SAME-SIGN TETRA-LEPTONS FROM TYPE II SEESAW

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TYPE II SEESAW

Neutrino mass can be originated from a new Higgs Triplet, which couples to lepton doublet, by acquiring a nontrivial vev. This mechanism is known as 'type II seesaw mechanism'.

Features of type II seesaw model:

1. Doubly charged boson can be cleanly probed
2. Lepton flavor structure of H^{++} decays to same-sign dileptons may allow discovering neutrino mass pattern

MODEL

The leptonic part of the Lagrangian for generation of neutrino masses is

$$\mathcal{L}_Y = f_{\alpha\beta} L_\alpha^T C i\tau_2 \Delta L_\beta + \text{H.c.}$$

and the scalar potential is

$$\begin{aligned} V(\Phi,\Delta) &= m^2\Phi^\dagger\Phi + \lambda_1(\Phi^\dagger\Phi)^2 + M^2\text{Tr}(\Delta^\dagger\Delta) \\ &+ \lambda_2\left[\text{Tr}(\Delta^\dagger\Delta)\right]^2 + \lambda_4(\Phi^\dagger\Phi)\text{Tr}(\Delta^\dagger\Delta) \\ &+ \lambda_3\text{Det}(\Delta^\dagger\Delta) + \lambda_5(\Phi^\dagger\tau_i\Phi)\text{Tr}(\Delta^\dagger\tau_i\Delta) \\ &+ \left[\frac{1}{\sqrt{2}}\mu(\Phi^T i\tau_2\Delta\Phi) + \text{H.c.}\right]. \end{aligned}$$

SPECTRUM AND MASS HIERARCHIES OF TRIPLETS

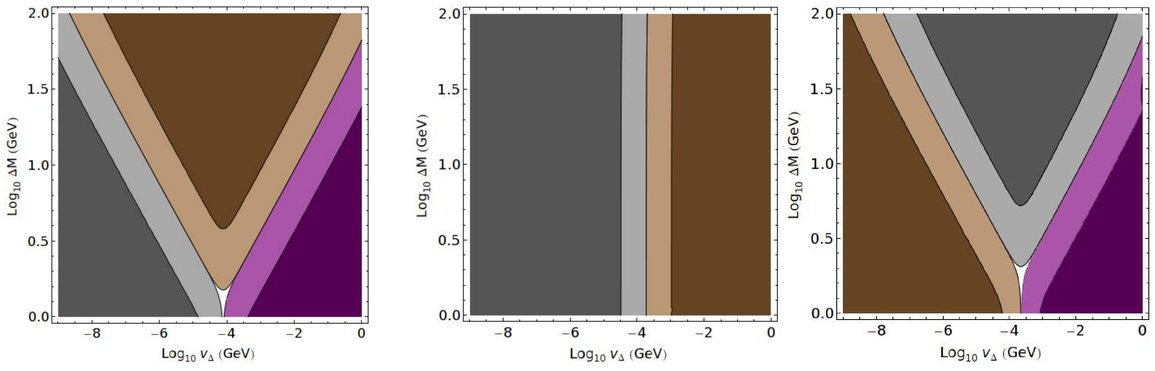
- $M^2_{H^{\pm\pm}} = M^2 + 2\frac{\lambda_4-\lambda_5}{g^2}M_W^2$
- $M^2_{H^{\pm}} = M^2_{H^{\pm\pm}} + 2\frac{\lambda_5}{g^2}M_W^2$
- $M^2_{H^0,A^0} = M^2_{H^{\pm}} + 2\frac{\lambda_5}{g^2}M_W^2$

Sign of λ_5 determines two mass hierarchies:

- $M_{H^{\pm\pm}} > M_{H^{\pm}} > M_{H^0/A^0}$ for $\lambda_5 < 0$;
- $M_{H^{\pm\pm}} < M_{H^{\pm}} < M_{H^0/A^0}$ for $\lambda_5 > 0$

PHASE DIAGRAMS FOR TRIPLET DECAY

The Phase diagrams for H^+(left), H^{++}(middle) and H^0(right) decays in the type II seesaw model.



For H^+

- Brown : $H^+ \to H^{++}W^{-*}$
- Gray : $H^+ \to \ell^+\nu$
- Purple : All others

For H^{++}

- Gray : $H^{++} \to \ell^+\ell^+$
- Brown: $H^{++} \to W^+W^+$

For H^0

- Gray : $H^0 \to H^+W^{-*}$
- Brown : $H^0 \to \nu\nu$
- Purple : All others

SAME-SIGN TETRA-LEPTONS AT THE LHC

We study a new possibility of observing same-sign four leptons (SS4L) at the LHC.

1. $q'\bar{q} \to W^* \to H^\pm H^0/A^0$ proceeded by $H^\pm \to H^{\pm\pm}W^{\mp^*}$ and $H^0/A^0 \to H^\pm W^{\mp^*} \to H^{\pm\pm}W^{\mp^*}W^{\mp^*}$;
2. $q\bar{q} \to Z^* \to H^0A^0$ proceeded by $H^0/A^0 \to H^\pm W^{\mp^*} \to H^{\pm\pm}W^{\mp^*}W^{\mp^*}$.

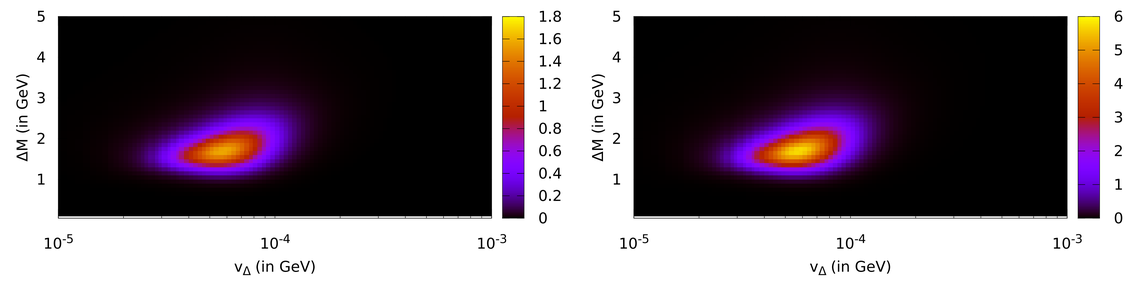
- An important quantity for a $4l^\pm$ signal is the mass splitting δM_{HA} between H^0 and A^0, $\delta M_{HA} = 2M_{H^0}v_\Delta^2/v_0^2$,
- SS4L cannot occur in the limit of $\mu, v_\Delta \to 0$ due to destructive interference between H^0 and A^0,
- Note that SS4L occurs as H^0 and A^0 can mix together like in the B^0-$\bar{B}^0$ system to produce wrong sign leptons in our system.
- Lepton number violating production of SS4L becomes sizable when $x_{HA} \equiv \frac{\delta M_{HA}}{\Gamma_{H^0/A^0}} \gg 1$,

Using proper NWA including interference effects, we write cross-section for process 1

$$\begin{aligned} \sigma\left(4\ell^\pm + 3W^{\mp^*}\right) &= \sigma\left(pp \to H^\pm H^0 + H^\pm A^0\right)\left[\frac{x_{HA}^2}{1+x_{HA}^2}\right]\text{BF}(H^0/A^0 \to H^\pm W^{\mp^*}) \\ &\times \left[\text{BF}(H^\pm \to H^{\pm\pm}W^{\mp^*})\right]^2\left[\text{BF}(H^{\pm\pm} \to \ell^\pm\ell^\pm)\right]^2; \end{aligned}$$

RESULTS

Bright region shows the allowed parameter space for SS4L signal at 8 TeV (Left) and 14 TeV (Right).



CONCLUSIONS

- A remarkable signal of SS4L, $l^\pm l^\pm l^\pm l^\pm$, is allowed in the type II seesaw mechanism
- For lightest H^{++}, all triplet pair-production may lead to SS4L signal.
- A crucial ingredient is the H^0-A^0 mixing which becomes large for smaller v_Δ and larger ΔM.