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Axion Physics in UPC and LbyL Scattering

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The light-by-light scattering (LbyL), $\gamma\gamma \rightarrow \gamma\gamma$, is a rare process in the Standard Model (SM) in which two photons interact and produce another pair of photons in the final state. The first direct evidence of this process at the LHC was established by the ATLAS experiment in 2017 [1] and subsequently confirmed by the CMS experiment in 2019 [2], both using data collected in 2015. ALICE is one of the LHC experiments where no evidence of LbyL scattering has been found. However, it is estimated that after its upgrade (ALICE3), evidence of LbyL scattering may be discovered, allowing for a comparison of the obtained data with Monte Carlo generator studies.

LbyL scattering occurs at the lowest order in Quantum Electrodynamics (QED) through virtual box diagrams and is prohibited in classical electrodynamics. Since strong interaction is sought to be minimized, this process is studied in ultra-peripheral collisions (UPC) of heavy ions at high energies. Furthermore, it has been proposed as a channel for exploring physics beyond the SM.

In this work, the phenomenological and experimental implications associated with SM or extension models (for example, an Axion-Like Particles (ALP) model), are analyzed under the context of ALICE physics. Monte Carlo studies are presented with the gamma-UPC+MadGraph5_aMC@NLO generators through diphoton invariant mass distributions for the LbyL scattering process and different scenarios for ALP-photon coupling at different values of ALP masses.

[1] ATLAS Collaboration. Evidence for light-by-light scattering in heavy-ion collisions with the ATLAS detector at the LHC. Nature Phys 13, 852–858, 2017.
[2] CMS Collaboration. Evidence for light-by-light scattering and searches for axion-like particles in ultraperipheral PbPb collisions at $\sqrt{S_{NN}} = 5.02$ TeV. Physics Letters B, 797, 2019.

Primary author: Mr RAMÍREZ ÁLVAREZ, César Omar (Benemérita Universidad Autónoma de Puebla)

Co-authors: Dr FERNÁNDEZ TÉLLEZ, Arturo (Benemérita Universidad Autónoma de Puebla); Dr HERNÁNDEZ JUÁREZ, Alan Ignacio (FES-Cuautitlán UNAM)

Presenter: Mr RAMÍREZ ÁLVAREZ, César Omar (Benemérita Universidad Autónoma de Puebla)

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