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Determining the Masses of Right-Handed Neutrinos in the Littlest Seesaw

INVISIBLES 2018 - **POSTER SESSION**

The Littlest Seesaw [1,2,3]

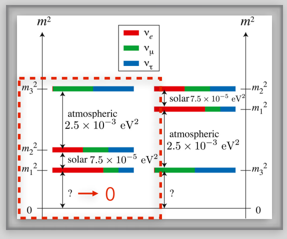
- SM extension with two new RHν singlets: [4]

$$N_R = \begin{pmatrix} N_R^{atm} \\ N_R^{sol} \end{pmatrix}$$

- Additional terms in the Lagrangian:

$$-\mathcal{L}_{LS} = -\mathcal{L}_{SM} + \left(\bar{\ell}_L Y_\nu \tilde{H} N_R + \frac{1}{2} \overline{N_R^c} M_R N_R + h.c. \right)$$

- Normal mass hierarchy with $m_1 = 0$
- Close to maximal atmospheric mixing $(\theta_{23} \simeq \pi/4)$
- Fixes the absolute scale of neutrino masses:



- Relevant Cases (A and D):

$$Y_\nu^A = \begin{pmatrix} 0 & b e^{i\eta/2} \\ a & n b e^{i\eta/2} \\ a & (n-2) b e^{i\eta/2} \end{pmatrix},$$

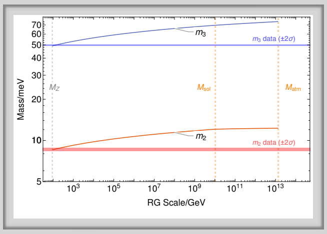
$$M_R^A = \begin{pmatrix} M_{atm} & 0 \\ 0 & M_{sol} \end{pmatrix}$$

$$Y_\nu^D = \begin{pmatrix} b e^{i\eta/2} & 0 \\ (n-2) b e^{i\eta/2} & a \\ n b e^{i\eta/2} & a \end{pmatrix},$$

$$M_R^D = \begin{pmatrix} M_{sol} & 0 \\ 0 & M_{atm} \end{pmatrix}$$

Renorm. Group Evolution [5,6]

Theory defined at $\mu = \Lambda_{GUT}$, data available at low energies ⟹ evolve observables to low scales using RG running (REAP [7]).



Leptogenesis [8]

Lepton asymmetry generated through decay of lightest RHν : $Y_{\Delta\alpha} = \eta_\alpha \epsilon_\alpha Y_{N1}^{eq}$

where
η_α : efficiency factor
ϵ_α : decay asymmetry
Y_{N1}^{eq} : eq. density of RHν

⟹ converted to baryon excess Y_B through sphaleron processes:

$$Y_B = \frac{12}{37} \sum_{\alpha = e,\mu,\tau} Y_{\Delta\alpha}$$

Methodology

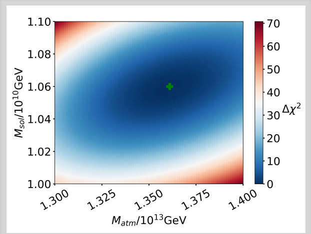
Fit high scale parameters to low scale neutrino data and BAU from Leptogenesis (χ^2 analysis).

Scan over neutrino masses:

$$1.0 \times 10^9 \leq M_1 \leq 5.0 \times 10^{12} \text{ [GeV]}$$
$$5 M_1 \leq M_2 \leq 1.0 \times 10^{16} \text{ [GeV]}$$

$n = 3$
$\eta = \pm 2\pi/3$
→ fixed

and a, b : free parameters

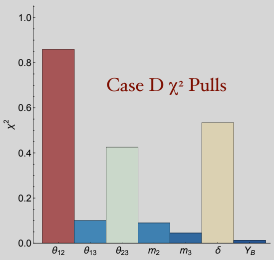


4-dim gridding allows visualisation of χ^2 minimum (B.P. Case D)

Results

	Case A	Case D
M_{atm} / GeV	5.05×10^{10}	1.36×10^{13}
M_{sol} / GeV	5.07×10^{13}	1.06×10^{10}
a	0.00806	0.135
b	0.0830	0.00116
χ^2 / d.o.f.	1.75 / 3	2.07 / 3

Table: Best Fit Points



The best fit point for each case was determined by χ^2 minimisation.

	Case A	Case D	NuFit3.2
θ_{12} / °	34.30	34.33	$33.62^{+0.78}_{-0.76}$
θ_{13} / °	8.59	8.59	$8.54^{+0.15}_{-0.15}$
θ_{23} / °	45.62	44.24	$47.2^{+1.9}_{-3.6}$
Δm_{12}^2 / 10^{-3} eV^2	7.36	7.34	$7.40^{+0.21}_{-0.20}$
Δm_{13}^2 / 10^{-3} eV^2	2.50	2.50	$2.494^{+0.033}_{-0.031}$
δ / °	-87.4	-93.0	-126^{+43}_{-31}
Y_B / 10^{-10}	0.860	0.861	0.87 [9] $^{+0.01}_{-0.01}$

Table: Benchmark Point Observables

Additional studies
- Dependence on Λ_{GUT}
- Future tests of the Littlest Seesaw

Conclusions

- LS is highly predictive: we extract 7 observables from 4 parameters.
- Enables testing in future experiments.
- Allows indirect prediction of RHν masses.
- Suggests $\delta \simeq -90°$, along with excellent fit to all other neutrino and BAU data.

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