

Aspects of non-standard Higgs scenarios

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Plan

- Extended Higgs sectors: standard and non-standard
- Three examples
 - NMSSM: Associated production of H^+W^-
(with Oscar Stål and Roman Pasechnik)
 - A “lopsided,” semi-fermiophobic, doublet model
(with Johan Rathsman and Glenn Wouda)
 - Higgs triplet models (type-II seesaw)
(with Viveca Lindahl and Glenn Wouda)

SM Higgs sector

The SM has *one* complex scalar SU(2)-doublet $\Phi = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix}$

$$\mathcal{L}_{bos} = |D_\mu \Phi|^2 + \mu^2 |\Phi|^2 - \lambda |\Phi|^4 - \frac{1}{4} B_{\mu\nu} B^{\mu\nu} - \frac{1}{4} W_{\mu\nu}^a W^{a,\mu\nu}$$

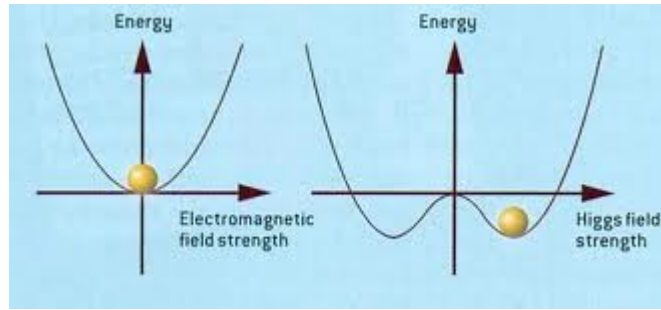
Electroweak
symmetry breaking:

$$\langle \Phi \rangle = \frac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ v \end{pmatrix} \quad \text{where } v \equiv \sqrt{\frac{-\mu^2}{\lambda}}$$

...and we write $\langle \Phi \rangle = \frac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ v \end{pmatrix} + \frac{1}{\sqrt{2}} \begin{pmatrix} \phi_1 + i\phi_2 \\ h + i\phi_3 \end{pmatrix}$

The
Higgs
boson

- The doublet has four degrees of freedom
- Three d.o.f. are “eaten” by the massive W and Z
- One remains: the Higgs



$= -V(\Phi)$
[scalar potential]

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Extended Higgs sectors

The most common way to extend the Higgs sector is by adding another doublet field so that there are 2 in total

This is done in minimal SUSY (MSSM)

Also: general two-Higgs doublet model (2HDM)

In the SM the doublet couples to down-type fermions and its complex conjugate to up-type fermions. This is not allowed by SUSY so we need two doublets.

There are now 8 d.o.f. – three are eaten by W, Z

→ **Five** physical Higgs bosons: h^0, H^0, A^0, H^\pm

CP-even

CP-odd

charged

Additional Higgses

- Thus, finding more than one neutral Higgs particle, or a charged Higgs, would be proof of an extended Higgs sector
- This is easier than it sounds
- In MSSM or 2HDM, each of these Higgses interacts in a “standard” way (production and decay)
- Tendency to only look for those “standard” scenarios
- I will show you some other possibilities

Additional Higgses

- Thus, if we would find more than one neutral Higgs particle, or a charged Higgs, it would be proof of an extended Higgs sector
- This is easier than it sounds
- There is a tendency for people to only consider this type of Higgs sector
- I will show you some other possibilities