The problem of initial conditions in Flavoured Leptogenesis

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(based on E.B., P. Di Bari, L. Marzola,
Nucl.Phys. B849 (2011) 521-548, arXiv:1007.1641 [hep-ph]

Planck 2011
May 31, 2011

Motivations

If YES, we need to know the exact history of the Universe to make predictions

Assumptions

Assumptions (M_i = RH neutrino mass):

- $\boxed{M_1 \ll M_2 \ll M_3}$ $\Rightarrow$ NO interference between decays and inverse decays of different RH neutrinos

- $\boxed{M_i \text{ not around } 10^{12} \text{ GeV or } 10^9 \text{ GeV}}$ $\Rightarrow$ NO need for a density matrix description

Flavoured Leptogenesis

How flavour enters in the game?

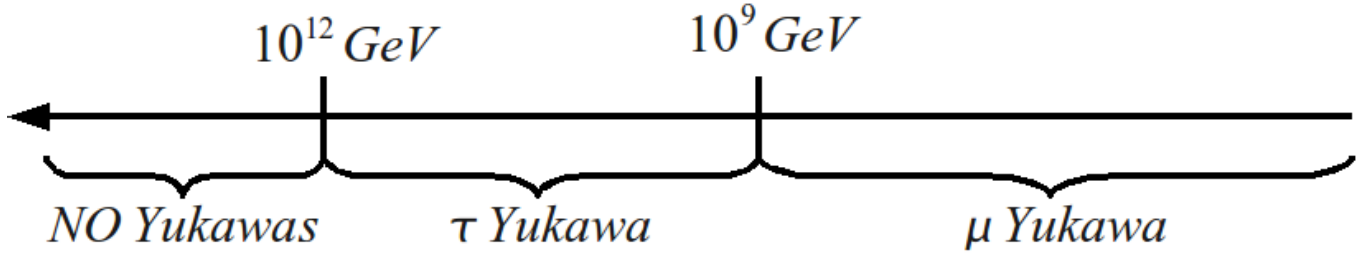
Two types of flavours:

- Heavy flavours: in $N_i \to \ell_i H^\dagger$, defined by $(-\mathcal{L} = \bar{\ell}_L h N_R \tilde{H})$

$$|\ell_i\rangle = \frac{1}{\sqrt{(hh^\dagger)_{ii}}} h^\dagger_{\alpha i} |\ell_{L\alpha}\rangle \quad (h = \text{Yukawa coupling})$$

  They are not orthogonal

- Light flavours: e, μ, τ, through their Yukawa interactions:



Our Results

$$\boxed{M_{1,2,3} \gg 10^9 \text{ GeV}}$$

$$\Downarrow$$

- independence only if pre-existing asymmetry along $|\ell_3\rangle$ direction

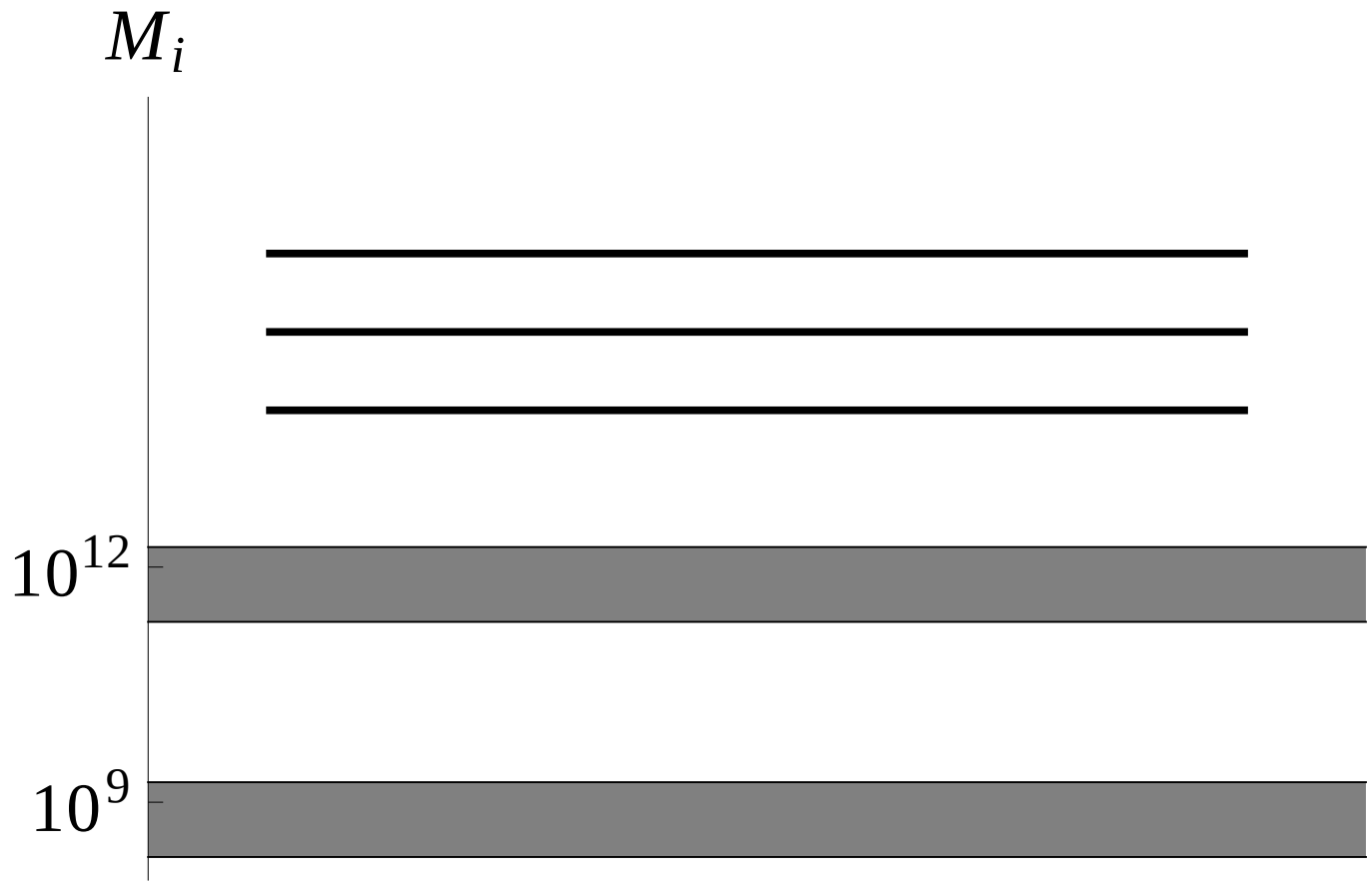
$$\boxed{M_1 \ll 10^9 \text{ GeV} \ll M_{2,3} \ll 10^{12} \text{ GeV}}$$

$$\Downarrow$$

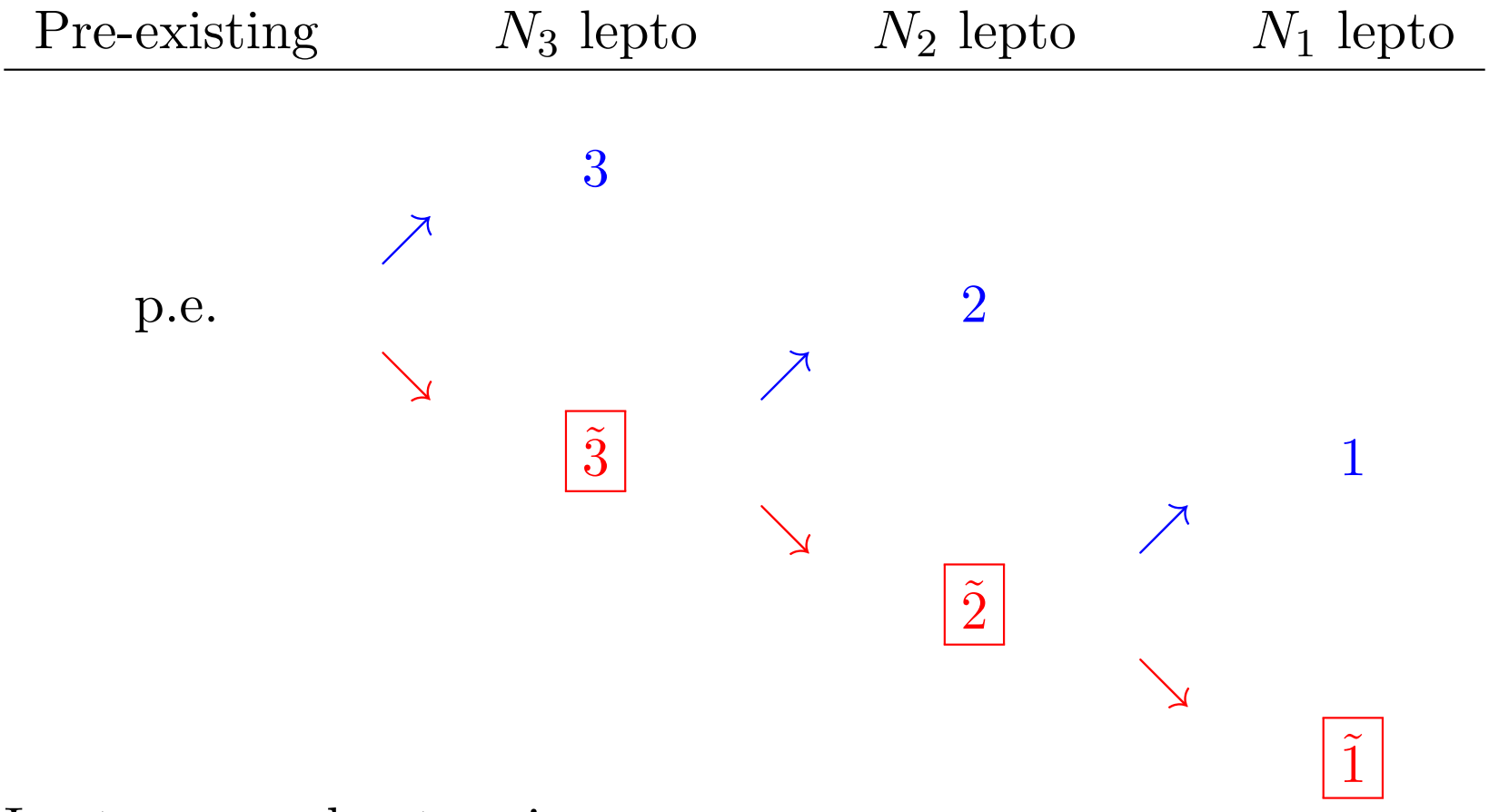
- if the asymmetry generated by N_2 (possibly N_3) is mainly along the τ direction, then independence on pre-existing asymmetry

Why?

First case:



First case



In strong washout regime:

WASHED-OUT

NOT WASHED-OUT $\Rightarrow$ a pre-existing component survives after all leptogenesis stages

Second case

Favourite case:

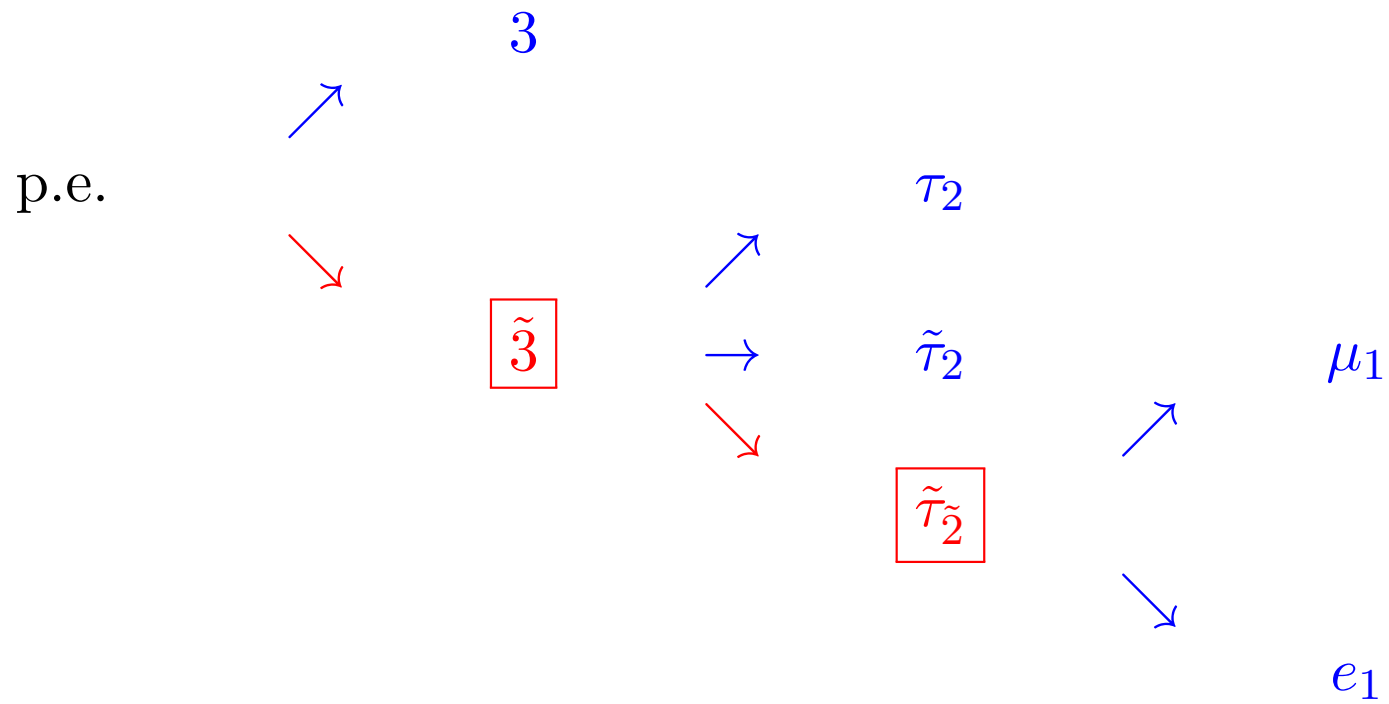
- $M_1 \ll 10^9$ GeV $\Rightarrow$ asymmetry from $N_1 \to \ell_1 H^\dagger$ NOT ENOUGH $\Rightarrow$ asymmetry from N_2 or N_3

- below 10^9 GeV all three light flavours are active $\Rightarrow$ efficient washout along all directions $\Downarrow$ at least along one direction weak washout

Why?

Spectrum

Pre-existing	N_3 lepto	N_2 lepto	N_1 lepto



In strong washout regime:

WASHED-OUT

NOT WASHED-OUT $\Rightarrow$

No pre-existing asymmetry survives and weak washout in τ_1 possible

Conclusions

$$\boxed{M_{1,2,3} \gg 10^9 \text{ GeV}}$$

$$\Downarrow$$

- independence only if pre-existing asymmetry along $|\ell_3\rangle$ direction

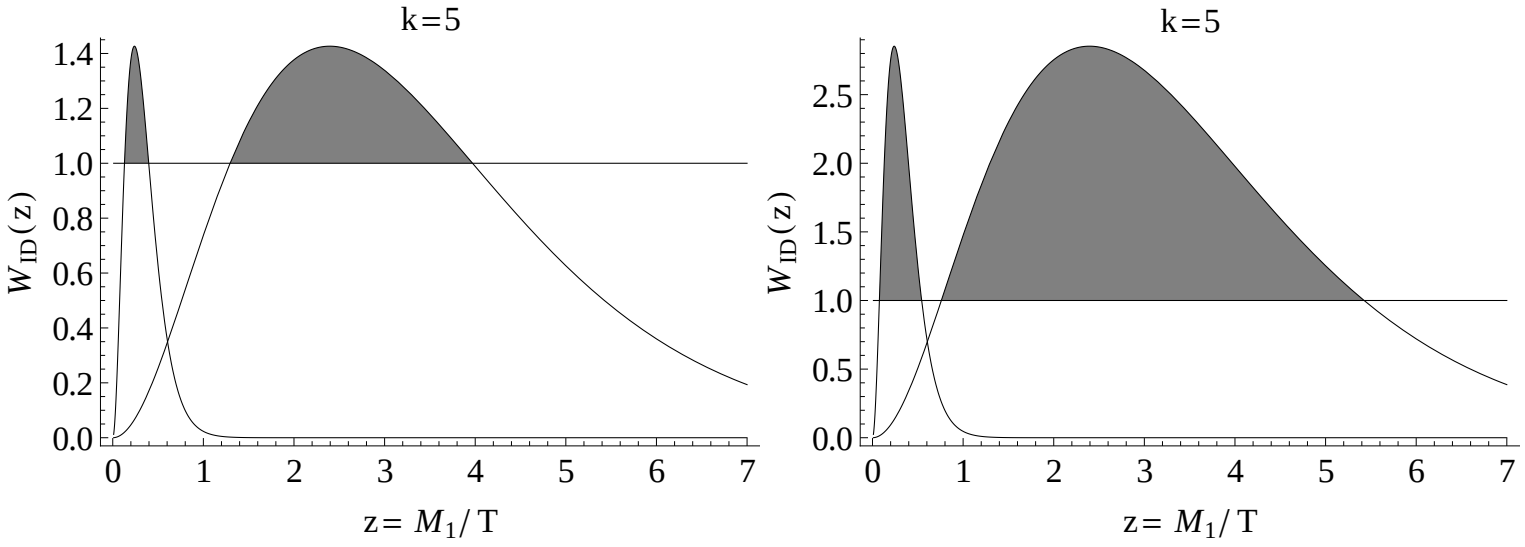
$$\boxed{10^9 \text{ GeV} \ll M_{2,3} \ll 10^{12} \text{ GeV}}$$

$$\Downarrow$$

- if the asymmetry generated by N_2 (possibly N_3) is mainly along the τ direction, then independence on pre-existing asymmetry

BACKUP SLIDES

Decay and inverse decays

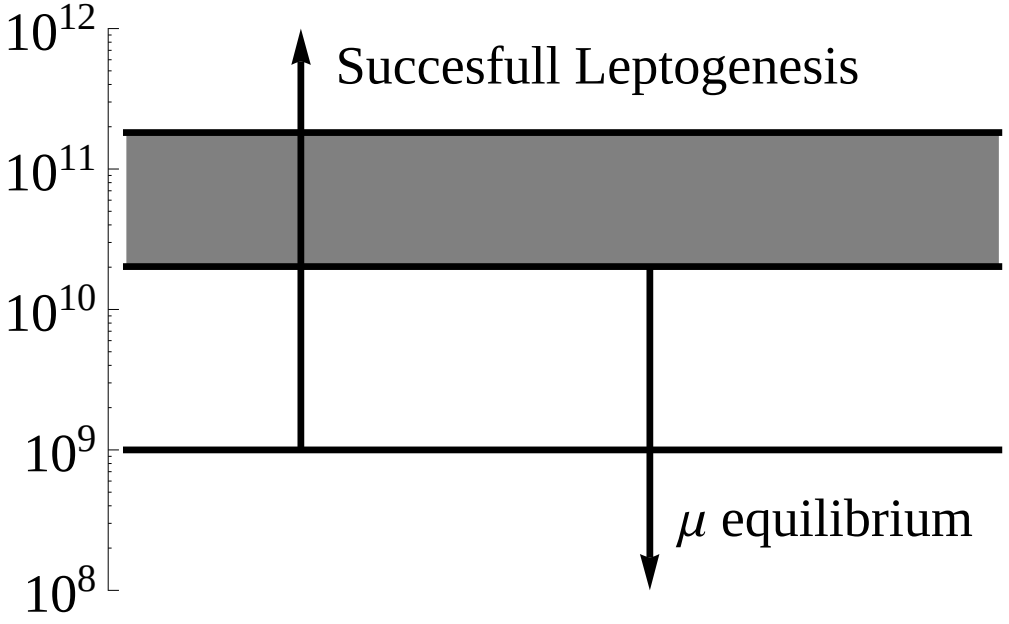


Buchmuller, Di Bari, Plumacher, hep-ph/0401240

Caveats

- Beyond hierarchical limit
- SUSY models: μ Yukawa in equilibrium below 10^9 GeV $\left(1 + \tan^2 \beta\right)$
- Spectator processes: $\mathcal{O}(1)$ corrections to the wash-out factors
- Phantom terms: additional dependence on pre-existing asymmetry (arXiv:1003.5132)

SUSY models


10^{12}
10^{11}
10^{10}
10^{9}
10^{8}
Succesfull Leptogenesis
μ equilibrium