Interacciones efectivas de Yukawa y texturas universales

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Introduction

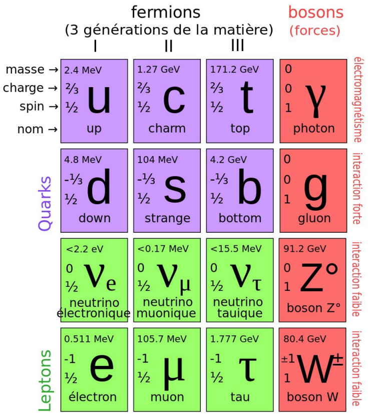

Figure: Particles of the SM

- Gauge theory that unifies the fundamental forces... most of them.
- Able to predict many experimental data.

SM Lagrangian

$$\mathcal{L}_{ME} = \mathcal{L}_G + \mathcal{L}_H + \mathcal{L}_D + \mathcal{L}_Y \quad (1)$$

- $\mathcal{L}_G$ (Gauge sector)
- $\mathcal{L}_H$ (Scalar Sector)
- $\mathcal{L}_D$ (Dirac Sector)
- $\mathcal{L}_Y$ (Yukawa Sector)

Neutrino massess

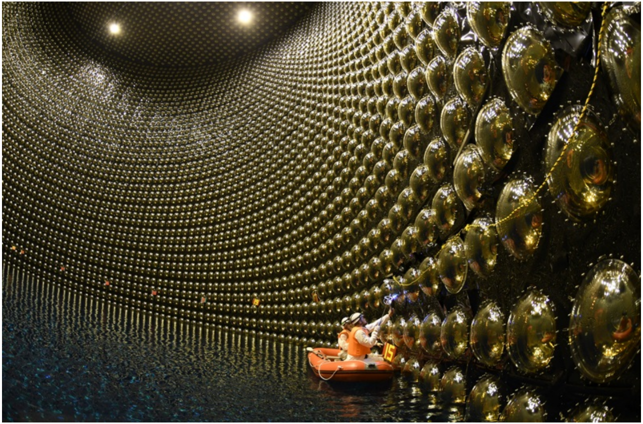

Figure: SuperKamiokande

Dark Matter

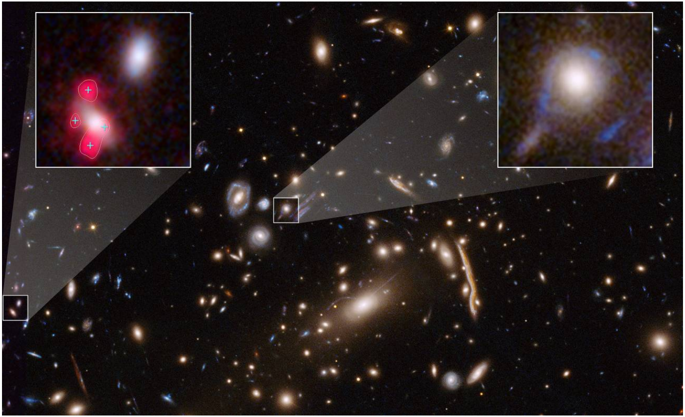

Figure: Gravitational lens

Hierarchy of masses

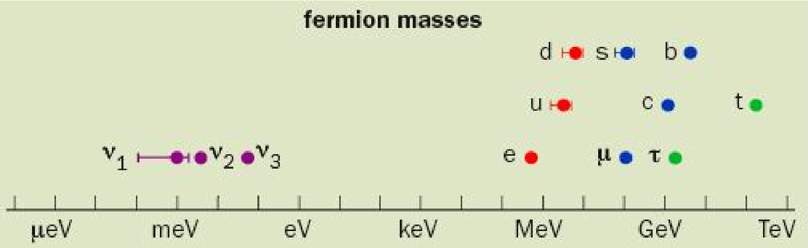

Figure: Hierarchy of masses

SM Questions

- Why we have this hierarchy on the fermions masses?
- All the parameters on the flavour sector are arbitrary? Are connected?

Yukawa Lagrangian

$$\mathcal{L}_Y = Y^d_{ij}\bar{Q}_{Li}\phi D_{Rj} + Y^u_{ij}\bar{Q}_{Li}\tilde{\phi}U_{Rj} + \\ Y^l_{ij}\bar{L}_{Li}\phi l_{Rj} + H.C \tag{2}$$

$$\mathcal{L}_Y = Y^d_{ij}\bar{Q}_{Li}\phi D_{Rj} + Y^u_{ij}\bar{Q}_{Li}\tilde{\phi}U_{Rj} + Y^l_{ij}\bar{L}_{Li}\phi l_{Rj} + \underline{Y^\nu_{ij}\bar{L}_{Li}\tilde{\phi}\nu_{Rj} + \mathcal{L}_m} + H.C \tag{3}$$

Considering the leptonic terms on the Yukawa Lagrangian

$$\mathcal{L}_Y \supset Y^l_{ij} \bar{L}_{Li} \phi l_{Rj} + Y^\nu_{ij} \bar{L}_{Li} \tilde{\phi} \nu_{Rj} + \mathcal{L}_m + HC \tag{4}$$

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About the model

- Entension of the SM that introduces particles of "flavon" types and right handed neutrinos.
- Inspired by the Froggat Nielsen Mechanism

$$\mathcal{L}_Y \supset Y_{ij}^{l} \bar{L_{Li}} \phi l_{Rj} + Y_{ij}^{\nu} \bar{L_{Li}} \tilde{\phi} \nu_{Rj} + HC \tag{5}$$

L_L the doublet of $SU(2)$ that agroups the left fermionic fields , l_R y ν_R are singlets from $SU(2)$. And ϕ it is de Higgs doublet.

If we proposses a "Yukawa Matrix at high energies"

$$Y'^{l}_{ij} = \frac{\lambda_l}{\Lambda} Z^{l\dagger}_{Li}(x) Z^{l}_{Rj}(x) \tag{6}$$

Such that, taking the VEV

$$\langle Y'^{l}_{ij} \rangle = \frac{\lambda_l}{\Lambda} \langle Z^{l\dagger}_{Li}(x) \rangle \langle Z^{l}_{Rj}(x) \rangle = Y^{l}_{ij} \tag{7}$$

Where, Z_L y Z_R are scalar fields transforming as triplets of flavor on the fundamental of $SU(3)_F$.

Where:

$$Z_i = e^{\frac{i\psi_a(x)T_a}{\Lambda_\psi}} X_i(x) \tag{8}$$

And if we rewrite the lagrangian

$$\mathcal{L}_Y \supset \bar{L_{Li}} Y'^{l}_{ij} \phi l_{Rj} + \bar{L_{Li}} Y'^{\nu}_{ij} \tilde{\phi} \nu_{Rj} + HC \tag{9}$$

And taking his explicit form:

$$Y_{ij}^{\prime l} = \frac{\lambda_l}{\Lambda} e^{\frac{-i\psi_a(x)T_a}{\Lambda_\psi}} X_{Li}^\dagger(x) X_{Rj}(x) e^{\frac{i\psi_a(x)T_a}{\Lambda_\psi}} \tag{10}$$

Applying the Baker-Campbell-Hausdorf we have:

$$Y_{ij}^{\prime l} = \frac{\lambda_l}{\Lambda}(X_{Li}^\dagger X_{Rj} - i\frac{\psi_a(x)}{\Lambda_\psi}[T_a, X_{Li}^\dagger X_{Rj}]) \tag{11}$$

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Resultados

- Using Python language we write a code where we generate the Yukawa matrix through the assignment of random parameters.
- χ^2 parameter to filter data.

We want to replicate the observables that we have

- $\Delta m^2_{32} \approx 2.515 \pm 0.027 \times 10^{-3}$
- $\Delta m^2_{21} \approx 7.42 \pm 0.21 \times 10^{-5}$

Δm^2_{32}

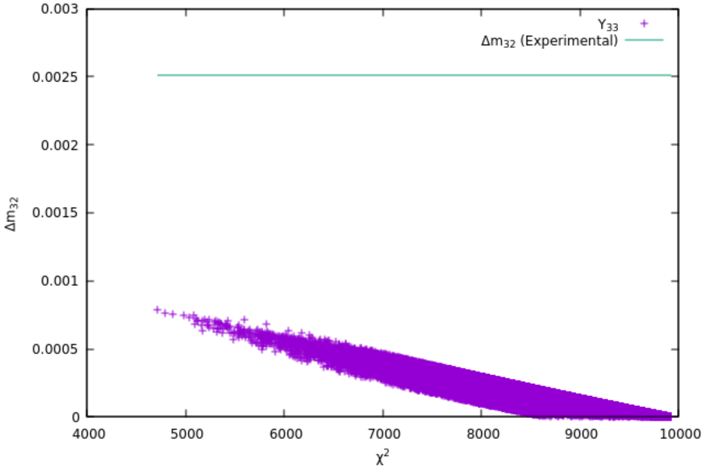

Figure: Δm^2_{32} vs χ^2

Δm^2_{21}

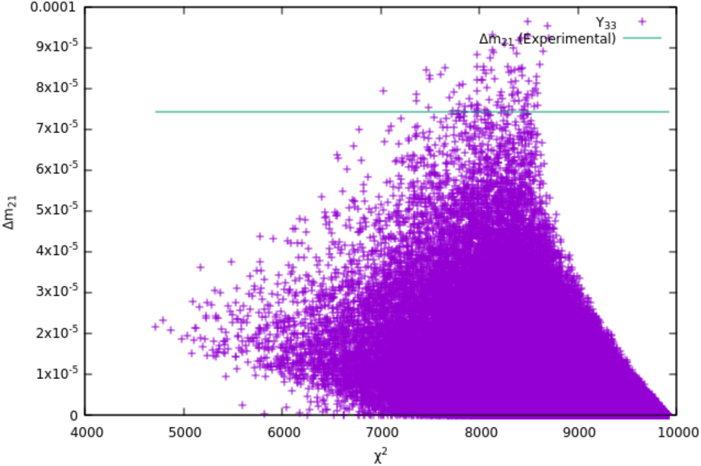

Figure: Δm^2_{21} vs χ^2

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Conclutions and perspective

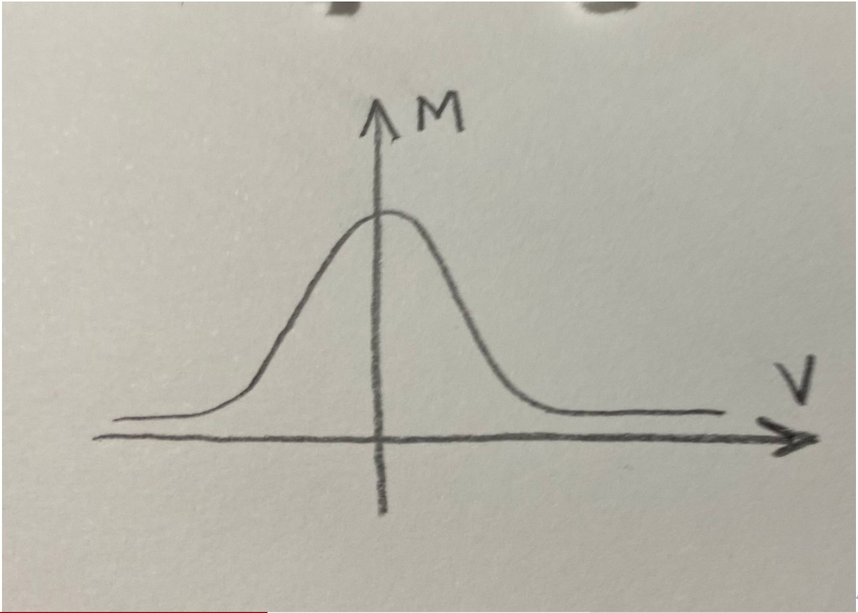
Conclutions

Introducing this structure of flavon type to generate the Yukawa Matrix it is possible to demonstrate that exists a common mechanism to generate the textures whose eigenvalues are the masses of the fermions.

Perspective

It is necessary to improve our model. The next scenario is including Majorana mass terms.

Thanks!



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