ANOMALOUS W/Z QUARTIC COUPLINGS

Revised February 2002 by C. Caso (University of Genova) and A. Gurtu (Tata Institute).

The Standard Model predictions for $WWWW$, $WWZZ$, $WWZ\gamma$, $WW\gamma\gamma$, and $ZZ\gamma\gamma$ couplings are small at LEP, but expected to become important at a TeV Linear Collider. Outside the Standard Model framework such possible couplings, a_0, a_c, a_n, are expressed in terms of the following dimension-6 operators [1,2];

$$L_6^0 = -\frac{e^2}{16\Lambda^2}\, a_0\, F^{\mu\nu}\, F_{\mu\nu}\vec{W}^{\alpha}\cdot\vec{W}_{\alpha}$$

$$L_6^c = -\frac{e^2}{16\Lambda^2}\, a_c\, F^{\mu\alpha}\, F_{\mu\beta}\vec{W}^{\beta}\cdot\vec{W}_{\alpha}$$

$$L_6^n = -i\frac{e^2}{16\Lambda^2}\, a_n \epsilon_{ijk}\, W_{\mu\alpha}^{(i)}\, W_{\nu}^{(j)}\, W^{(k)\alpha} F^{\mu\nu}$$

where F, W are photon and W fields, L_6^0 and L_6^c conserve C, P separately and generate anomalous $W^+W^-\gamma\gamma$ and $ZZ\gamma\gamma$ couplings, L_6^n violates CP and generates an anomalous $W^+W^-Z\gamma$ coupling, and Λ is a scale for new physics. For the $ZZ\gamma\gamma$ coupling the CP-violating term represented by L_6^n does not contribute. These couplings are assumed to be real and to vanish at tree level in the Standard Model.

Within the same framework as above, a more recent description of the quartic couplings [3] treats the anomalous parts of the $WW\gamma\gamma$ and $ZZ\gamma\gamma$ couplings separately leading to two sets parameterized as a_0^V/Λ^2 and a_c^V/Λ^2, where $V = W$ or Z.

At LEP the processes studied in search of these quartic couplings are $e^+e^- \to WW\gamma$, $e^+e^- \to \gamma\gamma\nu\overline{\nu}$, and $e^+e^- \to Z\gamma\gamma$ and limits are set on the quantities $a_0^W/\Lambda^2, a_c^W/\Lambda^2, a_n/\Lambda^2$. The characteristics of the first process depend on all the three couplings whereas those of the latter two depend only on the two CP-conserving couplings. The sensitive measured variables are the cross sections for these processes as well as the energy and angular distributions of the photon and recoil mass to the photon pair.

Different Monte Carlo descriptions of these couplings, *e.g.*, Ref. 2 and Ref. 4, do not agree, in particular for the $Z\gamma\gamma$ final state. Therefore, for the purpose of combining LEP results, only the measurements on $WW\gamma$ and $\gamma\gamma\nu\overline{\nu}$ final states are used and the 95% CL limits [5] are:

$$-0.018 < a_0^W/\Lambda^2 < 0.018,$$
$$-0.033 < a_c^W/\Lambda^2 < 0.047,$$
$$-0.17 < a_n/\Lambda^2 < 0.15.$$

References

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