A novel approach to probing new physics with neutral Gauge Boson couplings

Even before reaching the energy threshold for producing any new elementary particle beyond the Standard Model (SM) [1], new physics effects can be systematically described by effective operators with mass-dimensions higher than 4. These new operators together with the SM form the so-called SM effective theory (SMEFT). Most analyses consider only dimension-6 operators. However, these do not contribute to neutral triple gauge couplings (nTGCs), which first arise from dimension-8 operators [2]. Hence, precision probes of nTGCs at future e^+e^- colliders will provide a unique window to the possible new physics beyond the SM.

Three theorists recently proposed [3] a novel approach to probing nTGCs at planned future e^+e^- colliders [4], including the CEPC, FCC-ee, ILC, and CLIC. They constructed a new set of *pure gauge operators* of dimension-8 that contribute to nTGCs and are independent of the dimension-8 operator involving Higgs doublets. They found that such pure gauge operators generate both $Z\gamma Z^*$ and $Z\gamma\gamma^*$ vertices with rapid energy dependence $\propto E^5$, and can be probed sensitively via the reaction $e^-e^+ \rightarrow Z\gamma$. They demonstrated [3] that measuring the nTGCs via the reaction $e^+e^- \rightarrow Z\gamma$ with *hadronic decays* $Z \rightarrow q\bar{q}$ can probe the new physics scale of dimension-8 pure gauge operator O_{G+} up to the range 1-5 TeV at the CEPC, FCC-ee and ILC colliders with $\sqrt{s}=(0.25-1)$ TeV, and up to the range 10-16 TeV at CLIC with $\sqrt{s}=(3-5)$ TeV (cf. Table 3 and Figure 8 of ref. [3]). These sensitivities are compared with those of the dimension-8 nTGC operator O_{BW} (involving Higgs doublets) and the related dimension-8 fermionic contact operator O_{C+} (contributing to the $e^-e^+Z\gamma$ vertex).

The sensitivity reaches of the nTGC new physics scale as established in ref. [3] are substantially stronger than what the authors found previously [5] for the Higgs-related nTGC operator O_{BW} via Z decays into leptonic channels. This study [3] demonstrates the importance of probing the nTGCs from dimension-8 operators via the reaction $e^+e^- \rightarrow Z\gamma$, with sensitivity reaches of the corresponding new physics scales extending well into the multi-TeV regime. It provides a distinctive model-independent benchmark for new physics searches at e^+e^- colliders being planned [4] and strongly motivates further detector level simulations for probing the nTGCs.

Rong-Gen Cai

Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing 100190, China

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