Private Higgs at the LHC

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Outline

The Private Higgs framework

A model with all Yukawa couplings $\mathcal{O}(1)$.

- Standard Model (SM):

$$y_f^{\mathrm{SM}} = \frac{m_f}{\langle \phi^0_{\mathrm{SM}} \rangle} \sim 10^{-6} - 1 \ , \quad \langle \phi^0_{\mathrm{SM}} \rangle \sim m_t \ .$$

- Private Higgs (PH):

$$y_f^{\mathrm{PH}} = \frac{m_f}{\langle \phi^0_f \rangle} \sim 1 \implies \langle \phi^0_f \rangle \sim m_f \ .$$

Based on work by Rafael Porto and A. Zee (arXiv:0712.0448 [hep-ph])

Light fermion $\leftrightarrow$ heavy Higgs

The PH seesaw for Higgs doublets

- One $\phi_f \sim (1, 2, +\frac{1}{2})$ and one $S_f \sim (1, 1, 0)$ per fermion.

$$V = \sum_{f \neq t} \left[M^2_{\phi_f} \phi^\dagger_f \phi_f - \left(\mu_{tf} S_f \phi^\dagger_t \phi_f + h.c. \right) \right] + ...$$

- Therefore:

$$\langle \phi^0_f \rangle \sim \frac{\mu_{tf} \langle S_f \rangle}{M^2_{\phi_f}} \langle \phi^0_t \rangle \, .$$

- For example, $f = b$:

$$\mu_{tb} \sim \langle S_b \rangle \sim 10^2 \, \text{GeV} \, , \; M_{\phi_b} \sim \text{TeV}$$
$$\Longrightarrow \; \langle \phi^0_b \rangle \sim 10^{-2} \langle \phi^0_t \rangle \, .$$

Higgs-singlet mixing

The factor of $\cos\theta_S$ in hGG and hVV

- CP-even neutral scalars mix:

$$\begin{pmatrix} H_t \\ S \end{pmatrix} = \begin{pmatrix} \cos\theta_S & \sin\theta_S \\ -\sin\theta_S & \cos\theta_S \end{pmatrix} \begin{pmatrix} h \\ \chi \end{pmatrix} .$$

- Gauge interactions are depleted: $c_W = c_Z = c_G = \cos\theta_S$

$$\mu_{VV} \equiv \frac{\sigma(pp \to h) \times \mathcal{B}(h \to VV)}{\sigma(pp \to h)_{\rm SM} \times \mathcal{B}(h \to VV)_{\rm SM}} \approx \cos^4\theta_S \frac{\Gamma_h^{\rm SM}}{\Gamma_h} .$$

The $hb\bar{b}$ vertex

Flavor-dependent deviations from the SM

- PH+singlet result in:

$$\mathcal{L}_{hb\bar{b}} = -\frac{m_b}{v_t}\left\{\left(1-\lambda_{tb}\frac{v_t^2}{\mathcal{M}^2_{\phi_b}}\right)\cos\theta_S + \Delta_S \sin\theta_S\right\} hb\bar{b} + h.c.$$

- Analogous $c_{f\neq b,t}$ for other fermions

Summary

- All Yukawa couplings can be $y_f \sim \mathcal{O}(1)$.
- The $hf\bar{f}$ vertices can have $c_f \sim 1 \pm \Delta_f$, $\Delta_f \neq \Delta_{f'}$.
- Singlet phenomenology is important: $\cos\theta_S$ and Γ_h .

- Related aspects
  - The CKM matrix (will add to arXiv:1207.0467 [hep-ph])
  - The PMNS matrix (see arXiv:0807.0612 [hep-ph] and arXiv:1202.4234 [hep-ph])