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MeV-Scale Seesaw and Leptogenesis

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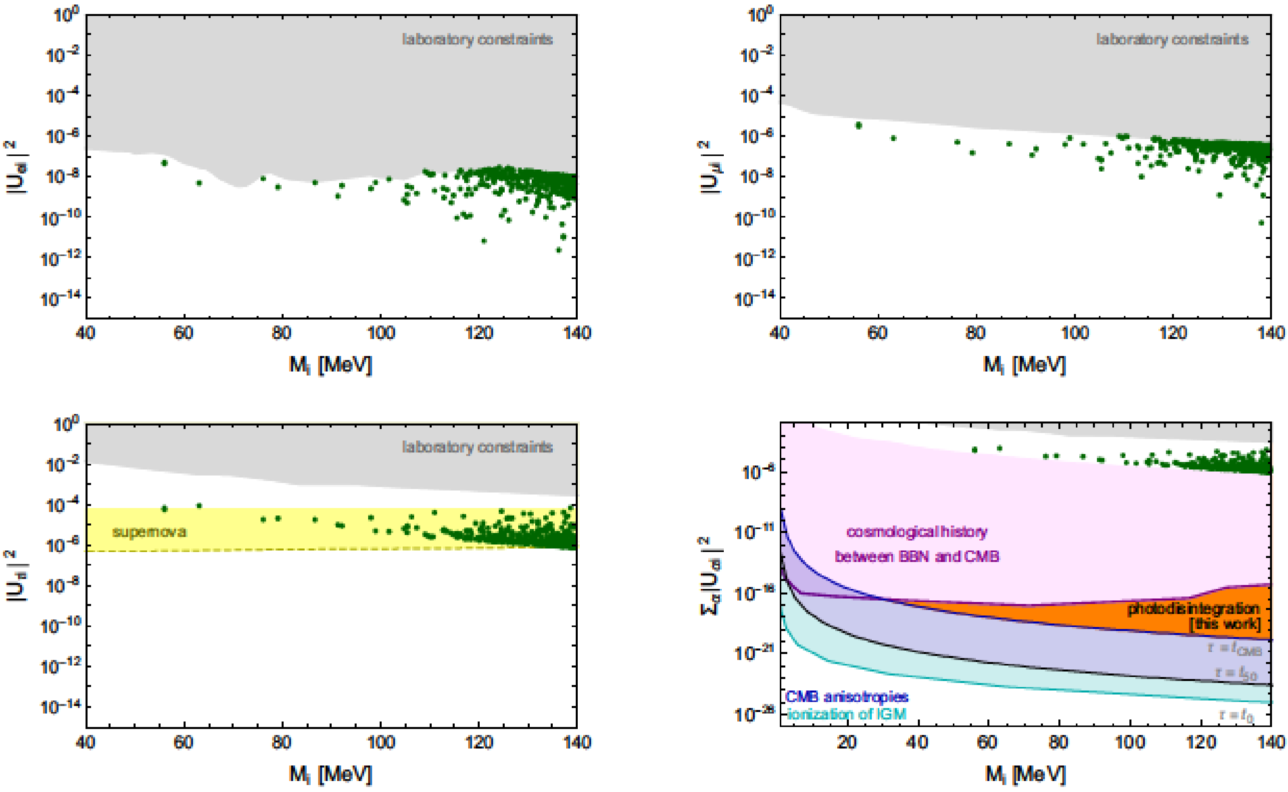

Figure 1: Constraints on the sterile neutrino mixing with SM neutrinos. The shaded regions are excluded by laboratory constraints (grey, see Sec. 2.1), cosmological constraints from Refs. [19] (pink), [21] (blue) and [20] (cyan) (see Sec. 2.2) and by the photodisintegration bound (orange, this work, Sec. 2.3). The supernova constraint from Ref. [55] is indicated by the yellow shaded region (see Sec. 2.4). The green dots show realisations of neutrino masses and mixings which reproduce the neutrino oscillation data (see Sec. 2.5). Every parameter point is represented by a triplet (one point for each N_i).

only a small fraction of the leptogenesis parameter space [9, 31, 54].

2.2 Summary of previously known cosmological constraints

Sterile neutrinos in the $\mathcal{O}(10-100)$ MeV mass range can alter our cosmological history and are hence strongly constrained by observations related to BBN and the CMB. Here we distinguish three cases, depending on the lifetime τ_i of the sterile neutrino N_i [56],

$$\tau_i^{-1} \approx 7.8\,\mathrm{s}^{-1} \left(\frac{M_i}{10\ \mathrm{MeV}}\right)^5 \left[1.4\, U_{ei}^2 + U_{\mu i}^2 + U_{\tau i}^2\right] . \tag{6}$$

(i) Short-lived N_i. If N_i decays significantly before BBN, its decay products are fully thermalised and merely lead to a shift in the overall temperature of the thermal bath, which only shifts the onset of BBN. Hence, the highly constrained process of nucleosynthesis as well as the post-BBN cosmic history remain largely unaltered. This condition results in an upper bound on the lifetime of N_i of $\mathcal{O}(0.2-1)$ s for 30 MeV$\leq M_i \leq$140 MeV [57–61]. Such short lifetimes require a sizeable mixing with SM neutrinos (above the region labeled '*cosmological history between BBN and CMB*' in Fig. 1), which leads to a

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However, in the mass range considered here, this symmetry does not suppress lepton number violating signatures in collider based experiments [53].

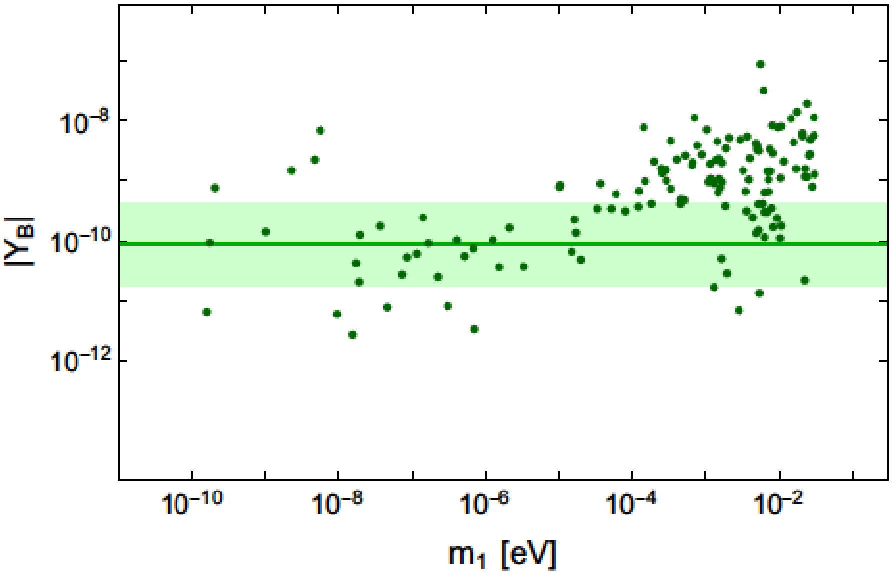

Figure 2: Predicted baryon asymmetry as a function of the lightest SM neutrino mass in scenario I). The green line indicates the observed value, the shaded region indicates an order of magnitude variance.

points give a final baryon asymmetry in the correct ball-park to explain the observed value. Given the well-known strong sensitivity of the relevant Boltzmann equations to small changes in the parameters, this is a highly non-trivial result. Our results provide a proof-of-existence for this viable leptogenesis scenario, but this is by no means an exhaustive study. Due to the high-dimensional parameter space, this requires more sophisticated numerical techniques, but we hope that the results presented here will trigger further work in this direction. This will be crucial in guiding experimental effort in fully testing freeze-in leptogenesis as the mechanism to generate the baryon asymmetry of our Universe.

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