Introduction on neutrinos beyond the SM

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3rd BCD school in Cargèse

About leptonic weak interaction

← Charged leptonic sector

← Neutral leptonic sector

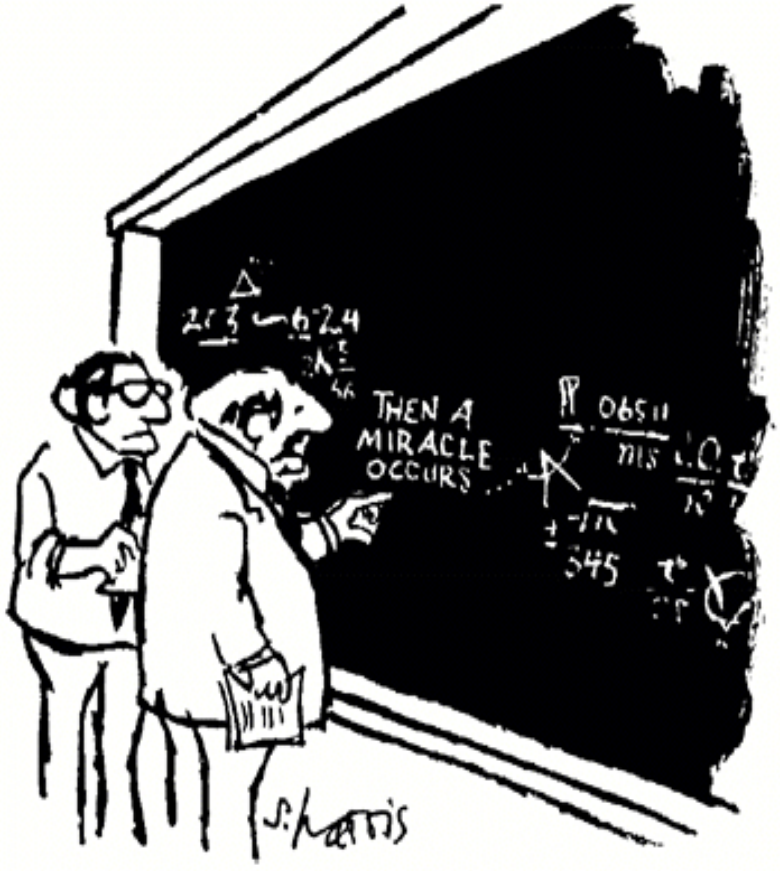
$$\mathcal{L} = \bar{e}_L \tilde{\sigma}^\mu i D_\mu e_L$$

$$-\frac{v}{\sqrt{2}}\, \bar{e}_L \phi M^e e_R + (\text{h.c.})$$

No mass term for neutrinos

Only left handed particles

Neutrino masses



"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

Higgs mechanism as for fermion masses

$$\mathcal{L}_Y = -Y' \, \bar{\nu}'_L \, \phi \, \nu'_R + (\text{h.c.})$$

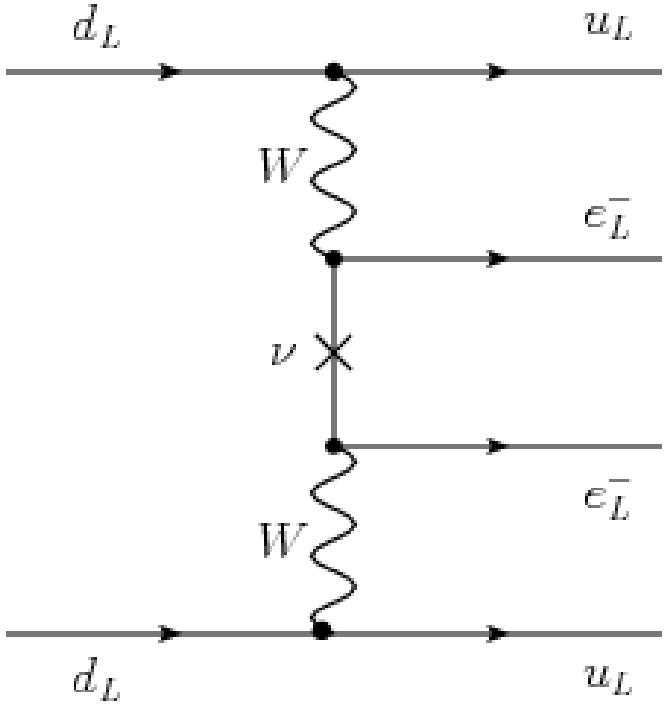
Sterile neutrinos

- Majorana particles
- Singlet

Neutrino masses

$$\mathcal{L} = \frac{1}{2}\frac{gv^2}{\mathcal{M}}\overline{\nu}_L^c \nu_L + h.c. \qquad \psi^c = C\overline{\psi}^T$$

Neutrinoless double beta decay



Particle is its own antiparticule : 2 dof

- RH → antiparticles
- LH → particules

Neutrino oscillation

1957, Pontecorvo : neutrino oscillations as K^0

Weak basis

$$\mathcal{L}_Y = -Y' \, \bar{\nu}'_L \, \phi \, \nu'_R + (\text{h.c.})$$

Mis-alignment of the 2 basis

→ Mixing quarks with PMNS matrix

Mass basis

$$V_L^{\nu\dagger} Y'^{\nu} V_R^{\nu} = Y^{\nu}$$

$$\mathcal{L}_Y = \frac{v}{\sqrt{2}} \bar{\nu}'_L V_R V_R^{\dagger} Y'^{\nu} V_L V_L^{\dagger} \nu'_R + h.c.$$

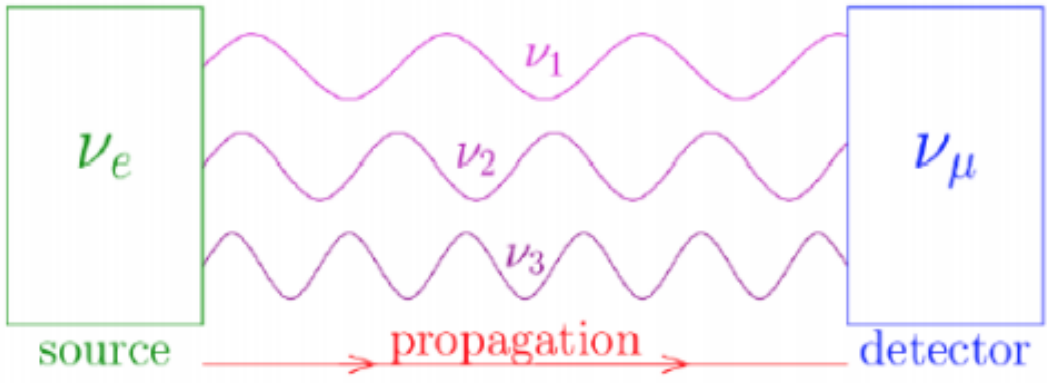
$$= -\frac{v}{\sqrt{2}} \bar{\nu}_L Y^{\nu} \nu_R + h.c.$$

$$\nu_L = V_L^{\dagger} \nu'_L \qquad \nu_R^{\dagger} = \bar{\nu}'_R V_R$$

Experimental expectations

Oscillation probability : (2 generations approximation)

$$P(\nu_\alpha \to \nu_\beta,\ t) = \sin^2 2\theta \sin^2\left(\frac{\Delta m^2}{4E} L\right)$$



C.Giunti

- Flavor states are produced in weak interaction
- Mass states propagate from the source to the detector

Oscillation active/sterile neutrinos
Electron antineutrinos reactor → SOLID experiment