Mapping the viable parameter space for testable leptogenesis

Yannis Georis
based on work in collaboration with M. Drewes and J. Klaric
[arXiv:2106.16226]

Searching for long-lived particles at the LHC and beyond:
Ninth workshop of the LLP Community
CERN, May 28, 2021

UCLouvain

Heavy neutral lepton (HNLs)

Heavy neutrinos can solve three problems at once:

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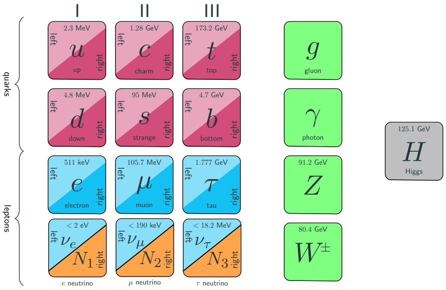

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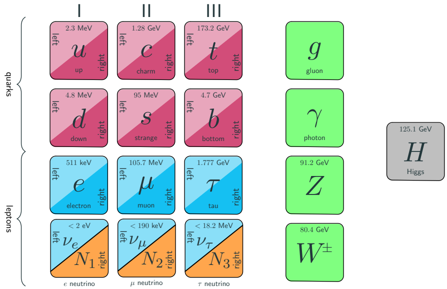

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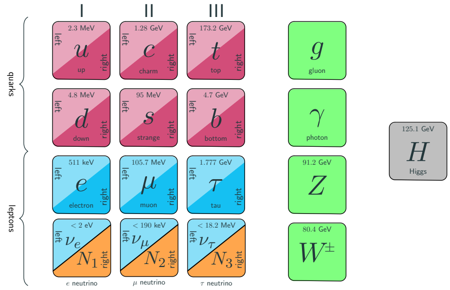
- Can be a **Dark Matter** candidate (**Dodelson/Widrow, hep-ph/9303287, Asaka/Shaposhnikov, hep-ph/0505013**)



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$\hookrightarrow$ Represented by the same set of equations !
(**cfr. B.Garbrecht 1812.02651**)

Quantum kinetic equations

$$i\frac{\mathrm{d}n_{\Delta_\alpha}}{\mathrm{d}t} = -2i\frac{\mu_\alpha}{T}\int\frac{\mathrm{d}^3k}{(2\pi)^3}\mathrm{Tr}[\Gamma_\alpha]\ f_N(1-f_N) + i\int\frac{\mathrm{d}^3k}{(2\pi)^3}\mathrm{Tr}[\overline{\Gamma}_\alpha(\rho_N-\rho_{\overline{N}})]$$

$$i\frac{\mathrm{d}\rho_N}{\mathrm{d}t} = [H,\rho_N] - \frac{i}{2}\{\Gamma,\rho_N-\rho_N^{eq}\} - \frac{i}{2}\sum_\alpha\overline{\Gamma}_\alpha\left[\frac{2\mu_\alpha}{T}\ f_N(1-f_N)\right]$$

$$i\frac{\mathrm{d}\rho_{\overline{N}}}{\mathrm{d}t} = -[H^*,\rho_{\overline{N}}] - \frac{i}{2}\{\Gamma^*,\rho_{\overline{N}}-\rho_{\overline{N}}^{eq}\} + \frac{i}{2}\sum_\alpha\overline{\Gamma}^*_\alpha\left[\frac{2\mu_\alpha}{T}\ f_N(1-f_N)\right]$$

- Rate equations for density matrices $\rho_N, \rho_{\overline{N}}$ and chemical potential μ_α.
- Allow to cover the whole mass range 100 MeV- 70 TeV

Seesaw type-I

- Seesaw mass term

$$\mathscr{L} \supset \frac{1}{2} \begin{pmatrix} \overline{\nu}_L & \overline{\nu}_R^c \end{pmatrix} \cdot \begin{pmatrix} 0 & m_D \\ m_D^t & M_M \end{pmatrix} \cdot \begin{pmatrix} \nu_L^c \\ \nu_R \end{pmatrix}$$

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- B-L approximate symmetry allows to avoid the naive seesaw bound

$$U_i^2 \sim \frac{\sqrt{\Delta m^2_{atm} + m^2_{light}}}{M} \lesssim 10^{-10} \frac{\text{GeV}}{M_i}$$

n=2 leptogenesis

Large U^2
$\longrightarrow$ large washout
$\longrightarrow$ asymmetric Yukawa coupling needed to hide BAU from the washout

Asymmetry

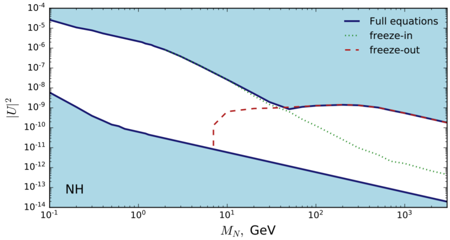
$$f \simeq \frac{\min|F_a|}{\max|F_a|}$$

constrained by neutrino oscillation data

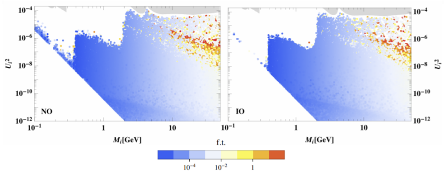
$$f > 5 \cdot 10^{-3}$$

$\longrightarrow$ high U^2 not possible.

For n=3, lepton number violating processes can play a significant role.



Klaric/Shaposhnikov/Timirsyasov 2008.13771



Abada/Arcadi/Domcke/Drewes/Klaric/Lucente hep-ph/1810.12463

n=3 leptogenesis

- Consistency with ν-oscillation data
- Casas-Ibarra parametrisation

$$F = \frac{i}{v} U_\nu \sqrt{m_\nu^{diag}} R \sqrt{M_M}$$

- 3 light neutrino masses (2)
  3 complex angles (1)
  3 Majorana masses (2)
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- Theoretical constraints:

1. Perturbative unitarity $\Gamma < \frac{M}{2}$
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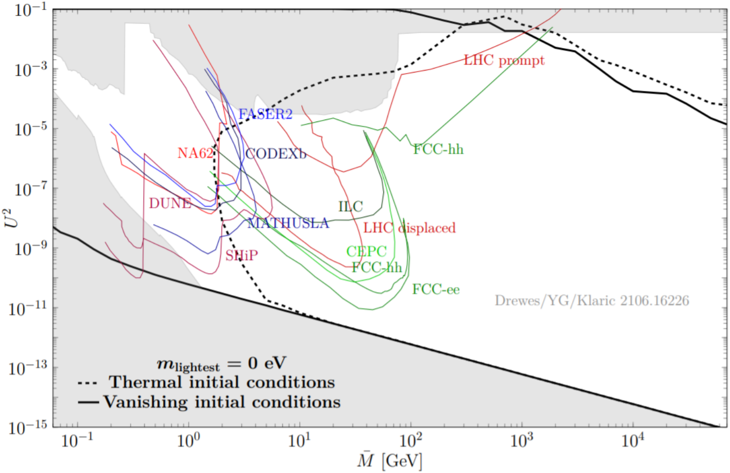
3. No large radiative corrections $(1 - \frac{m_{tree}}{m_{loop}})^2 < \frac{1}{4}$.

Results and conclusions



- Reaches theoretical constraint at low masses.
- Parameter space much larger than for the $n = 2$ scenario.
- Seesaw line reached as for $n = 2$.