Constraining Two-Photon Processes with Enhanced Experimental Parameters

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Elastic photon-photon interactions, such as light-light scattering, is a fundamental prediction of quantum electrodynamics (QED) with no classical analogue due to the linearity of Maxwell's equations. Detecting these processes experimentally still presents a real challenge; linear Breit-Wheeler production [1] has a large energy threshold in the zero momentum frame (ZMF), $E_{ZMF} \geq 2m_e c^2$, and photon-photon scattering via virtual electron-positron pairs [2] is an α^4-order process with an extremely small cross section (approximately 10^{16} times smaller than the Thomson cross section).

Past experimental campaigns using optical and x-ray beams were unsuccessful in direct observation of photon-photon scattering, instead bounding the magnitude of the cross section [3-6]. However, the tightest bound to date at 10^{11} times the theoretical value was achieved at a recent experiment at the Gemini laser facility, RAL, UK [7]. The interacting photons were comprised of two distinct sources – LWFA electrons striking a high-Z target to generate 100's MeV-scale bremsstrahlung, and keV-scale x-rays generated from an exploding foil.

Here, we consider setup of [7], upgraded with the capabilities of a multi-PW laser acting as the source for LWFA electrons and a kJ-class laser for x-ray production. Simulations of this upgraded configuration indicate that it will be possible to not only directly detect Breit-Wheeler pairs on a single-shot basis, but also to potentially observe photon-photon scattering within a realistic time frame or, at least, bounding it within $10^4 - 10^6$ times the theoretical value; up to seven orders of magnitude tighter than the current best.

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