Neutrino mass and phenomenology from a super-weak U(1)$_z$ symmetry

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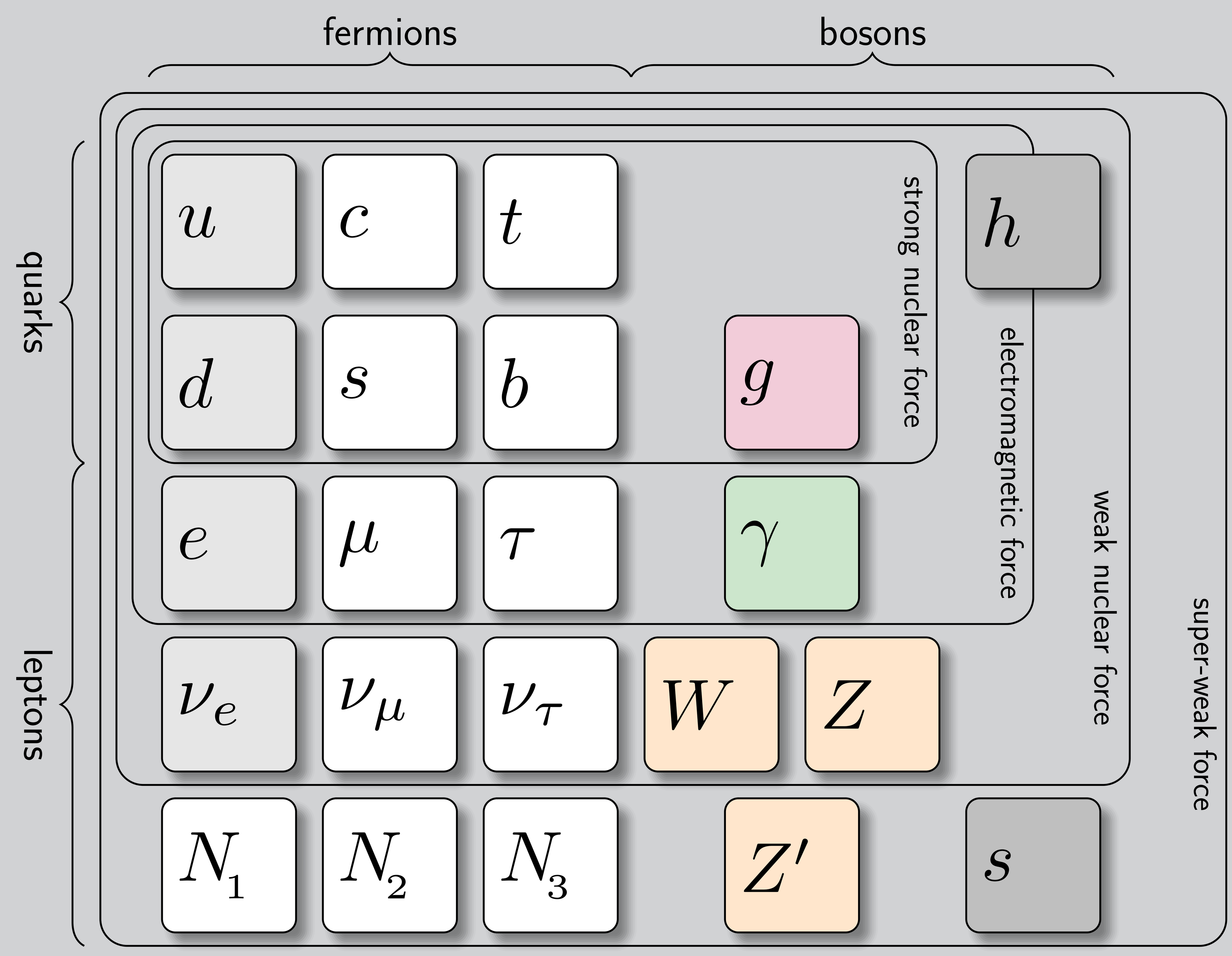
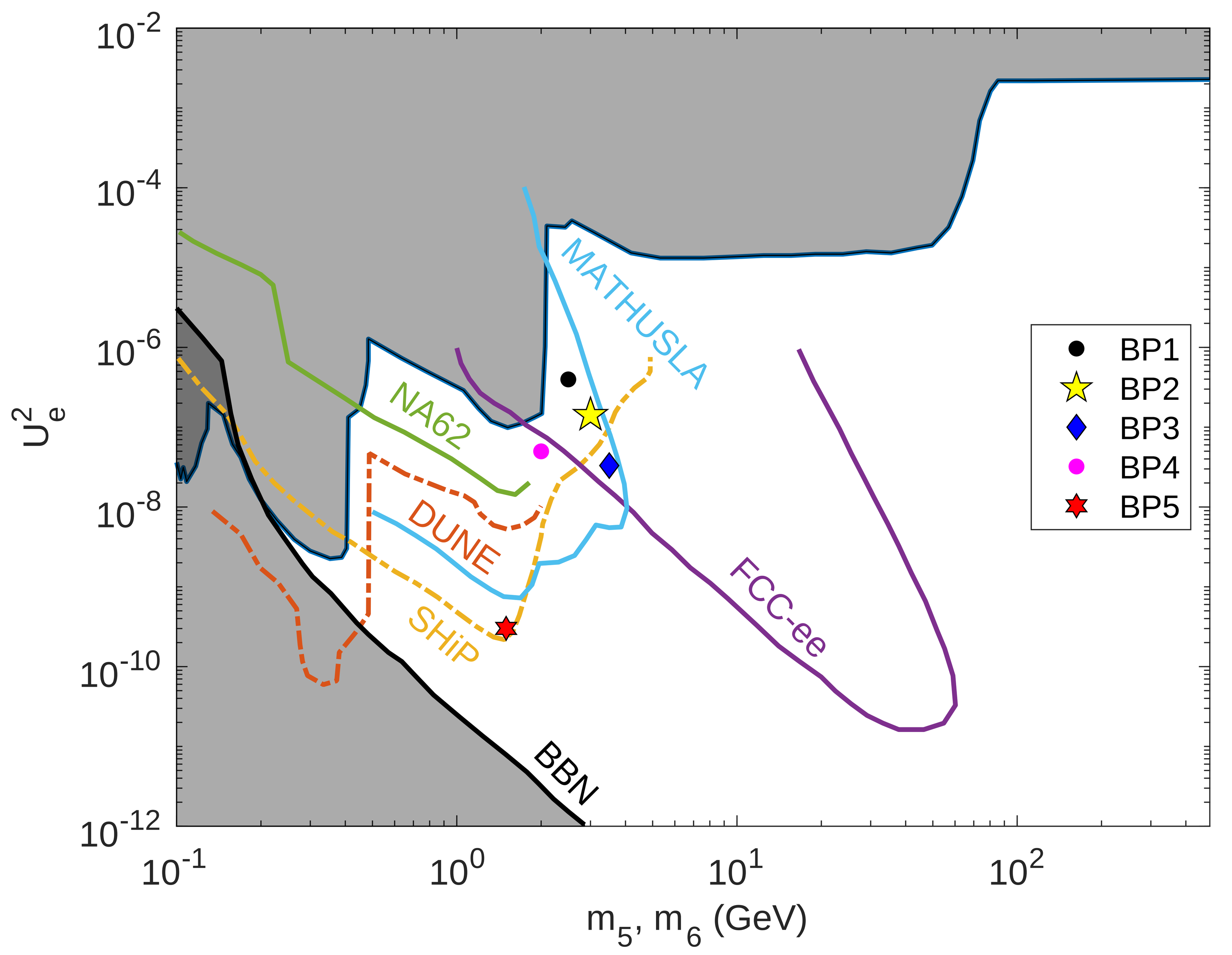


	$SU(2)_L$	$U(1)_Y$	$U(1)_z$
Q_L	**2**	$\frac{1}{6}$	$\frac{1}{6}$
u_R	**1**	$\frac{2}{3}$	$\frac{7}{6}$
d_R	**1**	$-\frac{1}{3}$	$-\frac{5}{6}$
L_L	**2**	$-\frac{1}{2}$	$-\frac{1}{2}$
ℓ_R	**1**	-1	$-\frac{3}{2}$
ϕ	**2**	$\frac{1}{2}$	1
N_R	**1**	0	$\frac{1}{2}$
χ	**1**	0	-1

Introduction

The super-weak model [1] is an economical U(1)-extension of the SM, aiming to explain the origin of neutrino mass and oscillations [2,3], dark matter [4], matter-antimatter asymmetry of the universe, cosmis inflation and to stabilize the vacuum [5]. New physics is manifested by nonstandard interactions and active-sterile neutrino mixing. The benchmark points provided fall within the sensitivity region of SHiP and MATHUSLA experiments.

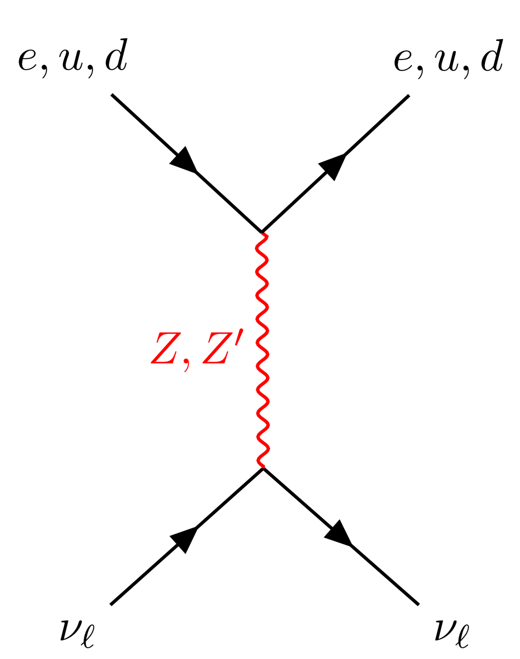
Experiments are sensitive to GeV neutrinos



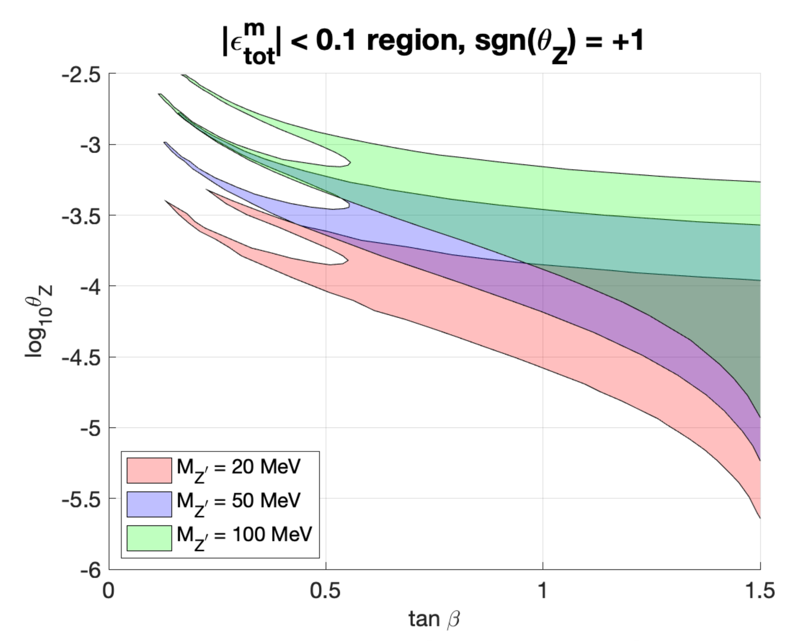
Benchmark point	BP1	BP2	BP3	BP4	BP5
m_1 (meV)	10	1	0	0.1	5
m_4 (keV)	30	7.1	40	50	25000
$m_{5,6}$ (GeV)	2.5	3.0	3.5	2.0	1.5
w (GeV)	100	750	250	500	175

Nonstandard interactions (NSI)

$$\mathcal{L}_{\rm NSI} = -2\sqrt{2}G_F\varepsilon^{ff'}_{\ell\ell'}(\overline{\nu_\ell}\gamma^\mu P_L\nu_{\ell'})(\overline{f'}\gamma_\mu P_L f)$$



$$\varepsilon^m_{\ell\ell} = \varepsilon^e_{\ell\ell} + 2\varepsilon^u_{\ell\ell} + \varepsilon^d_{\ell\ell} + \frac{N_n}{N_e}(\varepsilon^u_{\ell\ell} + 2\varepsilon^d_{\ell\ell})$$



Particle spectrum contains an extra neutral gauge boson, Z', which mixes with Z. The mixing angle θ_Z is constrained by NSI. We fix the Z' boson mass on MeV scale.

One-loop correction to light neutrino masses

$$\delta\mathbf{M}_L = \frac{1}{16\pi^2}\sum_{k=1,2}\left[3(\mathbf{Z}_{\rm G})^2_{k1}\frac{M^2_{V_k}}{v^2}\mathbf{F}(M^2_{V_k}) + (\mathbf{Z}_{\rm S})^2_{k1}\frac{M^2_{S_k}}{v^2}\mathbf{F}(M^2_{S_k})\right]$$

$$\mathbf{F}_{ij}(M^2) = \sum_{a=1}^{6}(\mathbf{U}^*_L)_{ia}(\mathbf{U}^\dagger_L)_{aj}\frac{m_a^3}{M^2}\frac{\ln\frac{m_a^2}{M^2}}{\frac{m_a^2}{M^2}-1}$$

We calculated the 1-loop m_ν correction and found it to be $\mathcal{O}(0.1)$ %.

References

[1] Z. Trócsányi, Symmetry **12**, 107 (2020), arXiv:1812.11189.
[2] S. Iwamoto, T. J. Kärkkäinen, Z. Péli and Z. Trócsányi, arXiv:2104.14571
[3] T. J. Kärkkäinen and Z. Trócsányi, arXiv: 2105.13360
[4] S. Iwamoto, K. Seller and Z. Trócsányi, arXiv: 2104.11248
[5] Z. Péli, I. Nándori and Z. Trócsányi, Phys. Rev. D **101** (2020), arXiv: 1911.07082