Extraction of Triple Gauge Couplings (TGCs)

Revised April 2017 by M.W. Grünewald (U. College Dublin) and A. Gurtu (Formerly Tata Inst.)

Fourteen independent couplings, seven each for ZWW and γWW, 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 seven TGCs, three conserve C and P individually, three violate CP, and one violates C and P individually while conserving CP. Assumption of C and P conservation and electromagnetic gauge invariance reduces the number of independent VWW couplings to five: one common set [1,2] is (κγ, κZ, λγ, λZ, gZ 1), where κγ = κZ = gZ 1 = 1 and λγ = λZ = 0 in the Standard Model at tree level. The parameters κZ and λZ are related to the other three due to constraints of gauge invariance as follows: κZ = gZ 1 - (κγ - 1) tan2 θW and λZ = λγ, where θW is the weak mixing angle. The W magnetic dipole moment, μW, and the W electric quadrupole moment, qW, are expressed as μW = e (1 + κγ + λγ)/2MW and qW = -e (κγ - λγ)/MW2.

Precision measurements of suitable observables at LEP1 has already led to an exploration of much of the TGC parameter space. 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 and the LHC, 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. While most analyses use the above gauge constraints in the extraction of TGCs, one analysis of W-pair events also determines the real and imaginary parts of all 14 couplings using unconstrained single-parameter fits [3]. The results are consistent. Some experiments have determined limits on the couplings under various non-LEP scenarios and assuming different values of the form factor Λ, where the coupling parameters are scaled by 1/(1 + s/Λ2)2. For practical reasons it is not possible to quote all such determinations in the listings. For that the individual papers may be consulted. Recently, EFT-inspired sets of couplings [4,5], such as cWW/Λ2, cW/Λ2, cB/Λ2 which are linearly related to the couplings discussed above, are also determined by the LHC experiments.

References:
2. G. Gounaris et al., CERN 96-01 p. 525.

P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2020)