

Sequestered String Models imply Split Supersymmetry

Hajime Otsuka (Kyushu University)

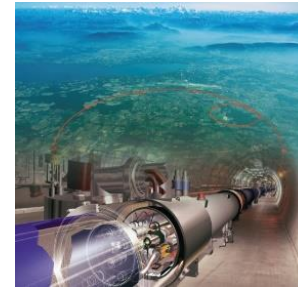
Reference :

M. Cicoli (Bologna U.), A. Cotellucci (Humboldt U.), H.O., arXiv:2309.05752

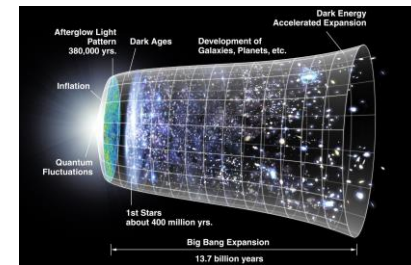
One of main challenges in string phenomenology

Realization of energy scales in 4D string models

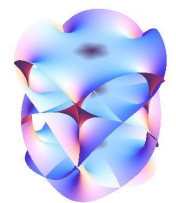
- EW scale ($\sim 10^2$ GeV)
- Inflation scale ($\sim 10^{14}$ GeV)



CERN Atlas



- They depend on VEVs of the string moduli (“Moduli stabilization”)
(Ubiquitous modulus : volume of internal 6D space V)



Can we reconcile a high inflationary scale with EW scale?

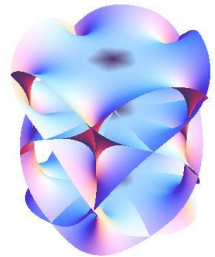
Large Volume Scenario (LVS)

Balasubramanian-Berglund-Conlon-Quevedo, 0502058

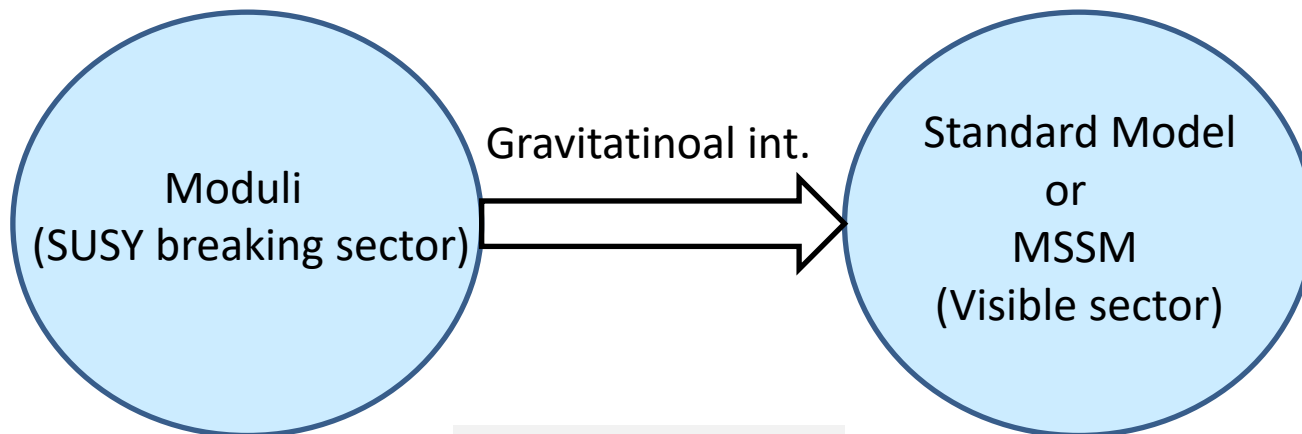
Ubiquitous modulus : volume of internal 6D space V

- Exponentially large volume

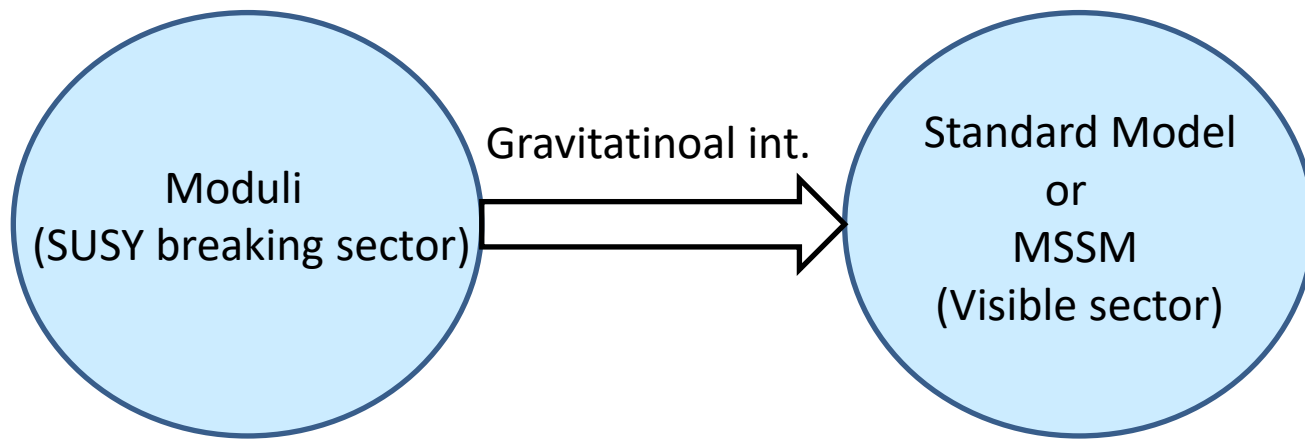
$$V \sim e^{c/g_s} \quad \begin{array}{l} O(1) \text{ constant : } c \\ \text{String coupling : } g_s \ll 1 \end{array}$$



- SUSY is spontaneously broken by F-term of V



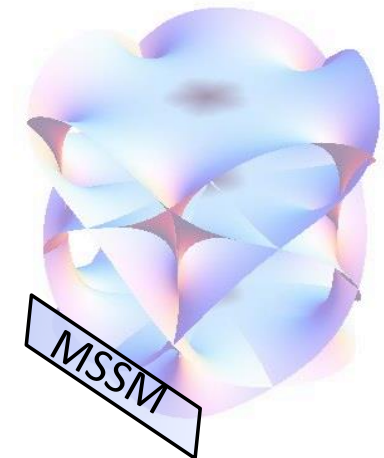
Sparticle Spectra ?



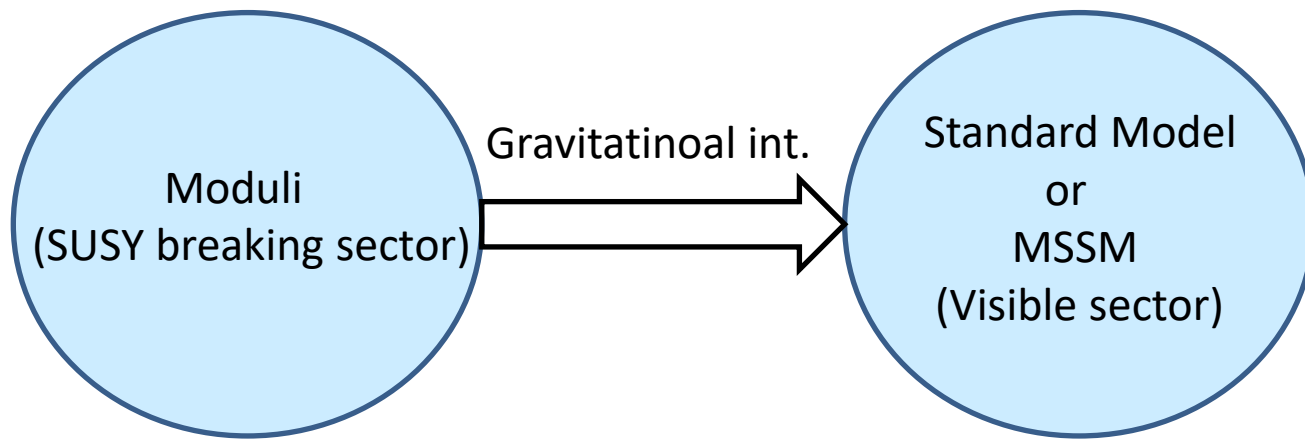
1. “Local model” (Sequestered string model)

- D3 branes at singularities

$$m_{\text{Sparticle}} \ll m_{3/2} \sim \frac{M_{\text{Pl}}}{V}$$



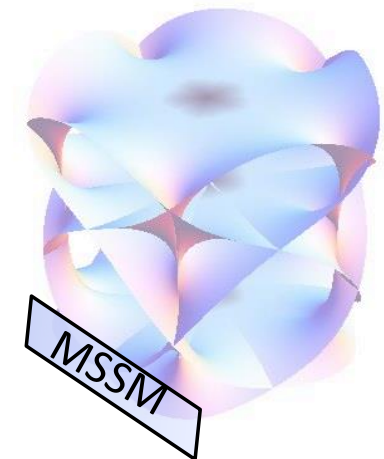
*Blumenhagen-Conlon-Krippendorf-Moster-Quevedo, 0906.3297,
Aparicio-Cicoli-Krippendorf-Maharana-Muia-Quevedo, 1409.1931,...*



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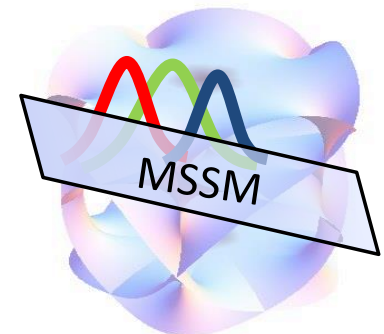


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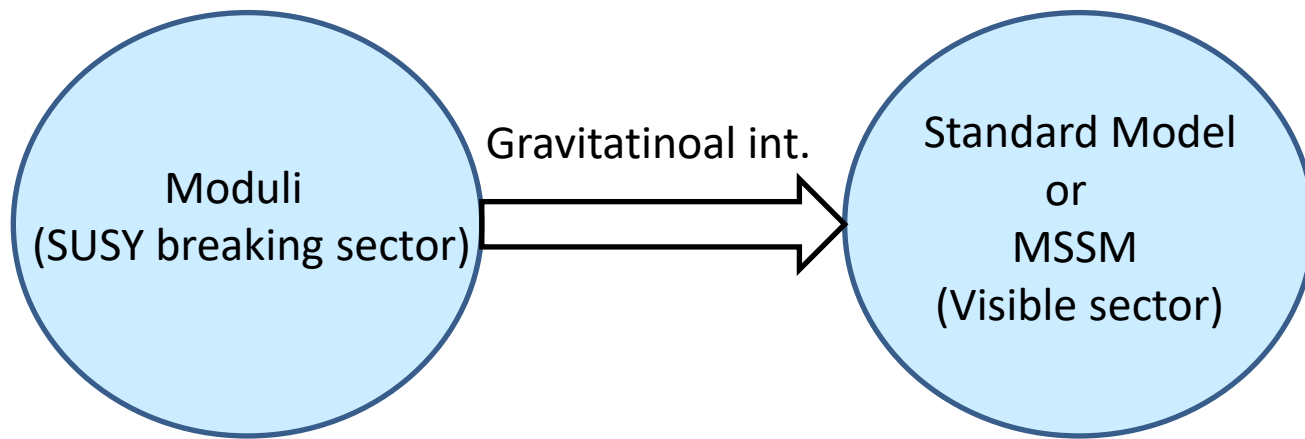
2. “Global model”

- Intersecting and magnetized D7-brane model

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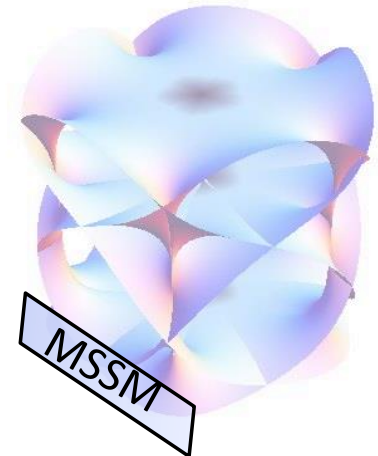
*Conlon-Quevedo-Suruliz, 0505076,
Conlon-Abdussalam-Quevedo-Suruliz, 060129,...*



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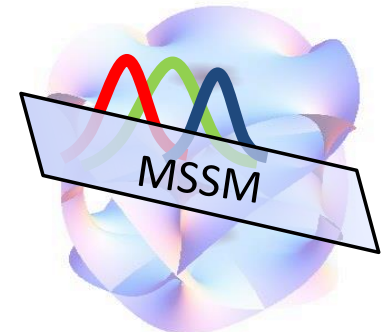


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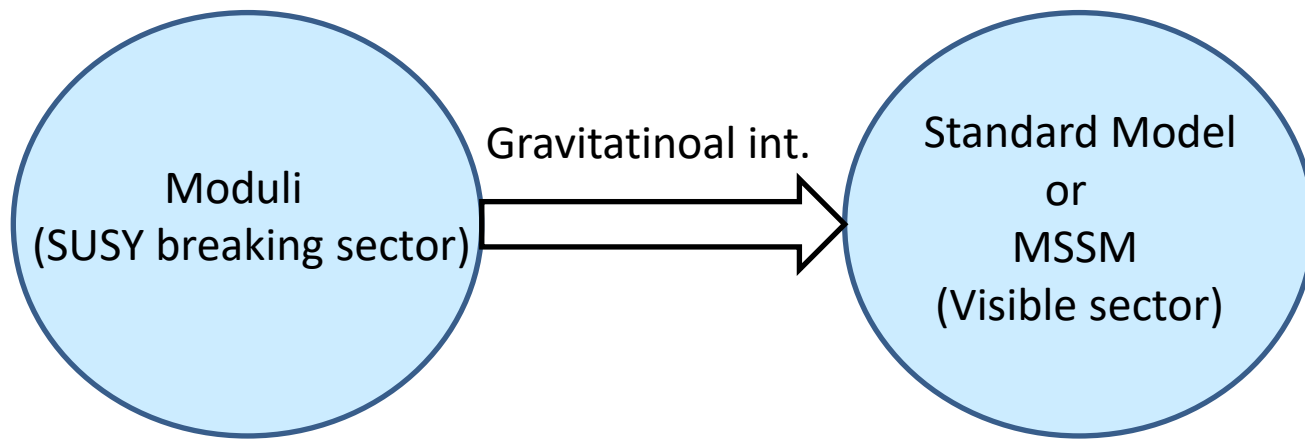
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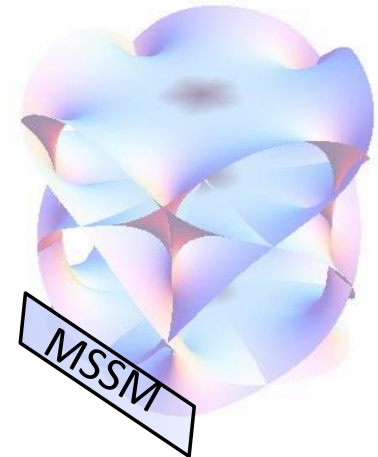
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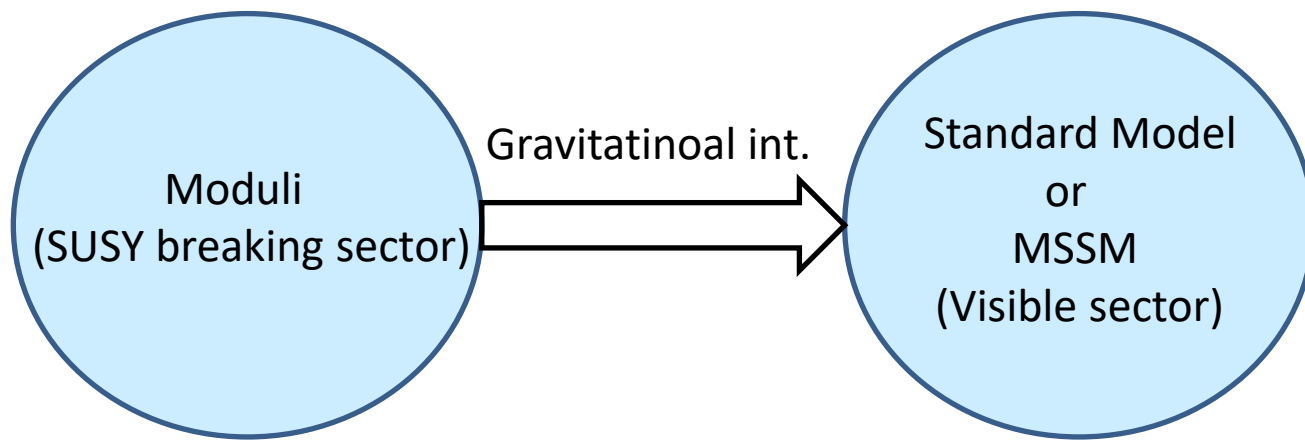
- D3 branes at singularities

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Advantages:

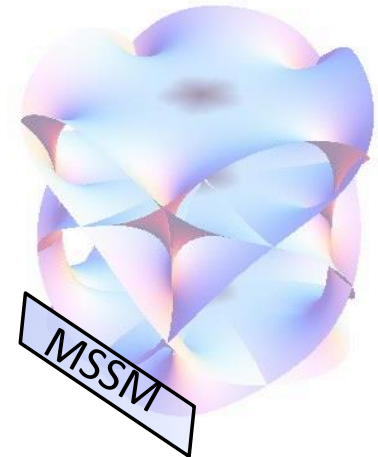
- reconciles a high inflationary scale with low-energy SUSY (which explains the smallness of EW scale)
- avoids any cosmological moduli problem



1. “Local model” (Sequestered string model)

- D3 branes at singularities

$$m_{\text{Sparticle}} \ll m_{3/2} \sim \frac{M_{\text{Pl}}}{V}$$



Constraints :

- SUSY flavor problems
- Stability problems in MSSM
- Charge and color breaking (CCB) minima etc.

Short summary

Sequestered string models

$$m_{\text{Sparticle}} \ll m_{3/2} \sim \frac{M_{\text{Pl}}}{V}$$

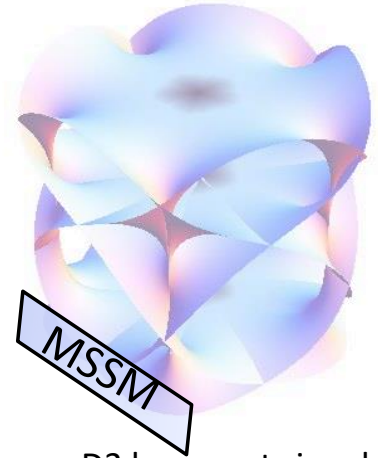
Constraints :

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- Charge and color breaking (CCB) minima in MSSM



Sequestering with

- Spectrum ($m_{\text{Sfermions}} \sim M_{\text{gaugino}}$) violates stability conditions
- A split SUSY spectrum ($M_{\text{gaugino}} \ll m_{\text{Sfermions}}$) is viable



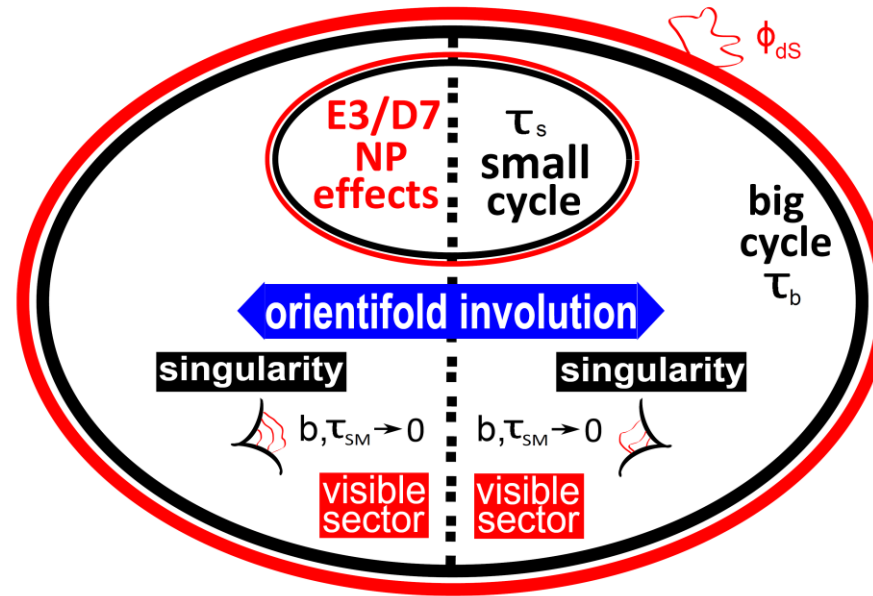
D3 branes at singularities

Thank you!⁹

String models with sequestered SUSY breaking

Moduli stabilization and SUSY breaking are under computational control

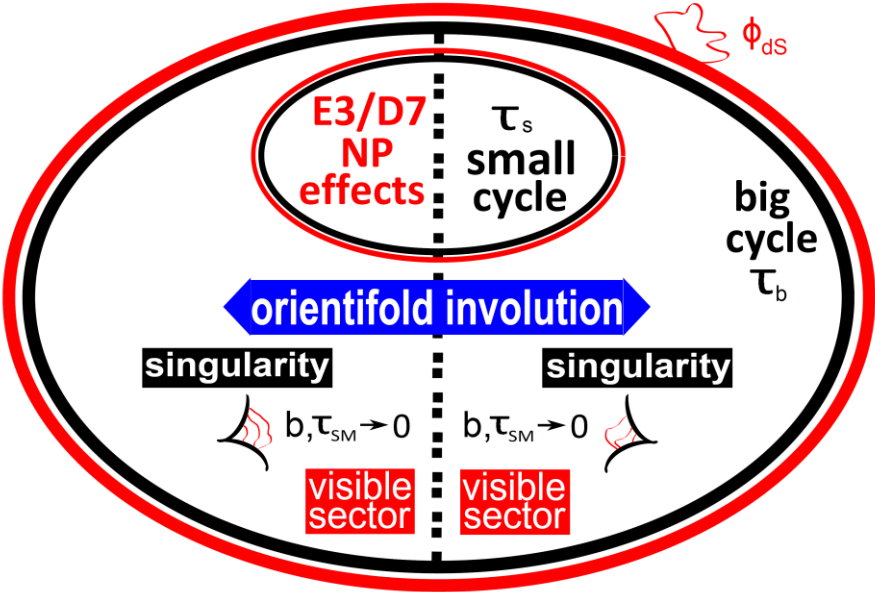
Setup : Type IIB flux compactifications with O3/O7-planes



From Fig. 1 of 1409.1931

1. String coupling g_s and complex structure moduli are fixed by fluxes
2. Big cycle $\tau_b \sim e^{2c/3g_s}$ and small cycle τ_s are stabilized as in LVS
3. MSSM is realized on D3-branes at a del Pezzo singularity
4. dS minimum can be realized by E(-1)-instantons (localized at $\tau_{dS} \rightarrow 0$)

Setup : Type IIB flux compactifications with O3/O7-planes



From Fig. 1 of 1409.1931

Physical Yukawa couplings (independent of the overall volume) :

$$Y_{\alpha\beta\gamma} = \frac{e^{\frac{K}{2}} y_{\alpha\beta\gamma}}{\sqrt{K_{\alpha\bar{\alpha}} K_{\beta\bar{\beta}} K_{\gamma\bar{\gamma}}}}$$

- $K_{\alpha\bar{\alpha}}$: Matter Kahler metric
- $y_{\alpha\beta\gamma}$: Hol. Yukawa couplings
- K : Kahler potential

Ansatz for matter Kahler metric :

$$K_{\alpha\bar{\alpha}} = h_{\alpha\bar{\alpha}}(U, S) e^{K/3}$$

- U : Complex structure moduli
- S : Axio-dilaton

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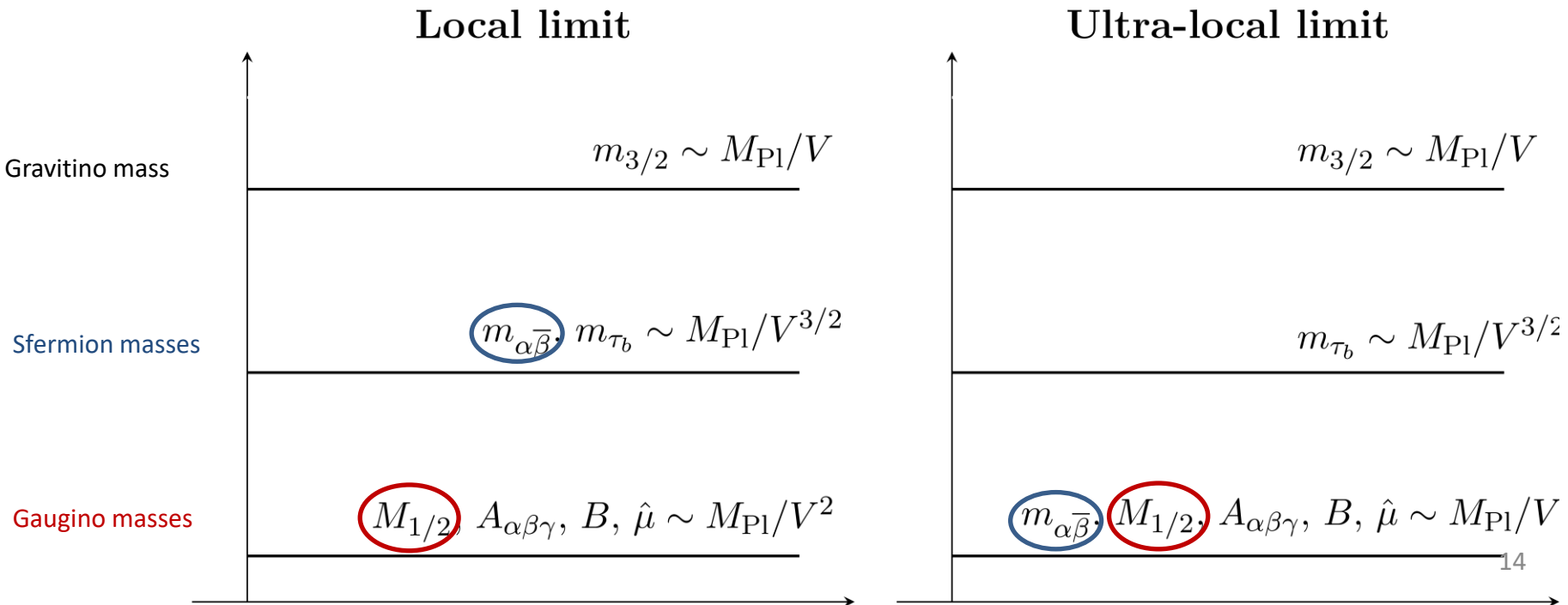
1. Local limit : it holds only at **leading order** in $V \gg 1$
2. Ultra-local limit : it holds also at **subleading order** in $V \gg 1$

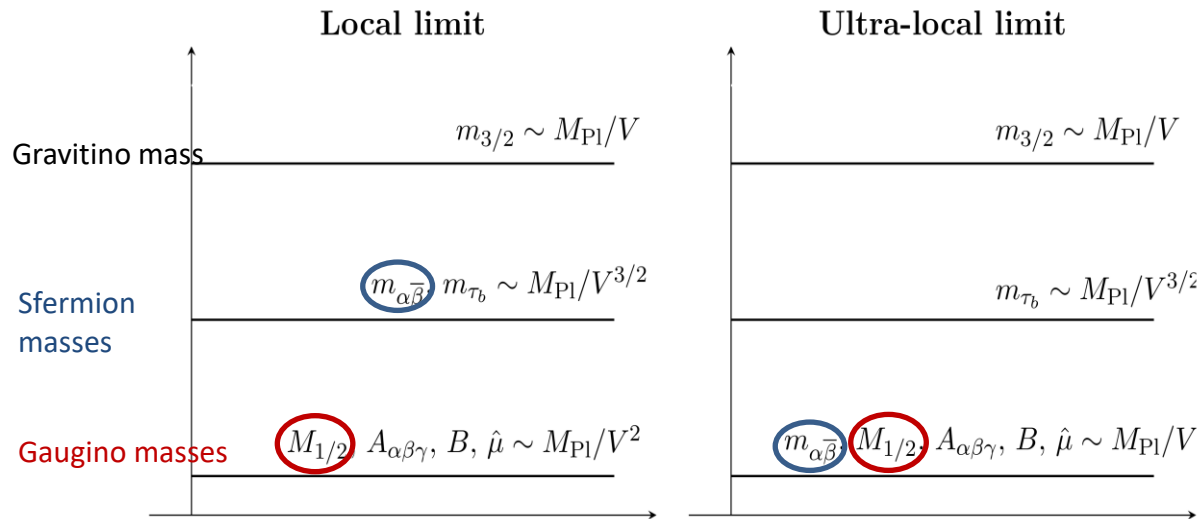
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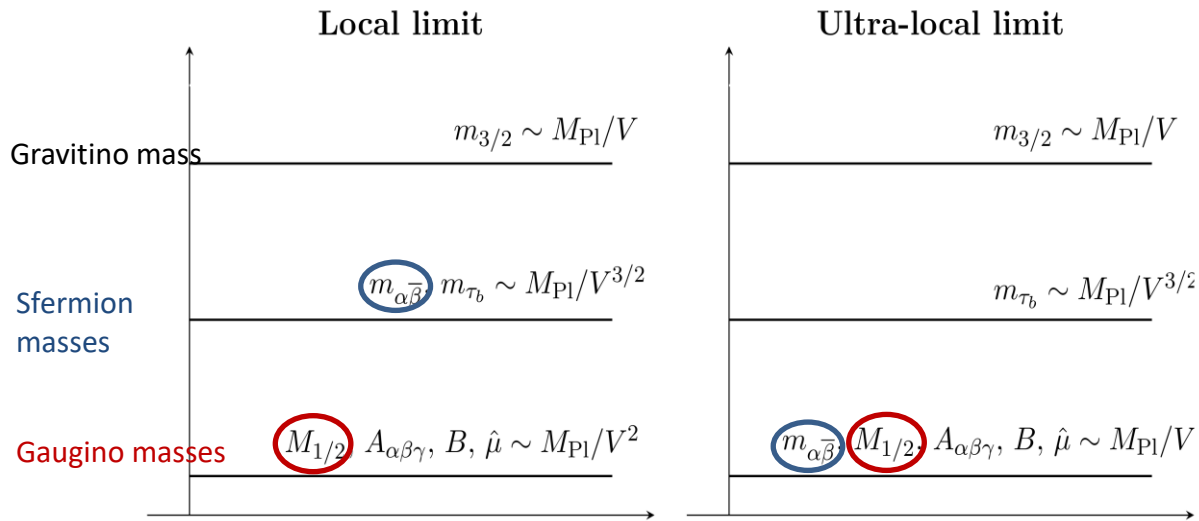
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1. Local limit (Split SUSY spectrum)

- No SUSY Flavor problems
- No stability problems in MSSM
- SUSY breaking soft-terms will be universal at leading order (determined by F-term of volume modulus)



2. Ultra-local limit ($m_{\text{Sfermions}} \sim M_{\text{gaugino}}$)

- No SUSY Flavor problems as long as $m_{\text{Sfermions}} > 10^6 \text{ GeV}$
- violates stability conditions (CCB minimum) in MSSM: Casas-Lleyda-Munoz ('95)
Casas-Dimopoulos ('96),..

E.x., in the lepton sector,
$$\left| \hat{A}_{\alpha\beta}^{(l)} \right|^2 \leq \left(Y_{\alpha\beta}^{(l)} \right)^2 \left(m_{L_\alpha}^2 + m_{R_\beta}^2 + m_{H_d}^2 \right)$$

$\alpha, \beta = 1, 2, 3$

is violated since $\hat{A}_{11}^{(l)} \sim Y_\tau m_0, Y_{11}^{(l)} = Y_e$

Conclusion

Sequestered string models

$$m_{\text{Sparticle}} \ll m_{3/2} \sim \frac{M_{\text{Pl}}}{V}$$

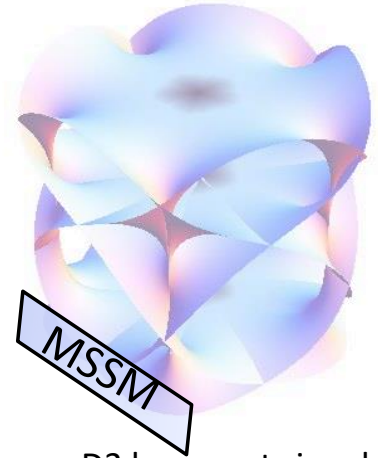
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