Neutrino Mass, Low Scale Leptogenesis and Dark Matter Candidates in an Extended Seesaw Model.

Neutrino 08

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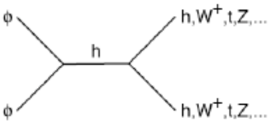
Introduction:

- Two unsolved issues in particle physics and cosmology:
  - Why is there more matter than antimatter in the present Universe ?
  - What is the origin of dark matter?
- Typical Leptogenesis and seesaw mechanism $\Longrightarrow$ require heavy Majorana neutrinos
  $\Longrightarrow$ undesirable in the light of experiments.
- Low scale leptogenesis $\Longrightarrow$ resonant leptogenesis
  $\Longrightarrow$ require tiny mass splitting between two heavy Majorana neutrinos.
- We propose a variant of seesaw model to simultaneously provide small neutrino masses, low scale leptogenesis and dark matter candidate.

Singlet S as a Dark Matter Candidate:

- S can be a dark matter, provided that $m_S \lesssim m_\Phi$.
- The annihilation cross section is too small $\Longrightarrow$ requiring coannihilation processes.
- For $\delta m = m_\Phi - m_S \approx T_f$, $\boxed{\Phi\Phi \to (SM)(SM)}$ through the s-channel can significantly affect the relic abundance of S.
- In the non-relativistic limit,

$$\sigma_{ann} v_{rel} = \frac{8\lambda^2 v_{EW}^2}{(4m_\Phi^2 - m_h^2)^2 + m_h^2\Gamma_h^2} F_X, \qquad (4)$$



Extended Seesaw Model We Proposed

- The Lagrangian we propose in the charged lepton basis as

  $$\mathcal{L}_f = Y_{D_{ij}} \bar{\nu}_i H N_j + M_{R_{ij}} N_i N_i + Y_{S_{ij}} \bar{N}_i \Phi S_j - m_{S_{ij}} S_i S_j + h.c.\ , \quad (1)$$

  - ν_i : $SU(2)_L$ doublet, N_i : RH singlet neutrino
  - S_i : newly introduced singlet neutrinos
  - H : $SU(2)_L$ doublet Higgs
  - Φ : $SU(2)_L$ singlet Higgs

- We impose Z_2 symmetry which S_i and Φ are odd and all other particles even

- The light neutrino masses : $m_\nu = \frac{(Y_D v_{EW})^2}{4M_R}$.
  their masses are expected to be of order of $\sqrt{\Delta m^2_{atm}} \simeq 0.05$ eV and $\sqrt{\Delta m^2_{sol}} \simeq 0.01$ eV for the hierarchical neutrino mass spectrum.

- The relic abundance : $\boxed{\Omega_S h^2 \simeq \frac{(1.07\times10^9)x_f}{g_*^{1/2} M_{pl} < \sigma_{ann} v_{rel} >}}$

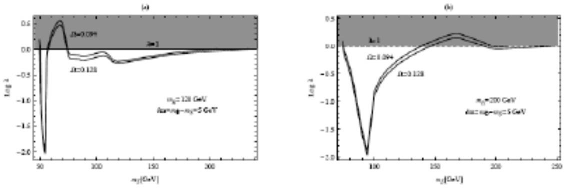


Figure: Relationship between λ and m_S for $\Omega_S h^2 = 0.128$ and 0.094 . $\delta m = m_\Phi - m_S = 5$ GeV and m_h : (a) 120 GeV and (b) 200 GeV.

$\boxed{\text{Singlet Scalar Boson } \Phi \text{ as a Dark Matter Candidate}}$:

- Φ can be a dark matter, provided that $m_\Phi \lesssim m_S$.

- The annihilation processes relevant to a successful candidate for dark matter can occur due to $\lambda\Phi^2 h^2$.

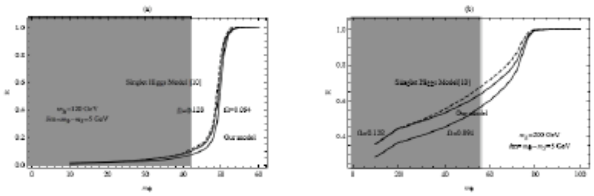


Figure: R *vs.* m_Φ for $\Omega_\Phi h^2 = 0.128$ and 0.094, respectively (solid lines) : (a) $m_h = 120$ GeV and (b) 200 GeV. The shadowed region :forbidden by XENON10 Dark Matter Experiment.

Case for $2m_\Phi > m_h$:

- Φ can be produced only through virtual Higgs exchange.
- The produced Φ can be detected as missing energy for $E \geq 2m_\Phi$.
- LHC is unlikely place for discovery of a missing energy signal.