Complex Triple Gauge Boson Couplings

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Outline

- Introduction to TGC Lagrangian
- SHERPA TGC simulations
- Complex couplings in SHERPA simulations

Introduction

- Interaction lagrangian for the electroweak force fields:

$$L_{boson} = -\frac{1}{4}B_{\mu\nu}B^{\mu\nu} - \frac{1}{4}\overrightarrow{W}^{\mu\nu}\cdot\overrightarrow{W}_{\mu\nu}$$

where

$$B_{\mu\nu} = \partial_\mu B_\nu - \partial_\nu B_\mu \qquad U(1)_Y$$

$$W^i_{\mu\nu} = \partial_\mu W^i_\nu - \partial_\nu W^i_\mu + g\epsilon^{ijk}W^j_\mu W^k_\nu \qquad SU(2)_L$$

- Physical fields are:

$$W^\pm_\mu = \frac{1}{\sqrt{2}}(W^1_\mu \mp W^2_\mu)$$

$$\begin{pmatrix} A_\mu \\ Z_\mu \end{pmatrix} = \begin{pmatrix} sin\theta_W & cos\theta_W \\ cos\theta_W & -sin\theta_W \end{pmatrix} \cdot \begin{pmatrix} W^3_\mu \\ B_\mu \end{pmatrix}$$

- All gauge bosons are massles. Applying the Higgs mechanism leads to 3 massive and one massless bosons.
- Inserting the physical fields and adding general Lorentz invariant terms leads to the effective TGC lagrangian.

TGC Lagrangian

$$\begin{aligned}
\frac{\imath L_{eff}^{WWV}}{g_{WWV}} &= g_1^V V^\mu (W^-_{\mu\nu} W^{+\nu} - W^+_{\mu\nu} W^{-\nu}) \\
&+ \kappa_V W^+_\mu W^-_\nu V^{\mu\nu} \\
&+ \frac{\lambda_V}{m_W^2} v_{\mu\nu} W^{+\rho}_\nu W^-_{\rho\mu} \\
&+ \imath g_5^V \varepsilon_{\mu\nu\rho\sigma} ((\partial^\rho W^{-\mu}) W^{+\nu} - W^{-\mu}(\partial^\rho W^{+\nu})) V^\sigma \\
&+ \imath g_4^V W^-_\mu W^+_\nu (\partial_\mu V_\nu + \partial_\nu V_\mu) \\
&- \frac{\tilde{\kappa}_V}{2} W^-_\mu W^+_\nu \varepsilon^{\mu\nu\rho\sigma} V_{\rho\sigma} \\
&- \frac{\tilde{\lambda}_V}{2m_W^2} W^-_{\rho\mu} W^{+\mu}_\nu \varepsilon^{\nu\rho\alpha\beta} V_{\alpha\beta} \\
\textit{where} &\qquad V = \gamma, Z, \\
W_{\mu\nu} = \partial_\mu W_\nu - \partial_\nu W_\mu &\qquad V_{\mu\nu} = \partial_\mu V_\nu - \partial_\nu V_\mu, \\
g_{WW\gamma} = e &\qquad g_{WWZ} = e cot\theta_W.
\end{aligned}$$

TGC Lagrangian

- CP-conserving:Δg_1^V, $\Delta\kappa_V, \lambda_V$ and g_5^V
- CP-violating: $g_4^V, \tilde{\kappa}_V, \tilde{\lambda}_V$
- Generally the couplings are assumed real, but this assumption is not required
- Present limits (from ALEPH 2005) are

Parameter	Real: SM value	Real: 95% CL	Imaginary: 95% CL
κ_γ	1	$[0.956, 1.193]$	$[-0.103, 0.236]$
λ_γ	0	$[-0.028, 0.229]$	$[-0.137, 0.142]$
g_1^γ	1	$[0.967, 1.289]$	$[-0.173, 0.231]$
κ_Z	1	$[0.949, 1.182]$	$[-0.062, 0.165]$
λ_Z	0	$[-0.086, 0.125]$	$[-0.086, 0.092]$
g_1^Z	1	$[0.920, 1.214]$	$[-0.0110, 0.156]$

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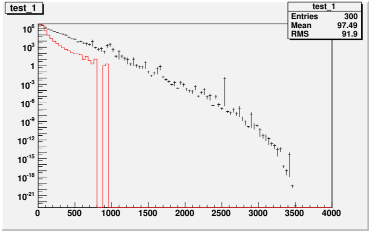
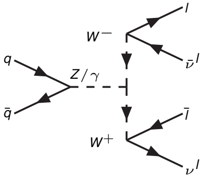
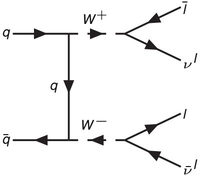


Figure: CalcHEP Standard Model test. Transverse momentum of e^+ plotted against SHERPA SM simulation.

SHERPA TGC simulations

- Simulations of W pair production in pp collisions.
- Focus on the purely leptonic decay channel $\bar{l}\nu l\bar{\nu}$, $l = e, \mu$.





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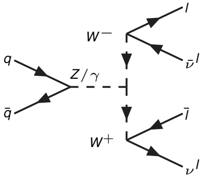
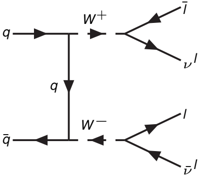




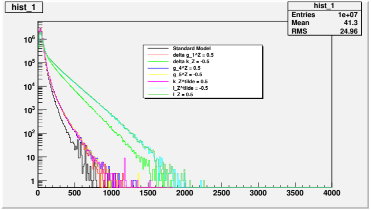
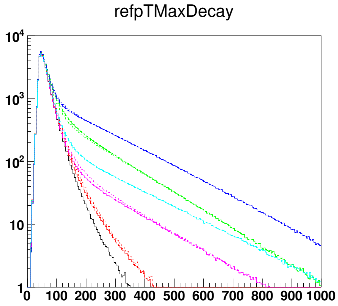


Figure: SHERPA simulations of TGCs. Transverse momentum of e^+

Complex couplings in SHERPA simulations - a work in progress

- Couplings modified so far: Δg_1^Z, $\Delta\kappa_V$ and λ_V.
- Real part have been set to zero, so only imaginary term is present.
- Values inserted for couplings: $\Delta g_1^Z = 0.5\imath$ (red), $\Delta\kappa_\gamma = 0.5\imath$ (magenta), $\Delta\kappa_Z = -0.5\imath$ (green), $\lambda_\gamma = -0.5\imath$ (cyan), $\lambda_Z = 0.5\imath$ (blue).



Thank you!