SOME PHENOMENOLOGICAL ANALYSES IN STRING THEORY AND M-THEORY

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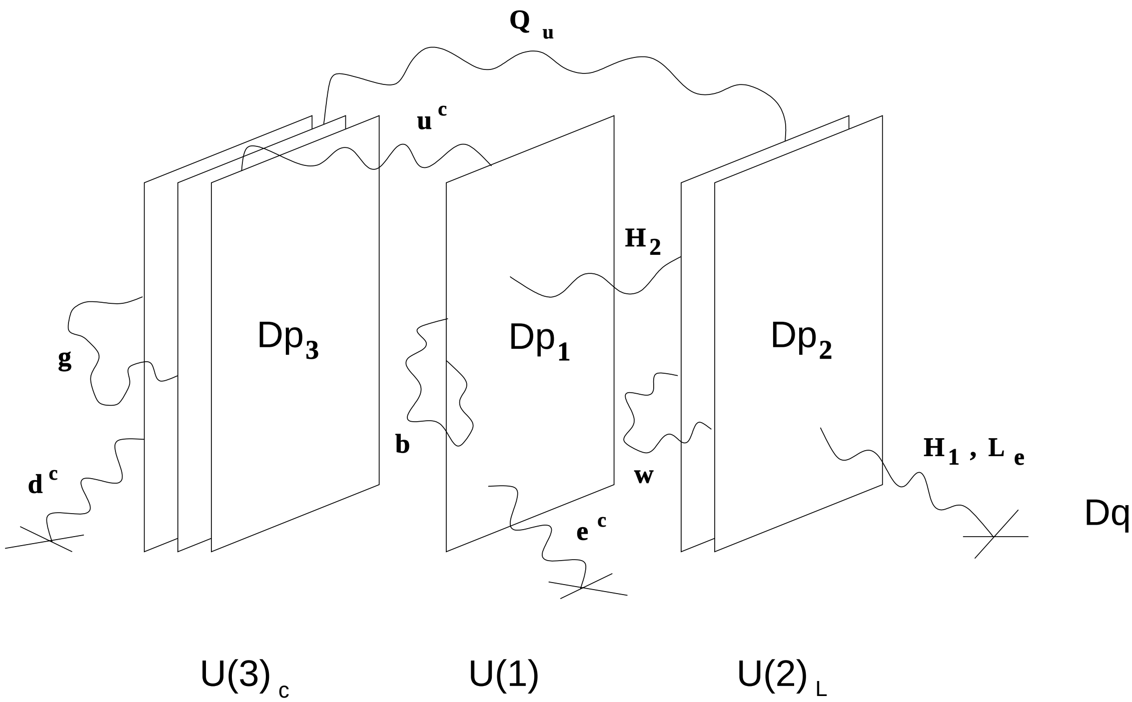
The string scale in D-brane scenarios

The MSSM can be built using D-brane configurations.



The SM gauge group can be embedded within

- ... the same set of D-branes
- ... different sets of D-branes

$U(1)_Y$ is in general a linear combination of the remaining $U(1)$ that reproduces the correct hypercharge for the matter.

$$Y = c_3\sqrt{6}Q_3 + c_2\sqrt{4}Q_2 + \sqrt{2}Q_1$$

(Antoniadis, Kiritsis, Tomaras '00)

From this ...

$$\frac{1}{\alpha_Y(M_I)} = \frac{2}{\alpha_1(M_I)} + \frac{4c_2^2}{\alpha_2(M_I)} + \frac{6c_3^2}{\alpha_3(M_I)}$$

... and the usual RGE's for gauge couplings

$$\frac{1}{\alpha_j(M_I)} = \frac{1}{\alpha_j(M_Z)} + \frac{b_j^{ns}}{2\pi}\ln\frac{M_s}{M_Z} + \frac{b_j^{s}}{2\pi}\ln\frac{M_I}{M_s}$$

An expression for the string scale in terms of low-energy data ($\alpha_i(M_Z)$) is found, e.g.,

$$\boxed{\ln\frac{M_I}{M_s} = 33.09 - \frac{1.05}{\alpha_1(M_I)} - 1.22\ln\frac{M_s}{M_Z}}$$

$$0.07 \lesssim \alpha_1(M_Z) \lesssim 0.1 \quad \rightarrow \quad M_I \approx 10^{10-12}\ \text{GeV}$$

• This possibility also arises for other configurations, such as $Dp_1 = Dp_3$ or considering the SM gauge group to be embedded within the same set of D-branes.

(Cerdeño, Gabrielli, Khalil, Muñoz, Torrente-Luján '01)

Soft SUSY-breaking terms

Under the assumption of dilaton/moduli supersymmetry-breaking, the structure of soft terms can be evaluated.

(Ibáñez, Muñoz, Rigolin '99)

These are generically non-universal, e.g., for the case of gaugino masses:

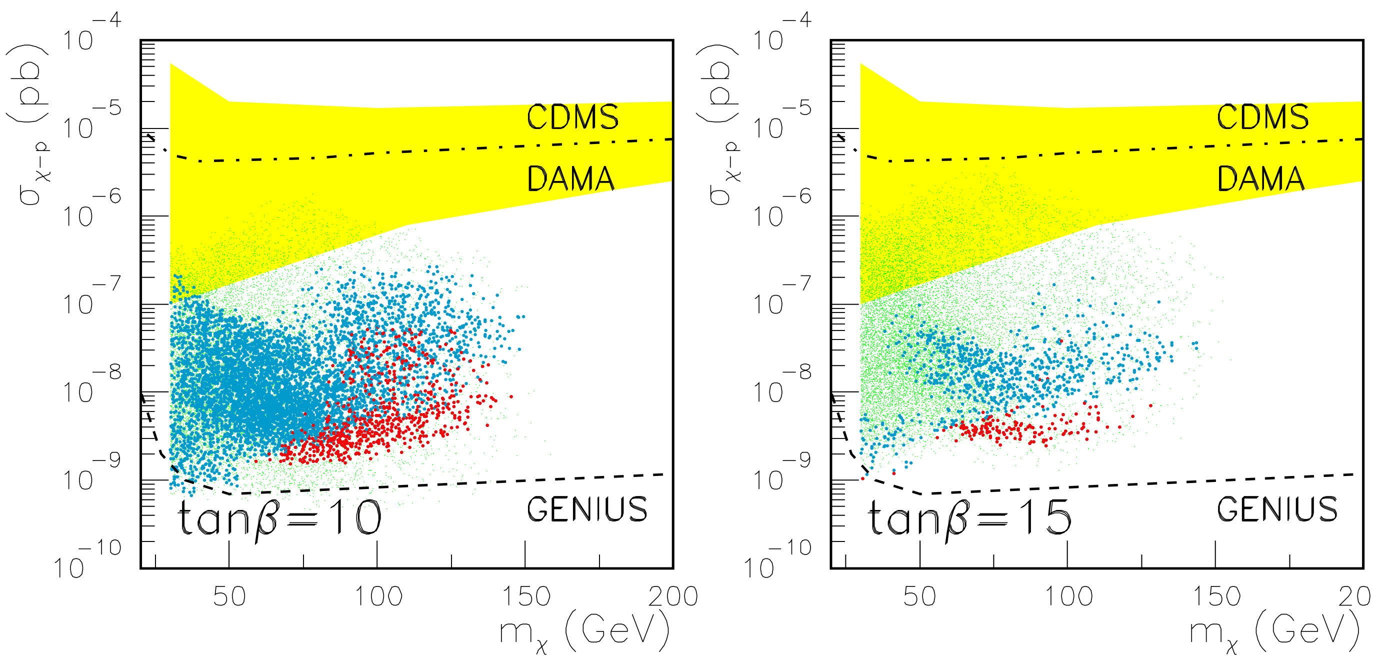
$$\begin{aligned}
M_3 &= \sqrt{3} m_{3/2} \sin\theta \ , \\
M_2 &= \sqrt{3} m_{3/2}\, \Theta_1 \cos\theta \ , \\
M_Y &= \sqrt{3} m_{3/2}\, \alpha_Y(M_I) \left(\frac{2}{\alpha_1(M_I)} \Theta_3 \cos\theta \right. \\
&\quad \left. + \frac{1}{\alpha_2(M_I)} \Theta_1 \cos\theta + \frac{6 c_3^2}{\alpha_3(M_I)} \sin\theta \right)
\end{aligned}$$

And also for the scalar masses and trilinear parameters.

Dark matter implications

Intermediate scales, together with non-universality of the soft terms may induce an increase of the interaction cross-section of supersymmetric dark matter (lightest neutralinos, $\tilde{\chi}_1^0$) in Earth detectors.

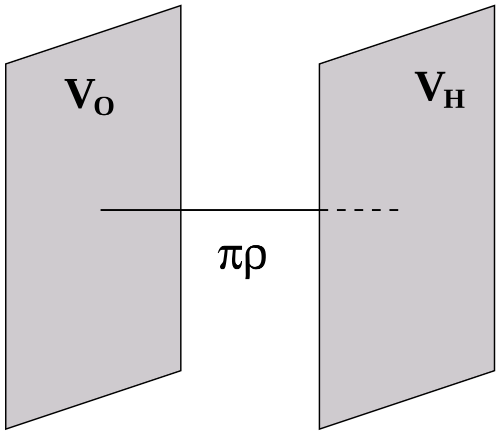
(Gabrielli, Khalil, Muñoz, Torrente-Luján '00)
(Accomando, Arnowitt, Dutta, Santoso '00)
(Arnowitt, Dutta '01)



This is here the case and compatibility with DAMA is possible.

(Cerdeño, Gabrielli, Khalil, Muñoz, Torrente-Luján '01)
(Cerdeño, Gabrielli, Muñoz '02)

Scales and soft SUSY terms in Heterotic M-theory



πρ = Orbifold Radius

V = Calabi−Yau Volume

M_{11} = 11d Planck mass

The GUT scale is identified with the Calabi-Yau compactification scale on the observable hyperplane, $V_O^{-1/6}$.

- Typically, $V_O^{-1/6} \approx 3 \times 10^{16}$ GeV.

  It can, however, be decreased under special circumstances.

  (Benakli '99)
  (Cerdeño, Muñoz '99)

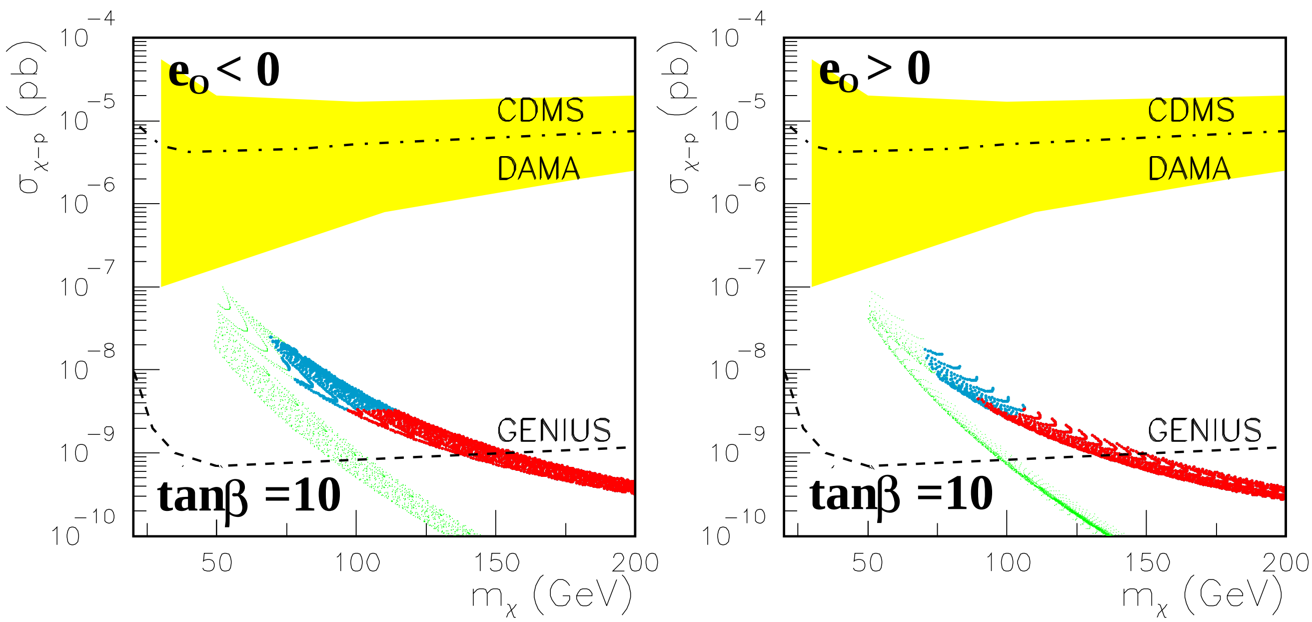
- We have considered a compactification on a CY with only one modulus (or overall modulus), in order to obtain universal soft terms.

  The soft terms are calculated taking into account the effect of five-branes in the bulk.

  (Cerdeño, Muñoz '02)

Dark matter implications of Heterotic M-theory

Being the soft terms universal and the initial scale for their running of the order of 10^{16} GeV, the predictions for $\sigma_{\tilde{\chi}_1^0 - p}$ are below the present sensitivities.



No compatibility with DAMA is achieved.

(Cerdeño, Muñoz '02)

CONCLUSIONS

♣ D-brane scenarios

- Intermediate scales, $\sim 10^{10-12}$ GeV, appear naturally in D-brane scenarios when low-energy experimental data are imposed.
- Non-universal soft terms are common in these scenarios.
- Interesting phenomenological implications, e.g., increasing the cross-section for dark matter detection is possible.

♣ Heterotic M-theory

- We have considered high values for the scale $\sim 3 \times 10^{16}$ GeV, and universal soft terms.
- The predictions for dark matter detection are much smaller, e.g., compatibility with DAMA is not achieved.