EXTRACTION OF TRIPLE GAUGE COUPLINGS (TGC’S)

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Fourteen independent couplings, 7 each for $ZWW$ and $\gamma WW$, completely describe the $VWW$ vertices within the most general framework of the electroweak Standard Model (SM) consistent with Lorentz invariance and $U(1)$ gauge invariance. Of each of the 7 TGC’s, 3 conserve $C$ and $P$ individually, 3 violate $CP$, and one TGC violates $C$ and $P$ individually while conserving $CP$. Assumption of $C$ and $P$ conservation and electromagnetic gauge invariance reduces the independent $VWW$ couplings to 5: one common set is $(\gamma, Z, \gamma, Z, g_{Z1})$, where $\gamma = Z = g_{Z1} = 1$ and $\lambda_\gamma = \lambda_Z = 0$ in the Standard Model at the tree level. The $W$ magnetic dipole moment, $\mu_W$, and the $W$ electric quadrupole moment, $q_W$, are expressed as $\mu_W = e (1 + \kappa_\gamma + \lambda_\gamma)/2M_W$ and $q_W = -e (\kappa_\gamma - \lambda_\gamma)/M_W^2$.

Precision measurements of suitable observables at LEP1 has already led to an exploration of much of the TGC parameter space. Three linear combinations of the TGC’s, $\alpha_{B\phi}$, $\alpha_{B0}$, and $\alpha_{W}$, have been proposed to investigate the leftover “blind” directions in the $CP$-conserving TGC parameter space, and two linear couplings, $\tilde{\alpha}_{BW}$ and $\tilde{\alpha}_{W}$ in the $CP$-violating TGC parameter space (see e.g., papers by Hagiwara [1], Bilenky [2], and Gounaris [3,4]). The relations between these parameters and those contained in the above set, expressed as deviations from the SM, are $\Delta g_1^T = \alpha_{W\phi}/c_w^2$, $\Delta \kappa_\gamma = \alpha_{W\phi} + \alpha_{B0}$, $\Delta \kappa_Z = \alpha_{W\phi} - t_w^2 \alpha_{B0}$ and $\lambda_\gamma = \lambda_Z = \alpha_{W}$, where $c_w$ and $t_w$ are the cosine and tangent of the electroweak mixing angle. Similarly, $\tilde{\kappa}_\gamma = \tilde{\alpha}_{BW}$, $\tilde{\kappa}_Z = t_w^2 \tilde{\alpha}_{B0}$ and $\tilde{\lambda}_\gamma = \tilde{\lambda}_Z = \tilde{\alpha}_{W}$ within the $CP$-violating sector. The LEP Collaborations have recently agreed to express their results directly in terms of the parameters $\Delta g_1^T$, $\Delta \kappa_\gamma$, and $\lambda_\gamma$.

At LEP2 the $VWW$ coupling arises in $W$-pair production via $s$-channel exchange or in single $W$ production via the radiation of a virtual photon off the incident $e^+$ or $e^−$. At the TEVATRON hard photon bremsstrahlung off a produced $W$ or $Z$ signals the presence of a triple gauge vertex. In order to extract the value of one TGC the others are generally kept fixed to their SM values.

References
3. G. Gounaris et al., CERN 96-01 525.