ANOMALOUS ZZγ, Zγγ, AND ZZV COUPLINGS

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In on-shell $Z\gamma$ production, deviations from the Standard Model for the $Z\gamma\gamma^*$ and $Z\gamma Z^*$ couplings may be described in terms of eight parameters, $h^V_i$ ($i = 1, 4; V = \gamma, Z$) [1]. The parameters $h^Z_i$ describe the $Z\gamma\gamma^*$ couplings and the parameters $h^Z_{\gamma}$ the $Z\gamma Z^*$ couplings. In this formalism $h^V_1$ and $h^V_2$ lead to $CP$-violating and $h^V_3$ and $h^V_4$ to $CP$-conserving effects. All these anomalous contributions to the cross section increase rapidly with center-of-mass energy. In order to ensure unitarity, these parameters are usually described by a form-factor representation, $h^V_i(s) = h^V_{io} / (1 + s/\Lambda^2)^n$, where $\Lambda$ is the energy scale for the manifestation of a new phenomenon and $n$ is a sufficiently large power. By convention one uses $n = 3$ for $h^V_{1,3}$ and $n = 4$ for $h^V_{2,4}$. Usually limits on $h^V_i$'s are put assuming some value of $\Lambda$, sometimes $\infty$.

In on-shell ZZ production, deviations from the Standard Model for the ZZγ* and ZZZ* couplings may be described by means of four anomalous couplings $f^V_i$ ($i = 4, 5; V = \gamma, Z$) [2]. As above, the parameters $f^\gamma_i$ describe the ZZγ* couplings and the parameters $f^Z_i$ the ZZZ* couplings. The anomalous couplings $f^V_5$ lead to violation of $C$ and $P$ symmetries while $f^V_4$ introduces $CP$ violation. Also here, formfactors depending on a scale $\Lambda$ are used.

All these couplings $h^V_i$ and $f^V_i$ are zero at tree level in the Standard Model; they are measured in $e^+e^-$, $pp$ and $pp$ collisions at LEP, Tevatron and LHC.

References