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STUDY OF QUARTIC BOSON VERTICES AT PHOTON COLLIDERS IN THE STANDARD MODEL AND BEYOND.

I. Marfin, V. Mossolov, T. Shishkina
NCPHEP, 153 Bogdanovitcha str.,220040 Minsk

ABSTRACT

The production of several vector bosons in $\gamma\gamma$-interactions is the best place to search directly for any anomalous behavior of triple and quartic couplings. A few anomalous quartic boson operators are considered in the paper. A high precision of anomalous effects can be achieved by calculation of the lowest order electroweak corrections: one-loop corrections, real photon and Z-boson emission.

The multiple vector-boson production would be a crucial test of the gauge structure of the Standard Model since the triple and quartic vector-boson couplings in this kind of reaction are constrained by the $SU(2) \otimes U(1)$ gauge invariance. Any small deviation from the Standard Model predictions for these couplings gives anomalous growth of the cross section with energy. The quartic gauge boson couplings lead to direct electroweak symmetry breaking, in particular in the scalar sector of the theory or, more generally, to "new physics" of electroweak gauge bosons. Since the processes $\gamma\gamma \to W^+W^-$ and $\gamma\gamma \to W^+W^-Z$ at high energies will give the unique possibility of quartic couplings investigation due to relatively large cross sections and low background for WW and WWZ productions [1]. Evaluating of anomalous contributions to cross sections of WW and WWZ productions requires a calculation of the lowest order electroweak corrections.

Constructing the structures contained anomalous quartic gauge boson couplings where at least one photon is involved one has to consider the operators with the the lowest dimension of 6 [2].

$$\mathcal{L}_0 = -\frac{e^2}{16\Lambda^2} a_0 F^{\mu\nu} F_{\mu\nu} \bar{W}^{\alpha} \bar{W}_{\alpha},, \quad \mathcal{L}_c = -\frac{e^2}{16\Lambda^2} a_c F^{\mu\alpha} F_{\mu\beta} \bar{W}^{\beta} \bar{W}^{\alpha},$$
$$\tilde{\mathcal{L}}_0 = -\frac{e^2}{16\Lambda^2} \tilde{a}_0 F^{\mu\alpha} \tilde{F}_{\mu\beta} \bar{W}^{\beta} \bar{W}^{\alpha}, \tag{1}$$

where

$$\bar{W}_\mu = \left(\frac{1}{\sqrt{2}}(W^+_\mu + W^-_\mu), \frac{i}{\sqrt{2}}(W^+_\mu - W^-_\mu), \frac{1}{\cos\theta_W} Z_\mu \right),$$
$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu, \;\; W^i_{\mu\nu} = \partial_\mu W^i_\nu - \partial_\nu W^i_\mu, \;\; \tilde{F}_{\mu\nu} = \frac{1}{2} \epsilon_{\mu\nu\rho\sigma} F^{\rho\sigma}. \tag{2}$$

The scale Λ ($\sim$ 80 GeV) is introduced to keep the coupling constant a_i dimensionless [3]. As one can see the operators $\mathcal{L}_0$ and $\mathcal{L}_c$ are C-, P-, CP-invariant. $\mathcal{L}_n$ violates both C- and CP-invariance. $\tilde{\mathcal{L}}_0$ is the P- and CP-violating operator. $\tilde{\mathcal{L}}_n$ conserves CP-invariance but violates C- and P-invariance separately.

Explicit expressions for the amplitude of the process $\gamma\gamma \to W^+W^-$ and $\gamma\gamma \to W^+W^-Z$ are contained in [4]. We suppose the following experimental conditions: unpolarized $\gamma\gamma$ beams at $\sqrt{s} = 1$ TeV with luminosity $\mathcal{L} = 100 fb^{-1}/year$. The contour plots for different deviations from the SM $\gamma\gamma \to W^+W^-$ total cross sections at $\sqrt{s} = 1$ TeV, in case two of the three anomalous couplings, are the most vivid and interesting for investigation of anomalous couplings. Figures 1 presents contour plots for different pairs of a_i. Here σ means a variance of total cross section. Figures 2 show the same contour plots with radiative correction. The first order radiative correction improves conditions of experiments concerning anomalous constant.

References

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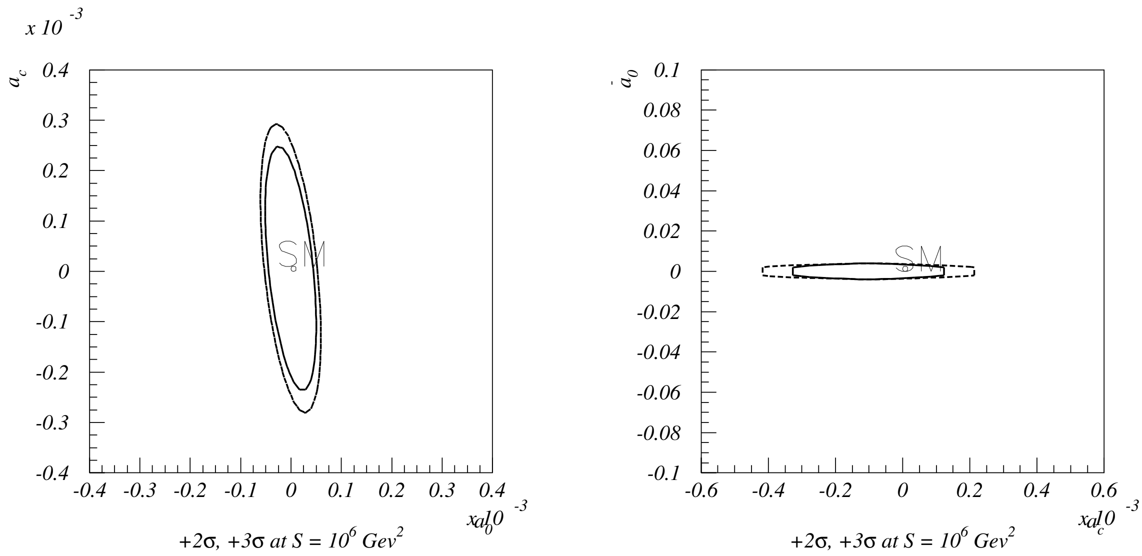

Figure 1: *Contour plots for +2σ and +3σ deviations of* $\sigma(\gamma\gamma \to W^+W^-)$

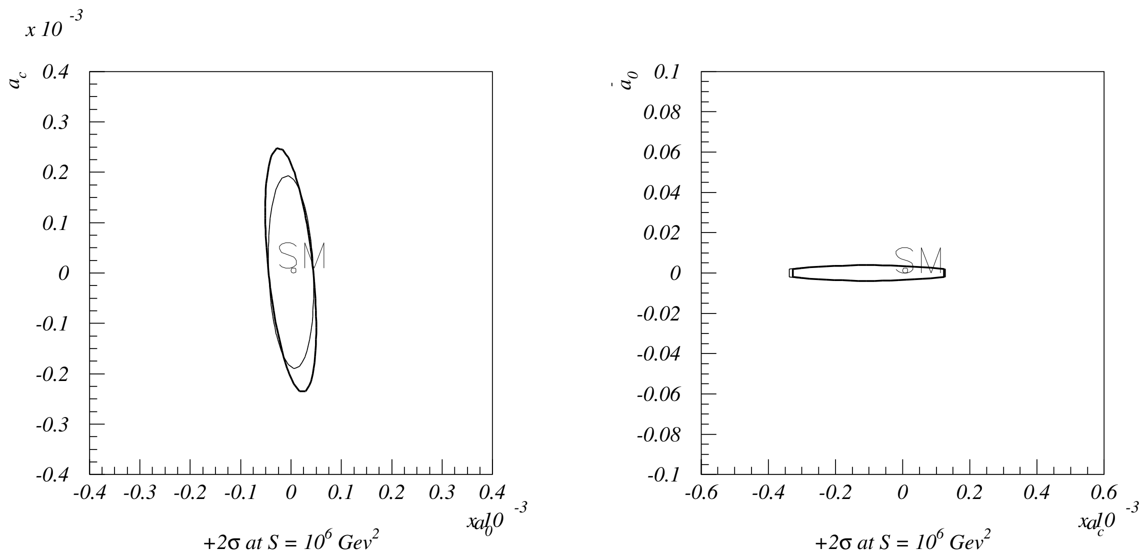

Figure 2: *Contour plots for +2σ deviation of* $\sigma(\gamma\gamma \to W^+W^-)$*: with correction (single line) and without correction (double line)*