

Singlet Scalar Model Benchmarks for Di-Scalar Production

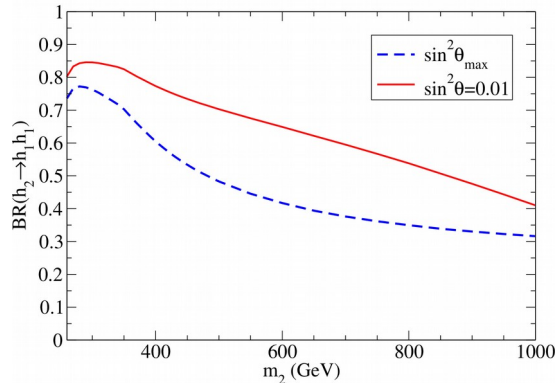
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Real Scalar Singlet

$$V(\Phi, S) = -\frac{\mu^2}{2}\Phi^\dagger\Phi + \frac{\lambda}{4}(\Phi^\dagger\Phi)^2 + \frac{a_1}{2}\Phi^\dagger\Phi S + \frac{a_2}{2}\Phi^\dagger\Phi S^2 + b_1 S + \frac{b_2}{2}S^2 + \frac{b_3}{3}S^3 + \frac{b_4}{4}S^4.$$

$$\begin{pmatrix} h_1 \\ h_2 \end{pmatrix} = \begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} h \\ S \end{pmatrix}$$

No Z_2 Symmetry



$$\sigma(pp \rightarrow h_2) = \sin^2\theta \sigma_{SM}(pp \rightarrow h_2).$$

Complex Scalar Singlet

$$V(\Phi, S_c) = \frac{\mu^2}{2}\Phi^\dagger\Phi + \frac{\lambda}{4}(\Phi^\dagger\Phi)^4 + \frac{b_2}{2}|S_c|^2 + \frac{d_2}{4}|S_c|^4 + \frac{\delta_2}{2}\Phi^\dagger\Phi|S_c|^2 + \left(a_1 S_c + \frac{b_1}{4} S_c^2 + \frac{e_1}{6} S_c^3 + \frac{e_2}{6} S_c |S_c|^2 + \frac{\delta_1}{4}\Phi^\dagger\Phi S_c + \frac{\delta_3}{4}\Phi^\dagger\Phi S_c^2 + \frac{d_1}{8} S_c^4 + \frac{d_3}{8} S_c^2 |S_c|^2 + \text{h.c.} \right)$$

$$S_c = (S_0 + i A)/\sqrt{2}$$

$\sin\theta_1$	m_2 (GeV)	$\text{BR}(h_2 \rightarrow h_1 h_3)$	Parameters
0.1	400	0.993	$\delta_2 = 6.47, \delta_3 = -2.77-3.22i, e_1/v = 2.41+38.8i, e_2/v = 5.27-7.42i$
0.1	500	0.987	$\delta_2 = 4.02, \delta_3 = 0.125-2.14i, e_1/v = -1.63+52.4i, e_2/v = -5.71+6.19i$
0.1	600	0.981	$\delta_2 = 16.3, \delta_3 = -9.45+9i, e_1/v = 2.39+141i, e_2/v = 1.70+7.81i$
0.1	700	0.974	$\delta_2 = 8.03, \delta_3 = 1.5+1.5i, e_1/v = 3.31+106i, e_2/v = 8.55-9.68i$
$\sin\theta_1$	m_2 (GeV)	$\text{BR}(h_2 \rightarrow h_3 h_3)$	Parameters
0.1	400	0.993	$\delta_2 = 4.4, \delta_3 = -2.39+3.05i, e_1/v = -10.1+21.7i, e_2/v = -6.59-1.36i$
0.1	500	0.987	$\delta_2 = 2.83, \delta_3 = 2.08-1.91i, e_1/v = 8.54-13.6i, e_2/v = -4.09+0.887i$
0.1	600	0.981	$\delta_2 = 12.4, \delta_3 = -4.54-5.99i, e_1/v = 14.3-42.6i, e_2/v = 4.98+2.76i$
0.1	700	0.974	$\delta_2 = 11.9, \delta_3 = -4.71+10.3i, e_1/v = -14.2+73i, e_2/v = -6.77-3.94i$

TABLE I: Benchmark points in the complex singlet model with large $\text{BR}(h_2 \rightarrow h_1 h_3)$ and $\text{BR}(h_2 \rightarrow h_3 h_3)$ for $m_3 = 130$ GeV and $\Gamma_2/m_2 = 0.1$. Other parameters are set to $\theta_2 = 0$, $d_1 = 0.1 + 0.1i$, $d_2 = 0.4$, and $d_3 = 0.1 + 0.1i$.