De la Supersymétrie à la matière noire

Un voyage vers la Physique au-delà du Modèle Standard

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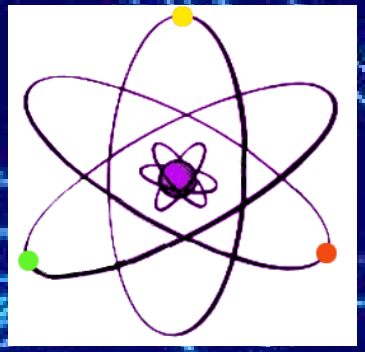
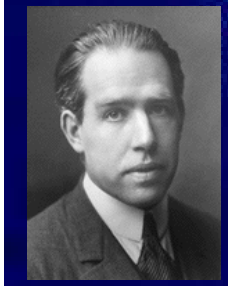
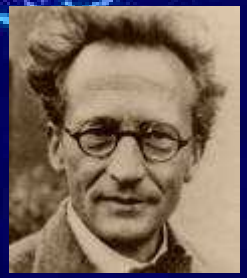
Introduction:
De l'infiniment grand à l'infiniment petit.



Physique Quantique

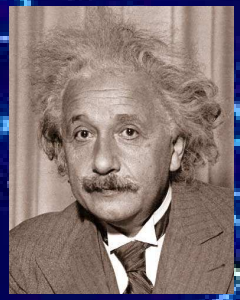


Bohr
(1922)



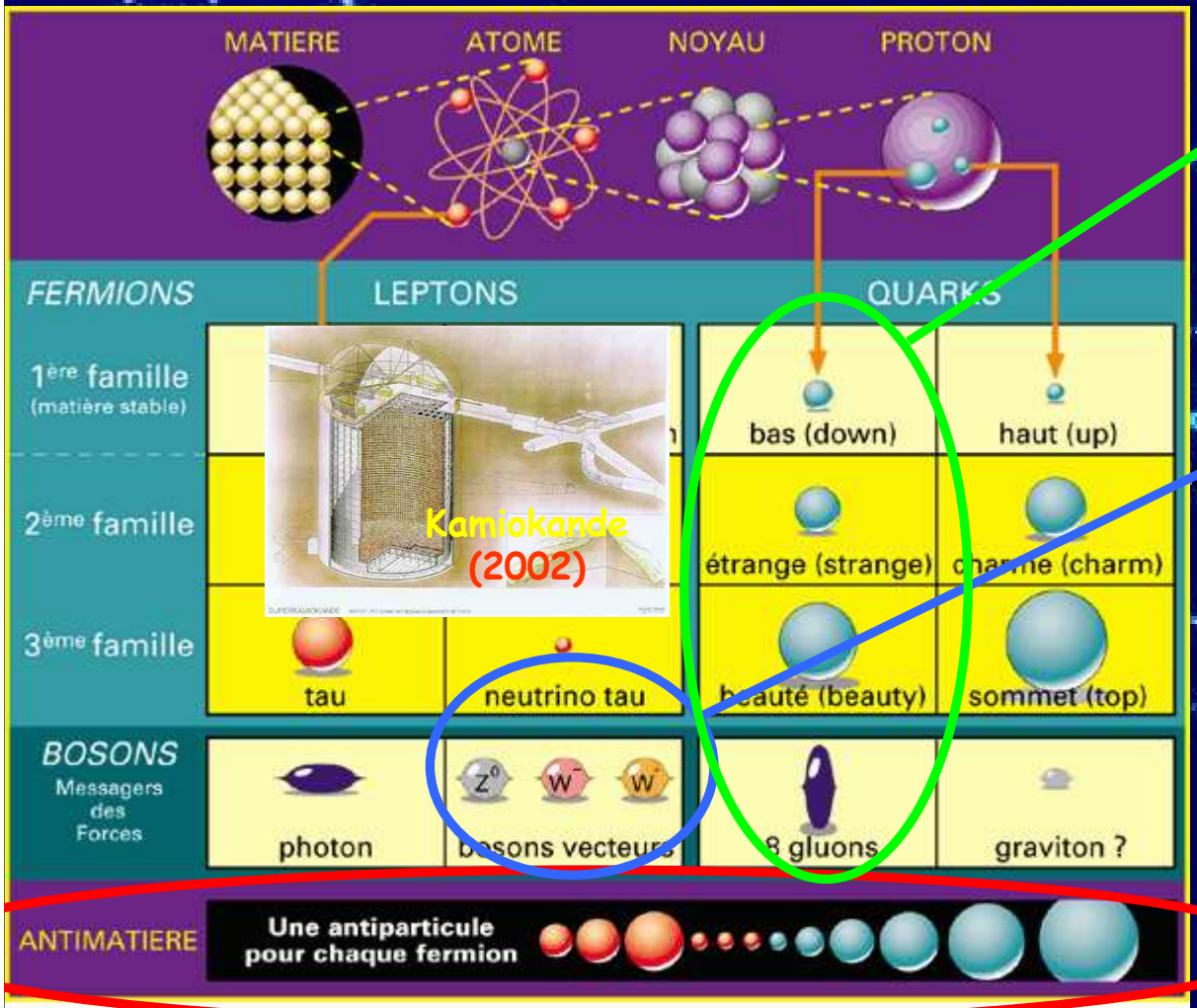
Schrodinger
(1933)

Pauli
(1945)



Einstein
(1921)

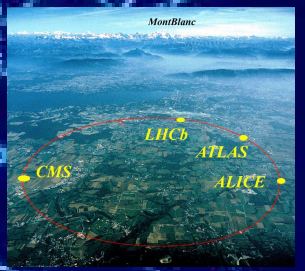
Le Modèle Standard de la physique des particules



Gross
(2004)

Politzer Wilczek
(2004)

Weinberg
(1973)

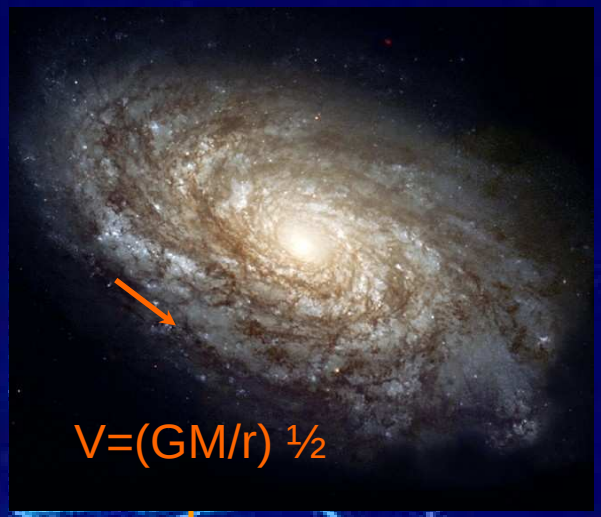


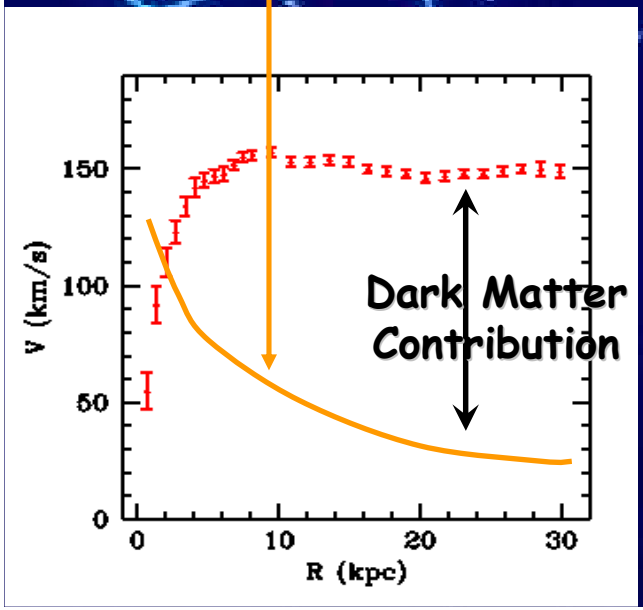
Rubbia
(1983)

Dirac
(1933)

Anderson
(1936)

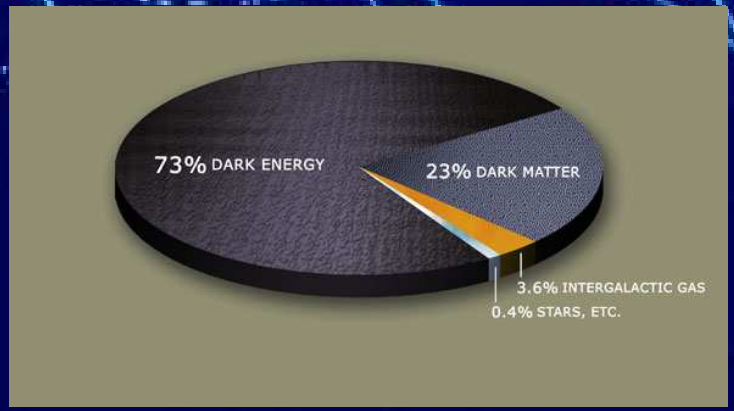
Les insuffisances du MS (I)
La matière noire





Zwicky (1931)

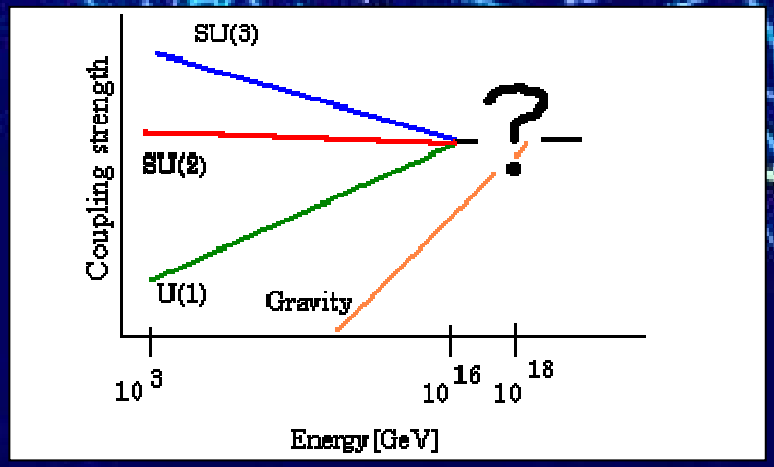
$\rho \sim 1/r^2$



Les insuffisances du MS

La masse des neutrino

Où est passé la gravité?



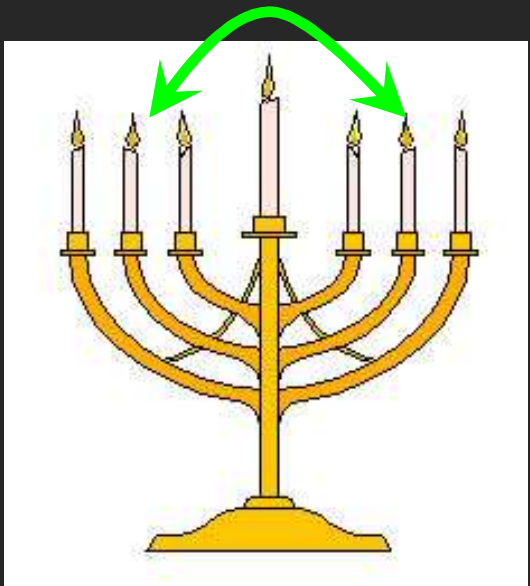
La hiérarchie

Le rôle (fondamental) des symétrie en physique des particules

Il existe deux types de symétries

Les symétries d'espace-temps : translation / rotation

Les symétries internes



Menorah' = (cos θ +i sin θ)*Menorah

$$\text{Menorah}' = e^{i\theta}\ \text{Menorah}$$

Symétrie U(1)

$$\mathcal{L} = \overline{\psi}\,\gamma^{\mu}\,\partial_{\mu}\,\psi + m\,\overline{\psi}\,\psi$$

$$\psi' = e^{i\theta(x)}\,\psi \qquad \text{Symétrie U(1)}$$

$$\mathcal{L} + \mathcal{L}_{U(1)} = \overline{\psi}\,(\gamma^{\mu}\partial_{\mu} + A_{\mu})\,\psi + m\,\overline{\psi}\,\psi$$

$$\begin{pmatrix} \Psi_{\nu} \\ \Psi_{e} \end{pmatrix}' = e^{i\theta(x)T} \begin{pmatrix} \Psi_{\nu} \\ \Psi_{e} \end{pmatrix} \qquad \text{Symétrie SU(2)}$$

$$\mathcal{L} + \mathcal{L}_{U(1)} + \mathcal{L}_{SU(2)} = \overline{\psi}\,(\gamma^{\mu}\partial_{\mu} + A_{\mu} + B_{\mu})\,\psi$$

$$\begin{pmatrix} q \\ q \\ q \end{pmatrix}' = e^{i\theta(x)T} \begin{pmatrix} q \\ q \\ q \end{pmatrix} \qquad \text{Symétrie SU(3)}$$

$$\mathcal{L} + \mathcal{L}_{U(1)} + \mathcal{L}_{SU(2)} + \mathcal{L}_{SU(3)} = \overline{\psi}(\gamma^{\mu}\partial_{\mu} + A_{\mu} + B_{\mu} + G_{\mu})\psi$$

SUperSYmétrie, Supergravité

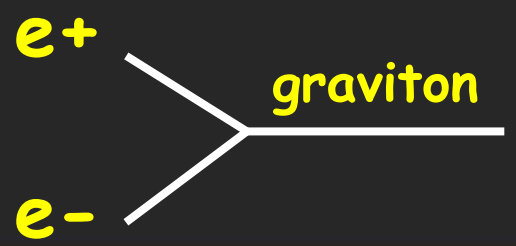
Fermions $\longleftrightarrow$ SUSY $\longrightarrow$ Bosons

$e^{i\zeta(x)}$ (↑) = ↓

$e^{i\zeta_1(x)}\, e^{i\zeta_2(x)} = P(x)$ Translation espace temps

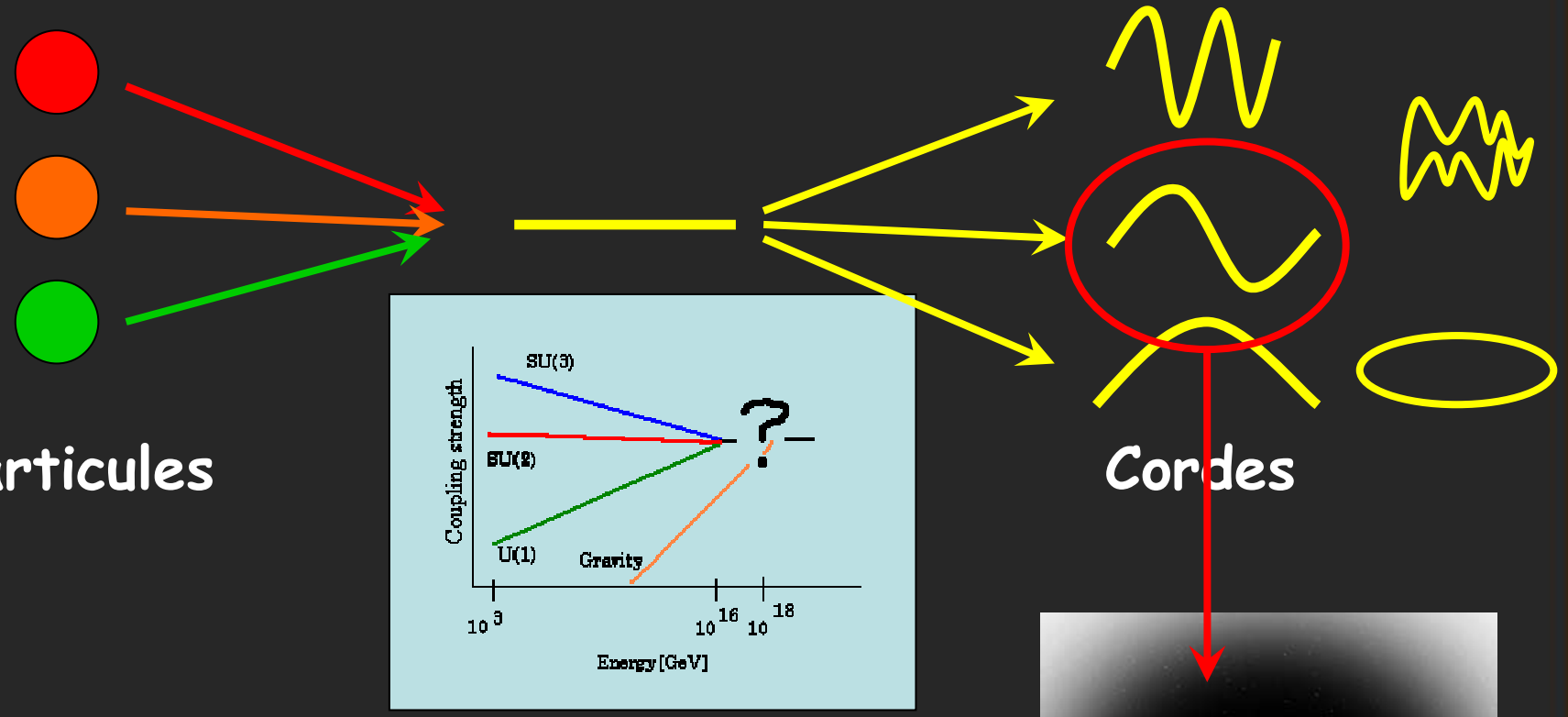
$$\mathcal{L}_{SUGRA} = \mathcal{L}_{U(1)} + \mathcal{L}_{SU(2)} + \mathcal{L}_{SU(3)} + \mathcal{L}_{einstein}$$

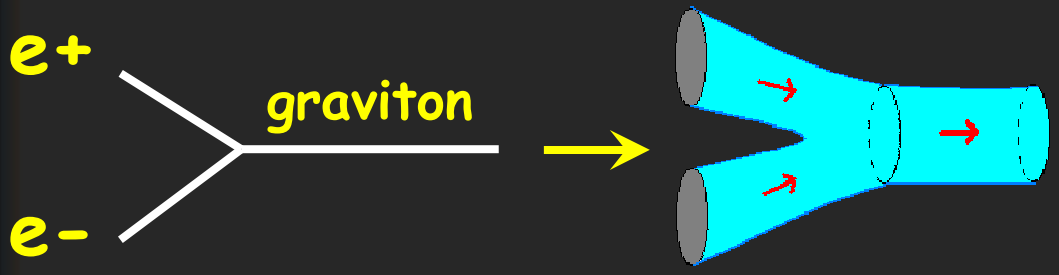
Probleme : SUGRA
pas renormalisable



= infini

La théorie des cordes





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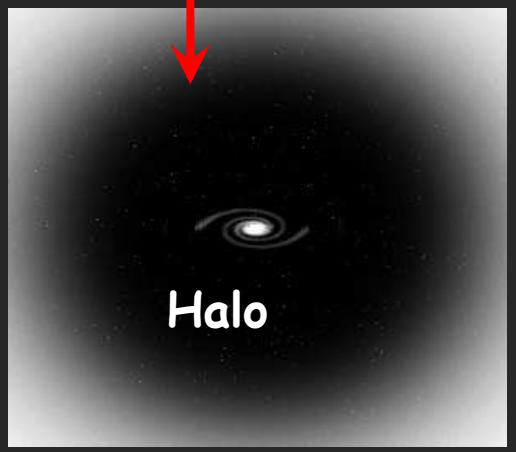
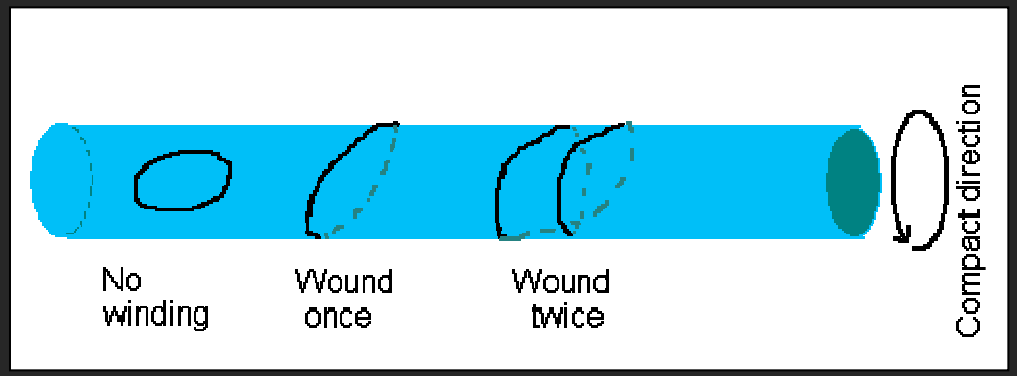
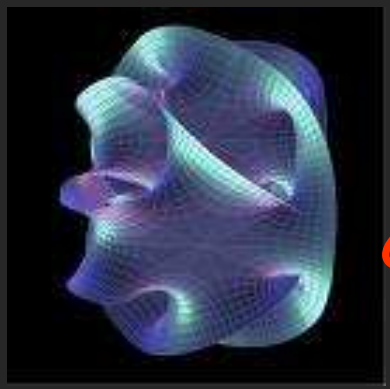


Les dimensions supplémentaires

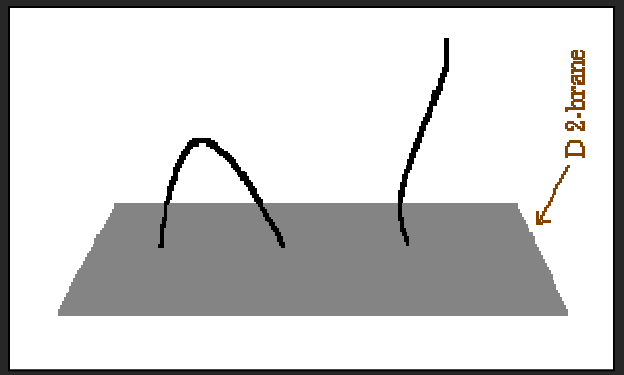
MAIS, la théorie est libre d'anomalies uniquement en 9 (6 + 3) dimension d'espace (10 d'espace-temps). 6 dimensions compactes



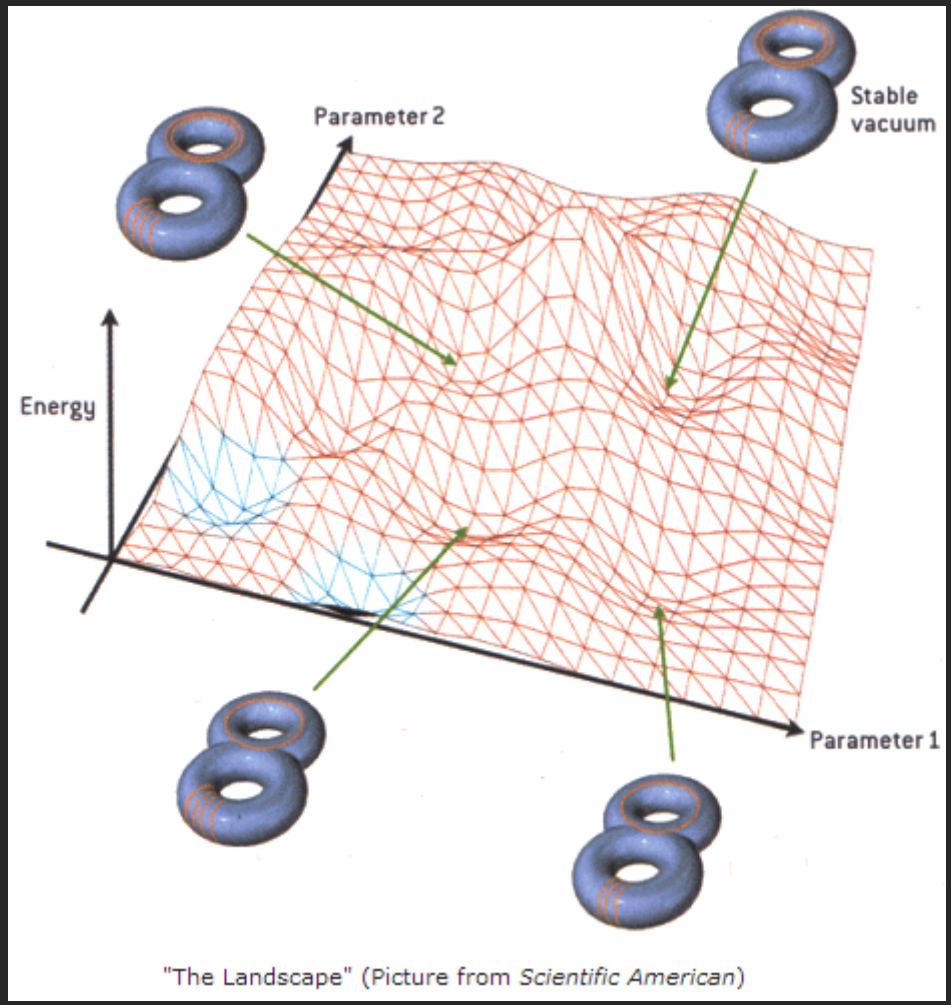


Espace de Calabi-Yau

Brane Worlds



The « String Landscape »



"The Landscape" (Picture from *Scientific American*)

Conclusion

Tout ce qu'il reste à faire

Prédictions matière noire/accélérateur LHC SUSY

Théorie de supergravité cohérente

Comprendre les espaces compacts en théorie de cordes