Probing the seesaw mechanism and leptogenesis

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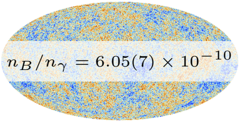
based on 1710.03744, with Stefan Antusch, Eros Cazzato, Marco Drewes, Oliver Fischer, Björn Garbrecht and Dario Gueter

Recontres de Moriond EW 2018

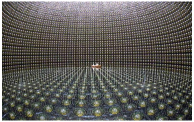
La Thuile, March 15th 2018

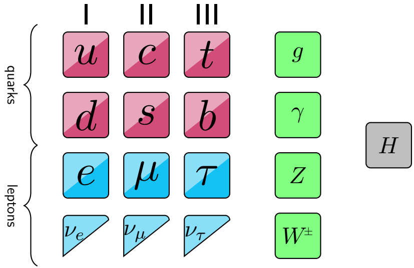
Some of the missing pieces of the standard model:

The Baryon Asymmetry of the Universe



Neutrino masses





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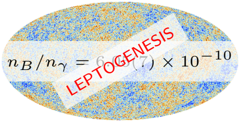
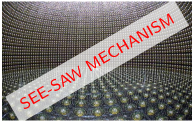
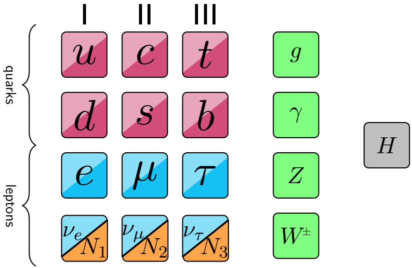
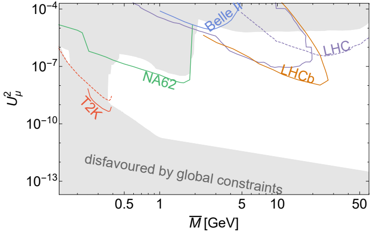


Neutrino masses





Where to look for them: Normal hierarchy



[Drewes/Garbrecht/Gueter/JK 1609.09069]

- lower limits on the mixing angles from the seesaw mechanism and BBN
- low scale seesaw testable with current experiments

  [see talks by: Parkinson, Verbeke, Drewes, Marcano, Negro]
- leptogenesis within reach of NA62/ LHC

  [see talks by: Domcke, Lopez Pavon]

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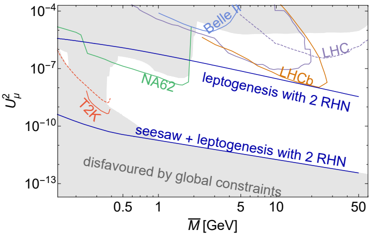

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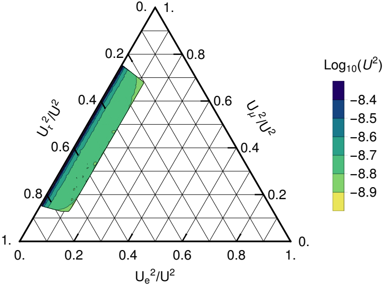
Constraints on flavour patterns

- large mixing angles require a **flavour asymmetric washout**, which corresponds to a flavour asymmetric mixing
- together with **seesaw constraints** this imposes constraints on the mixing patterns for **large mixing angles**

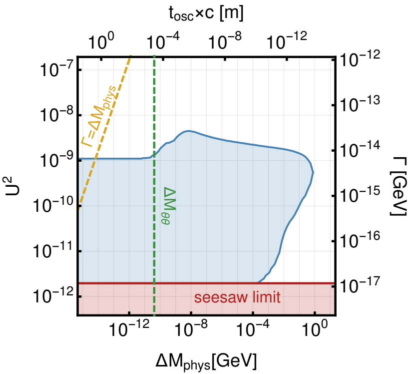


$\bar{M} = 30\,\mathrm{GeV}$

[Antusch/Cazzato/Drewes/Fischer/Garbrecht/Gueter/JK 1710.03744]

Measuring the mass splitting

Normal Ordering:

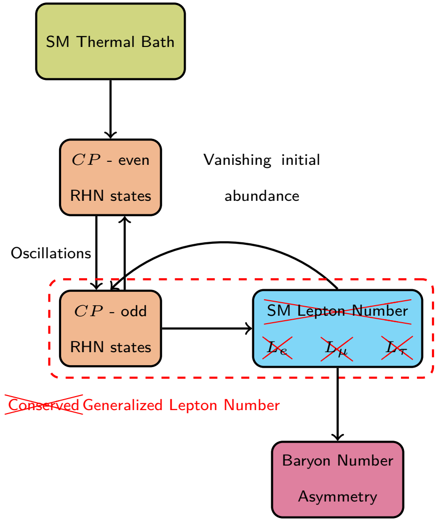


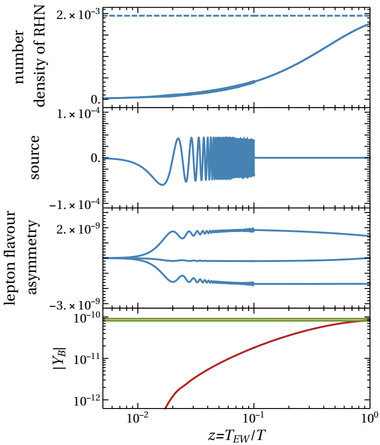
- large range of viable ΔM consistent with leptogenesis
- extremely small mass splitting can be measured via oscillations $10^{-13}\text{GeV} \sim 1\text{cm}$
- nontrivial same sign/opposite sign dilepton ratios require $\Delta M \sim -\Delta M_{\theta\theta}$

Conclusions

- adding GeV-scale RHNs to the standard model can explain both the observed **neutrino masses** and the **BAU**
- the seesaw mechanism gives constraints on **RHN mixing patterns** (stronger if δ is measured!)
- testable seesaw and leptogenesis within reach of present (NA62 and LHC) experiments
- large mixing angles $+$ leptogenesis $\rightarrow$ even stronger predictions on the flavour patterns, easily falsifiable LG
- while complete determination of the RHN parameters is possible in principle, it requires extreme experimental sensitivity

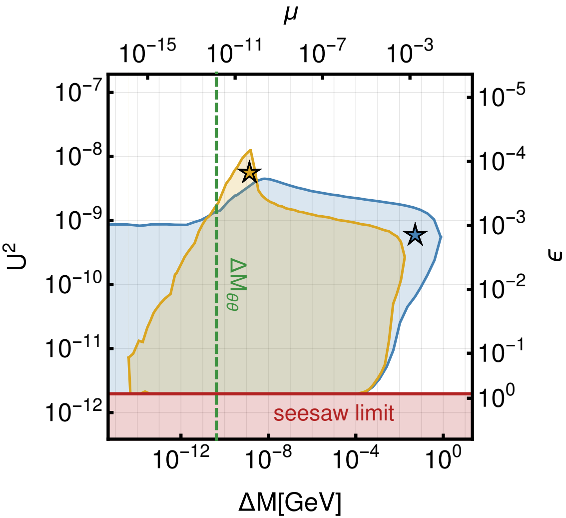
Leptogenesis via Neutrino Oscillations

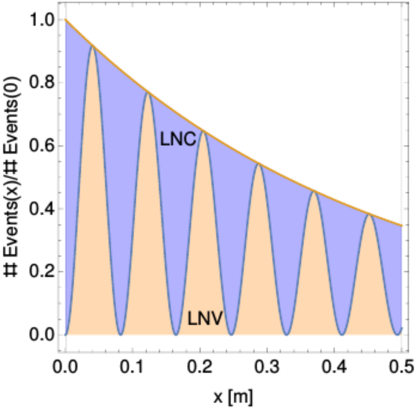




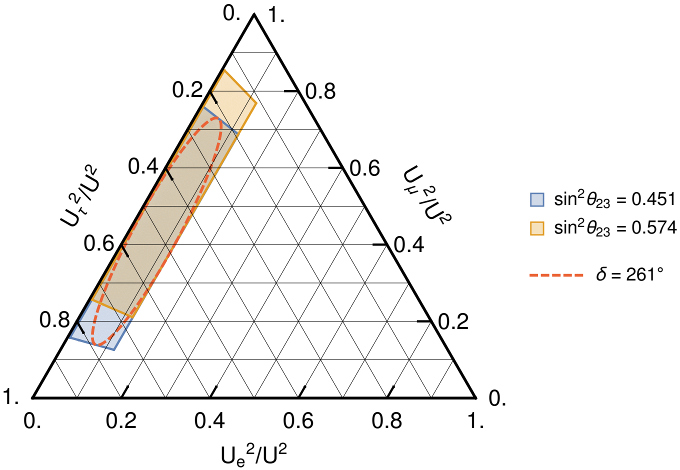
Full Testability?

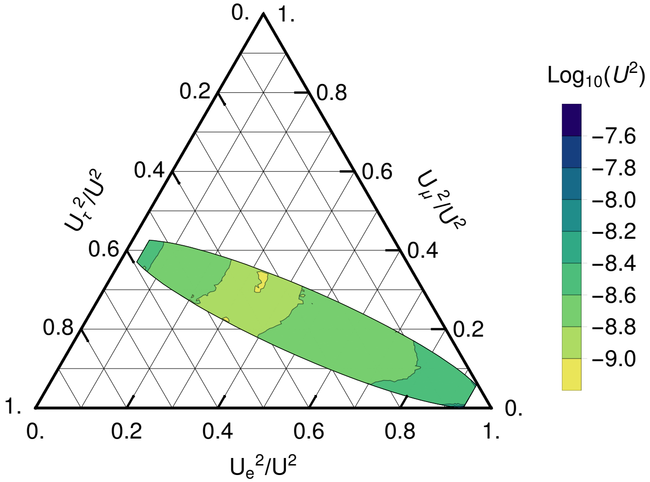
- full testability requires a complete determination of the RHN parameters
- in principle possible from a measurement of all mixing angles and masses
- "flavoured" mixing angles U_a^2 can be measured via flavour ratios
- the two remaining parameters $(\Delta M, \mathrm{Re}(\omega))$ could be probed by:
    - neutrinoless double β decay requires small M, large ΔM and U^2
      [Hernández/Kekic/López-Pavón/Salvado 1606.06719, Eijima/Drewes 1606.06221]
    - CP violation requires ΔM comparable to the decay width Γ obscured by $\Delta M_{\theta\theta}$
    - lepton number violation requires ΔM comparable to Γ obscured by $\Delta M_{\theta\theta}$
    - oscillations in the lab: tiny ΔM_{phys}


μ
10^−15 10^−11 10^−7 10^−3
U^2
10^−7 10^−8 10^−9 10^−10 10^−11 10^−12
ε
10^−5 10^−4 10^−3 10^−2 10^−1 10^0
ΔM_θθ
seesaw limit
10^−12 10^−8 10^−4 10^0
ΔM[GeV]



[Antusch/Cazzato/Fischer 1709.03797]


0.
1.
0.2
0.8
0.4
0.6
0.6
0.4
0.8
0.2
1.
0.
0.
0.2
0.4
0.6
0.8
1.
$U_\tau{}^2/U^2$
$U_\mu{}^2/U^2$
$U_e{}^2/U^2$
$\sin^2\theta_{23} = 0.451$
$\sin^2\theta_{23} = 0.574$
$\delta = 261°$


0.
1.
0.2
0.8
0.4
0.6
0.6
0.4
0.8
0.2
1.
0.
0.
0.2
0.4
0.6
0.8
1.
U_τ^2/U^2
U_μ^2/U^2
U_e^2/U^2
$\mathrm{Log}_{10}(U^2)$
−7.6
−7.8
−8.0
−8.2
−8.4
−8.6
−8.8
−9.0