SWSM Phenomenology

ELTE EÖTVÖS LORÁND TUDOMÁNYEGYETEM

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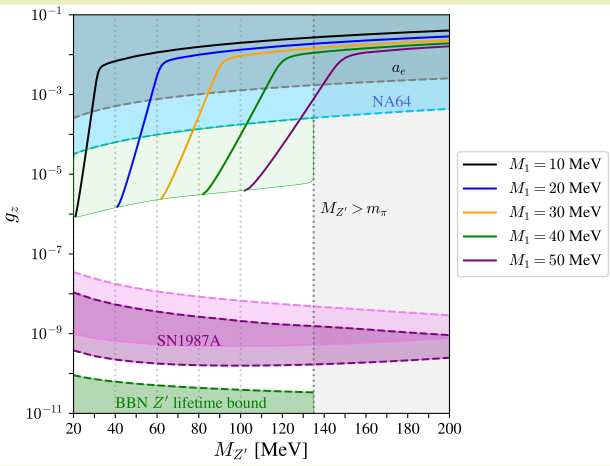
Dark matter candidate [2]

- Portal candidate: Z′ couples to all particles
- Dark matter candidate: lightest right-handed neutrino ν_1
- Mechanism: both freeze-in and freeze-out are possible
- Freeze-out is viable only if DM produced resonantly, $2m_{\nu_1} \simeq M_{Z'}$

Experimental constraints [3]

- Anomalous magnetic moments of charged leptons
- Direct search for dark photon in NA64
- Supernova cooling
- Big Bang Nucleosynthesis



Allowed region in the $g_z - M_{Z'}$ plane to provide correct abundance of DM with resonant freeze-out

for more details see
K. Seller's talk on Friday, 9 am, DM session

- Non-standard interactions give further constraints

for more details see
T.J. Kärkkäinen's poster (518)

Superweak (SW) extended standard model (SM) [1]

designed to explain observations in particle physics and cosmology, not understood within the SM:
the origin of

- **dark matter [2,3]**
- **masses and mixing of neutrinos [4,5]**
- baryon asymmetry
- late time accelerated expansion and cosmological inflation

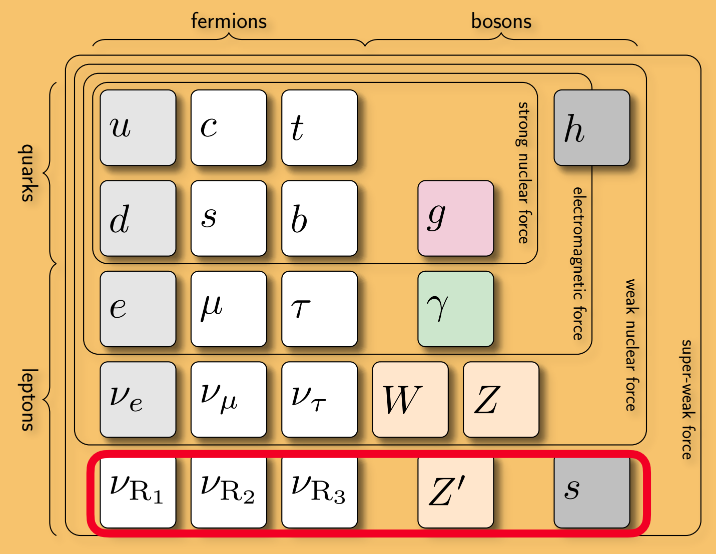
Are these all possible within a single model?

We explore the **viable parameter space** [5] respecting

- precision tests of the SM
- lack of finding new particles at the LHC
- cosmological constraints

New in SW as compared to the SM [1]

- a complex scalar
- three right handed neutrinos
- a gauged $U(1)_z$: all particles charged



Masses and mixing of neutrinos [4]

- **Dirac and Majorana mass terms** appear at tree level by SSB (not radiatively):

$$M_D = \frac{v}{\sqrt{2}} Y_\nu, \quad M_R = \frac{w}{\sqrt{2}} Y_N, \quad M' = \begin{pmatrix} 0_3 & M_D^T \\ M_D & M_R \end{pmatrix}$$

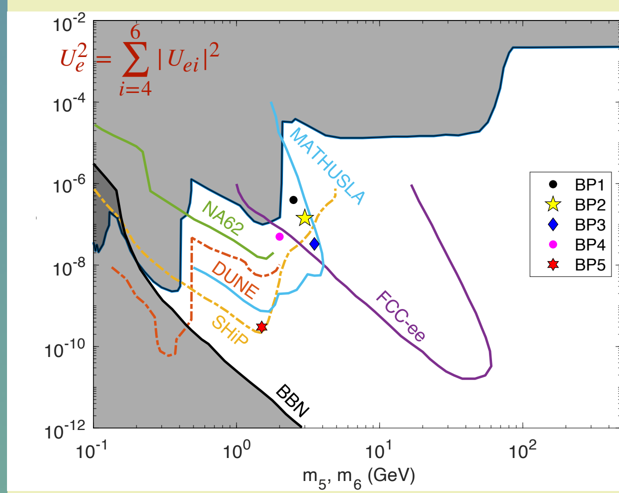
- Light neutrino masses generated via Type-I seesaw:

$$M_\nu = -M_D^T M_R^{-1} M_D$$

- Light neutrinos mix: $U_2^T M_\nu U_2 = M_\nu^{\rm diag}$ where we may choose U_2 coincide with the PMNS matrix

Neutrino benchmarks [5]

Parametrize Y_ν to scan for allowed parameter space (at present only benchmark points **BP**) testable by future experiments:



	BP1	BP2	BP3	BP4	BP5
m_1 (meV)	0	0.4	0	0.16	1.0
M_1 (keV)	30	7.1	40	50	25000
$M_{2,3}$ (GeV)	2.5	3.0	3.5	2	1.5
w (GeV)	100	750	250	500	175
U_e^2	5.0×10^{-7}	1.4×10^{-7}	3.3×10^{-8}	6.3×10^{-8}	3.0×10^{-10}

U_{ai} is the active-sterile mixing matrix

Scalar sector constraints [6]

Scalar sector resembles singlet scalar extension of the SM (mixes with the Higgs scalar *H*) with important extra features: the new scalar *S*

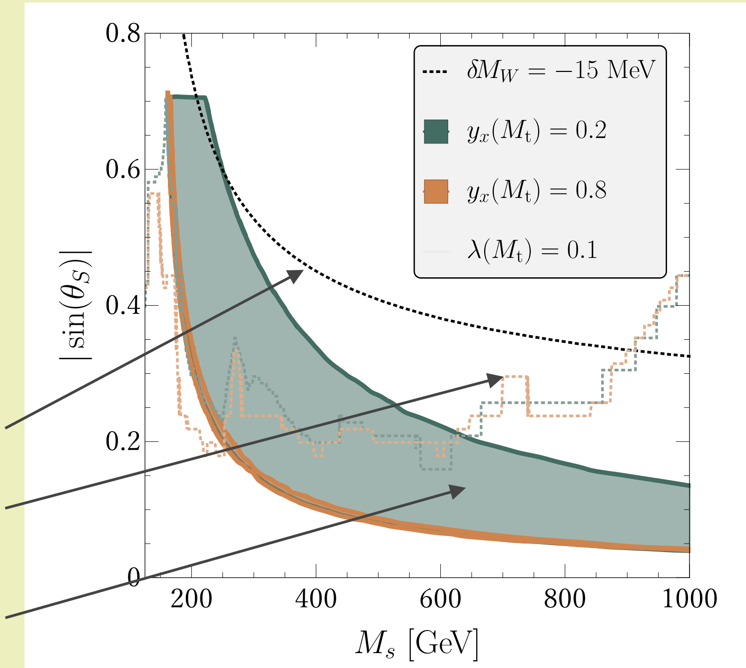
- couples to neutrinos
- interacts with all fermions via Z′
- gives mass to Z′ ⇒ *mixing with Z⁰*

Parameter space in scalar mixing angle – scalar mass plane (depends on mixed quartic coupling) see also Z.Péli's poster (1195)

Exclusion limit from *W* mass

Excluded by `HiggsBounds 5`

Preferred by stability of the vacuum in 2nd order perturbation theory



Work in progress

- Combination of constraints in a global scan
- Estimation of baryogengesis
- Exploration of cosmological consequences
- Prediction of observable new effects

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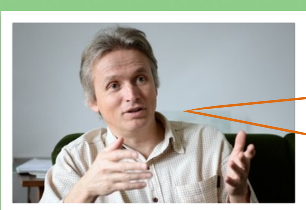

Questions or doubts?
Please, contact me:
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References

[1] Z. Trócsányi, arXiv:1812.11189.

[2] S. Iwamoto, K. Seller, Z. Trócsányi, arXiv:2104.11248.

[3] K. Seller, arXiv:2112.00525.

[4] S. Iwamoto, T.J. Kärkkäinen, Z. Péli, Z. Trócsányi, arXiv:2104.14571.

[5] T.J. Kärkkäinen, Z. Trócsányi, arXiv:2105.13360.

[6] Z. Péli, Z. Trócsányi, arXiv:2204.07100.