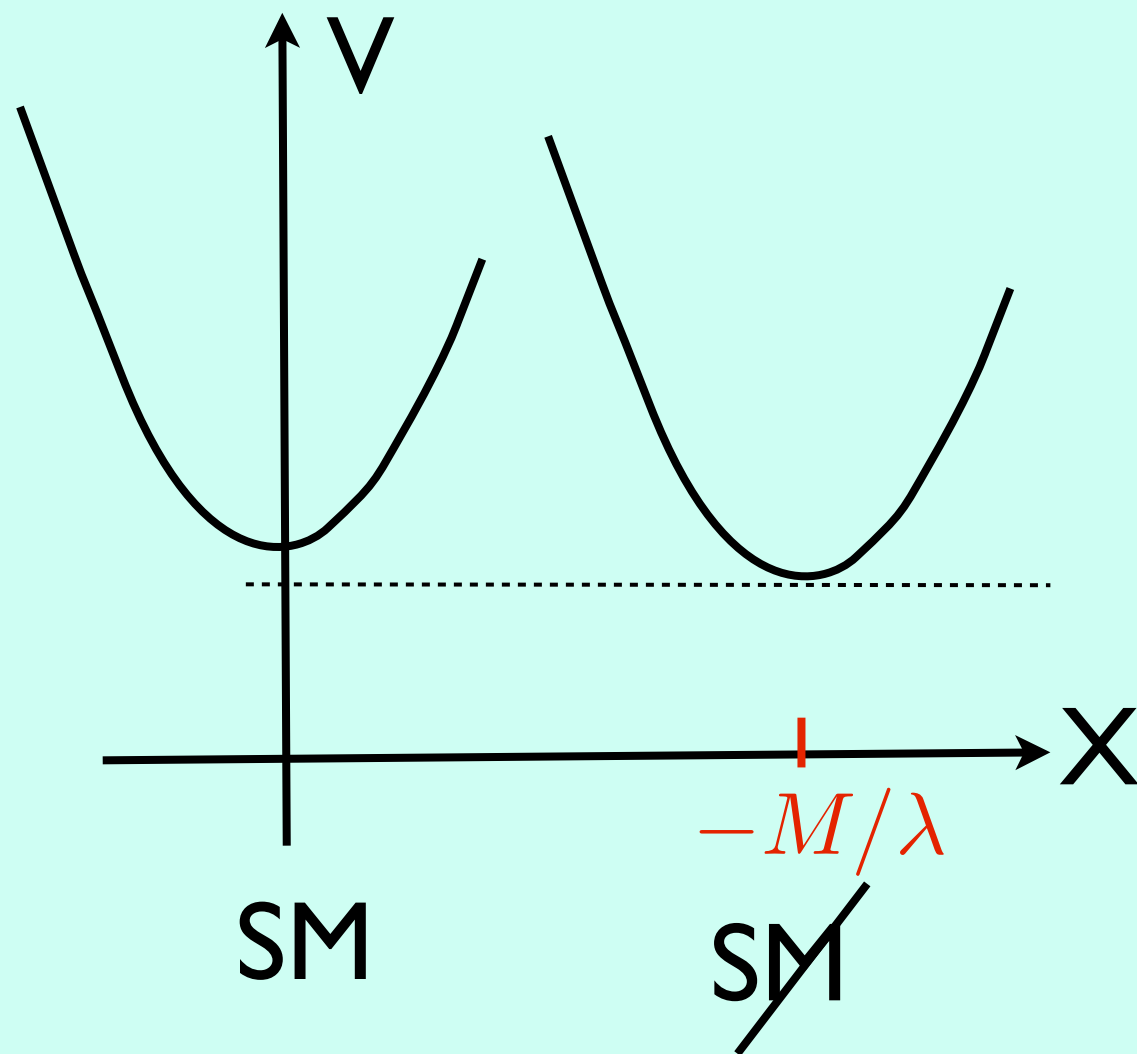




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Classical : Instability



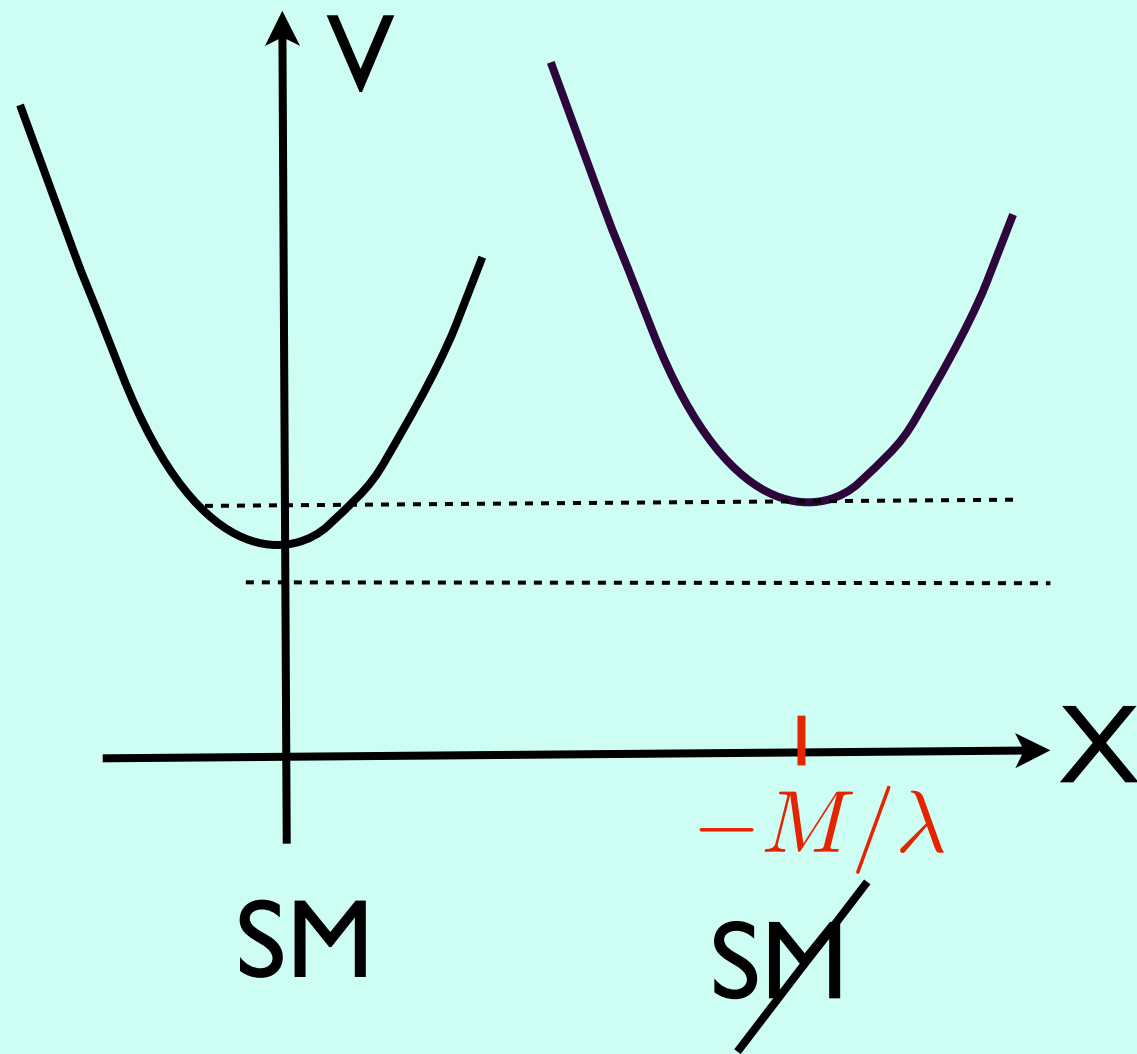
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Quantum corrections:
metastability

II Quantum corrections and stability



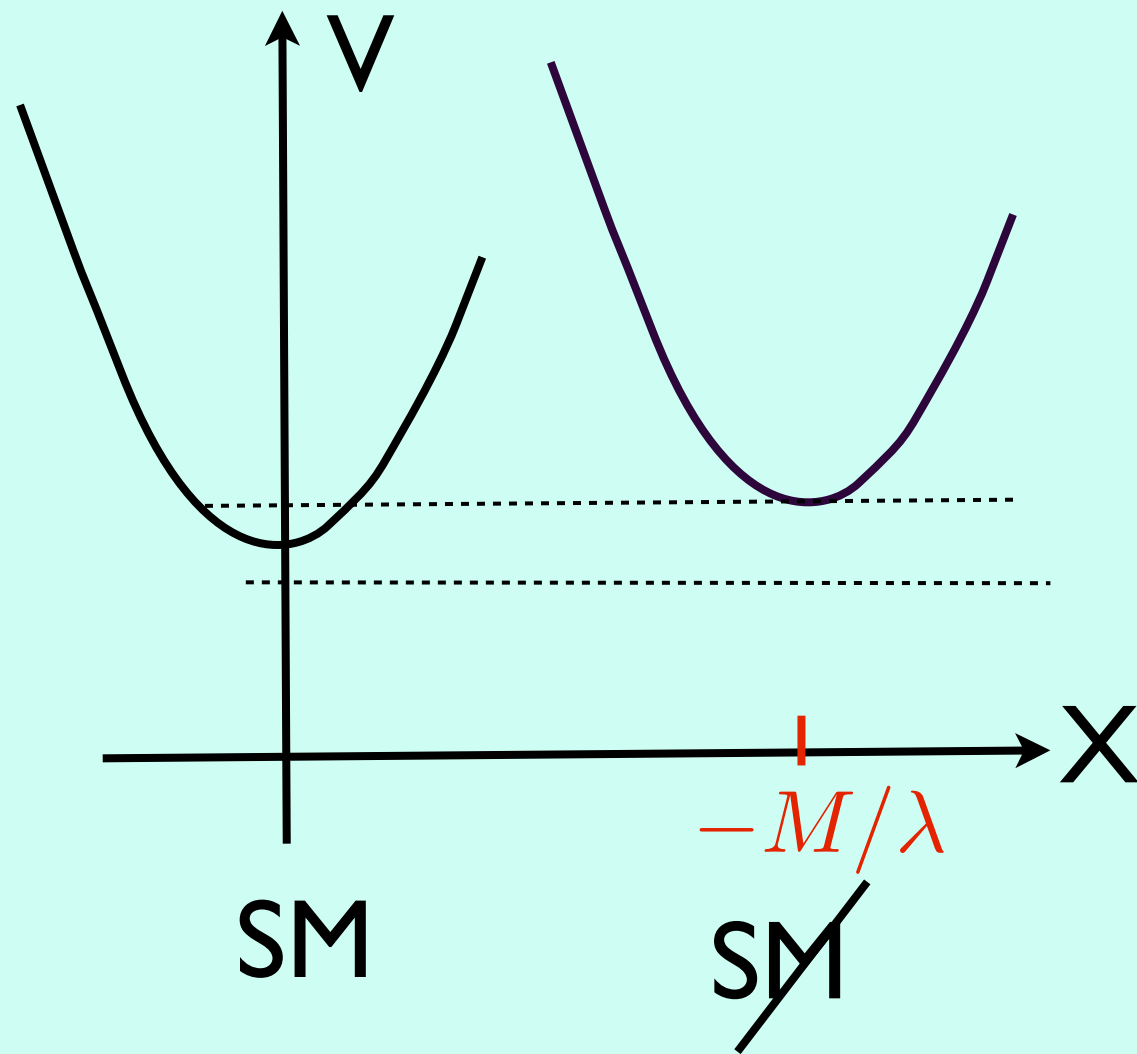
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$$\cancel{V_{SM}} = V_{SM} + \frac{|\sum \lambda_i^* F_i|^2}{\sum |\lambda_i|^2}$$

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fine-tuning on classical $\sum \lambda_i^* F_i$

~ quantum corrections

$$W = X_i (f_i + m_i^a \psi_a + h_i^{a,b} \psi_a \psi_b) + (\lambda_i X^i + M) \phi \tilde{\phi}$$

$$\Lambda_{SM} - \Lambda_{SM} = - \frac{|\sum_i \lambda_i^* f_i(\psi)|^2}{\sum_j |\lambda_j|^2}$$

$$+ \frac{1}{128\pi^2} \left(|\sum_i \lambda_i^* f_i(\psi)|^2 \left(2 - \frac{\sum_{a,b} |\sum_j h_{a,b}^{j,*} \lambda_j|^2}{(\sum_i |\lambda_i|^2)^2} \right) \right)$$

$$+ \frac{1}{128\pi^2} \frac{1}{\sum_i |\lambda_i|^2} \sum_{a,b} \left(\sum_j h_{a,b}^{j,*} f_j(\psi) \sum_k h_{a,b}^{k,*} \lambda_k \sum_i \lambda_i^* f_i(\psi) + cc \right)$$

$$+ \frac{1}{64\pi^2} c \frac{|\sum_i \lambda_i^* f_i(\psi)|}{\sum_i |\lambda_i|^2}$$

Conclusions

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GM and O'R \rightarrow instability, metastability, or stability

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small fine tuning on $\sum_i \lambda_i^* f_i$
no hierarchical spectrum