Tri-resonant Leptogenesis

Dimitrios Karamitros
University of Jyväskylä

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P. Candia da Silva, DK, T. McKelvey, A. Pilaftsis arXiv:2206.08352[hep-ph] JHEP **11**, 065 (2022)
DK, T. McKelvey, A. Pilaftsis arXiv:2310.03703[hep-ph]

Outline

1. Introduction
   - Matter-antimatter asymmetry
   - Leptogenesis
2. Model
   - Yukawa structure
   - Resonant leptogenesis
3. Leptogenesis and TRL
   - Initial conditions
   - Varying relativistic degrees of freedom
   - Results
4. Summing up

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Introduction – Matter-antimatter asymmetry

Observations consistently show that there are more particles than antiparticles:[1]

$$\eta_B = \frac{n_B}{n_\gamma} \approx 6 \times 10^{-10} \ .$$

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- Baryon-number violation.
- C and CP violation.
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Direct evidence of new physics (?).

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A popular scenario of baryon asymmerty production is *baryogenesis through leptogenesis*:

- CP and L violation from *new physics*.
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Violation of L-number terms are naturally connected to neutrino masses.

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Tri-resonant model:

$$-\mathcal{L}^{\nu_R} = \boldsymbol{h}^{\nu}_{ij}\overline{L}_i\tilde{\Phi}\nu_{R,j} + \frac{1}{2}\overline{\nu}^{C}_{R,i}\left(\boldsymbol{m}_M\right)_{ij}\nu_{R,j} + \mathrm{H.c.}\ ,$$

$$\boldsymbol{h}^{\nu} = \boldsymbol{h}^{\nu}_0 + \delta\boldsymbol{h}^{\nu}\ .$$

$$\boldsymbol{h}^{\nu}_0 = \begin{pmatrix} a & a\,\omega & a\,\omega^2 \\ b & b\,\omega & b\,\omega^2 \\ c & c\,\omega & c\,\omega^2 \end{pmatrix}\ ,$$

with $\omega = exp\left(\frac{2\pi i}{3}\right)$; *i.e.* generator of $\mathbb{Z}_3$.[3]

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Model – Yukawa structure

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Reason: Tree-level and 1-loop neutrino masses vanish at leading order of $\boldsymbol{h}^{\nu}_0$. Dominant contribution comes from $\delta\boldsymbol{h}^{\nu}$.

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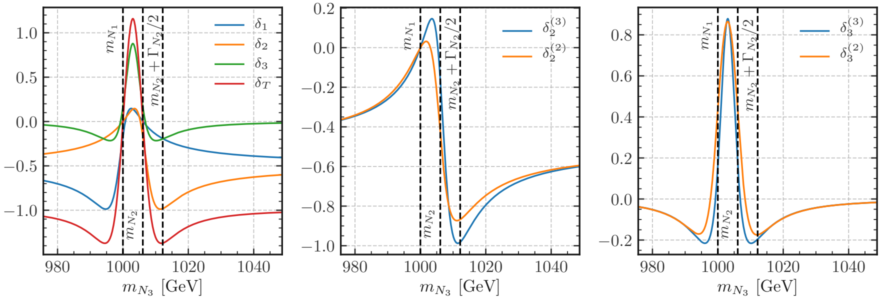
CP asymmetry, is enhanced if two right-handed neutrinos obey

$$|m_{N_\alpha} - m_{N_\beta}| \sim \Gamma_\beta/2 \ .$$

Tri-resonant case produces even larger asymmetry:



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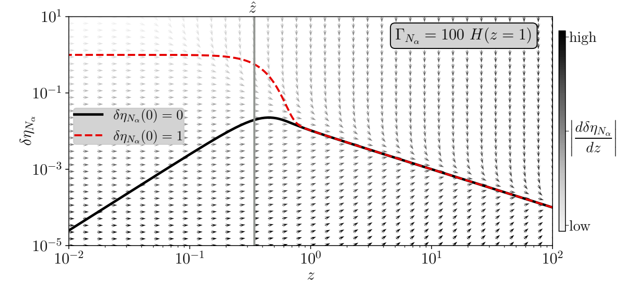

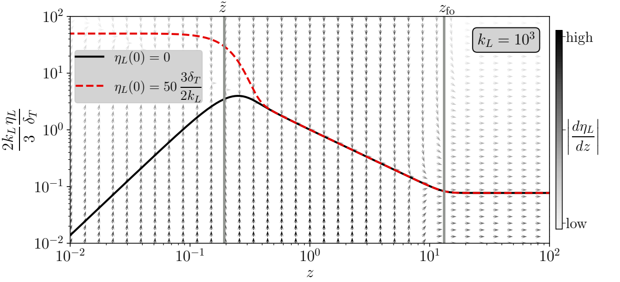

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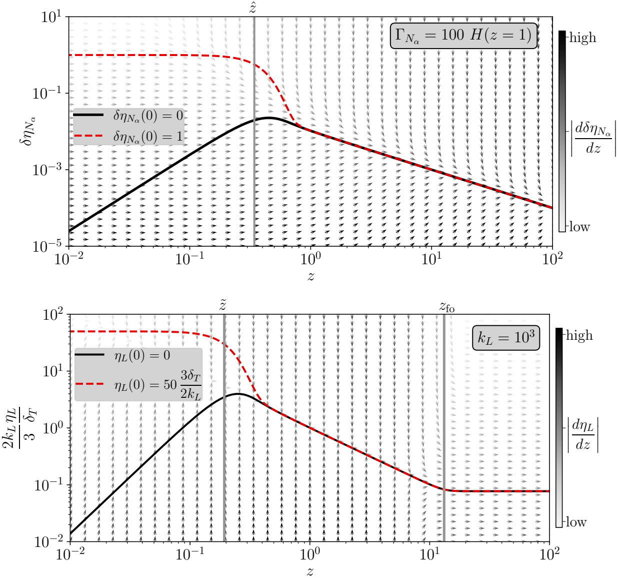

The initial conditions do not really matter!

Leptogenesis and TRL – Varying relativistic degrees of freedom

Changing $d/dt \to d/dT$ introduces extra terms proportional to dh_{eff}/dT (ignored in the literature).

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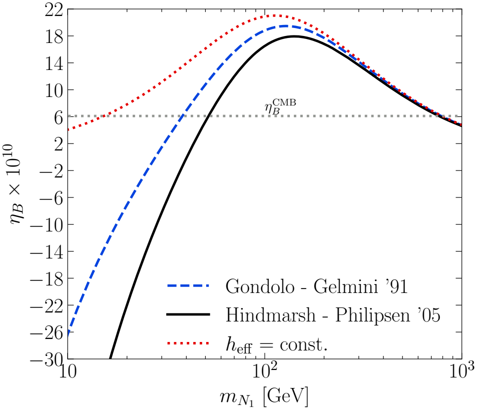
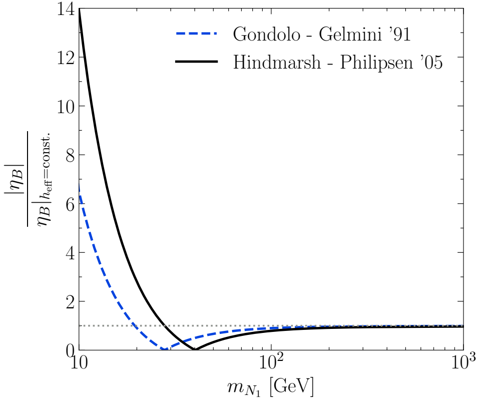
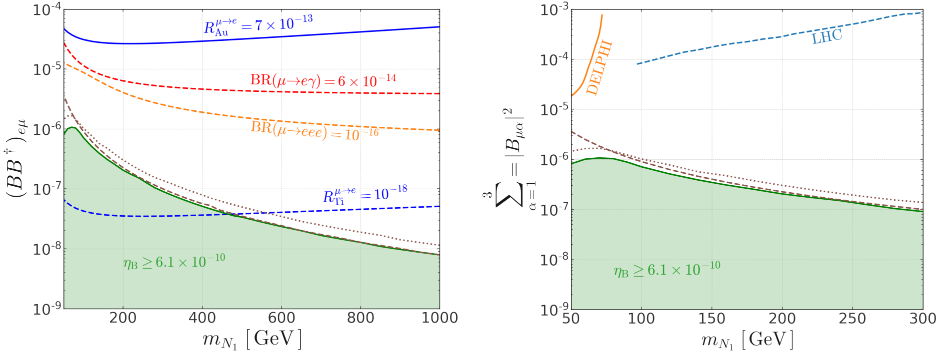




Things change significantly for $m_{N_1} \lesssim 100\ \mathrm{GeV}$:



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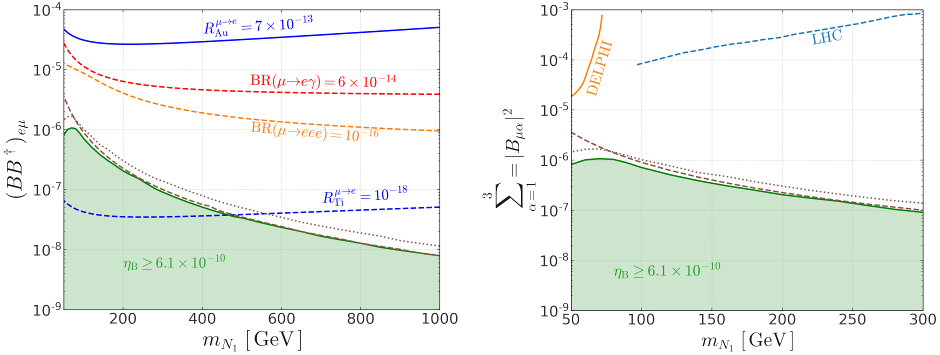

Possible probe: $\mu \to e$ transitions within Titanium.[4]

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As for the future:

- Multi-resonant leptogenesis?
- Study known models including varying h_{eff}, to find how much they change.
- Extensions of TRL might introduce additional CP violations or mixing, making the parameter space better?

Thank you!