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Possibility of pair creation in collision of gamma-ray beams produced with a high intensity laser

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Direct production of electron-position pairs in photon collisions is one of the basic processes in the Universe. The electron-positron production γ+γ to e^++e^- (linear Breit-Wheeler process) is the lowest threshold process in photon-photon interaction, controlling the energy release in Gamma Ray Bursts, Active Galactic Nuclei, black holes and other explosive phenomena [1]. It is also responsible for the TeV cutoff in the photon energy spectrum of extra-galactic sources. The linear Breit-Wheeler process has never been clearly observed in laboratory with important probability of matter creation [2]. Thank with MeV photon source new experimental set-up based on numerical simulation with QED effect is proposed to achieved more than 10^4 Breit-Wheeler pairs per shot.

This scheme offers a possibility of conducting a multi-shot experiment with a reliable statistics on laser systems with pulse energies on the level of a few joules and in a low noise environment without heavy elements. This scheme relies on a collision of relatively low energy (few MeV), intense photon beams. Such beams can be created in interaction of intense laser pulses with thin plastic targets (See Figure).

Figure: Experimental setup for the Breit–Wheeler pairs production with MeV colliding photon beams.[5]

By colliding two of them in vacuum, one would be able to produce a significant number of electron-positron pairs in a controllable way. We provide details of the experimental setup, estimates from model and numerical simulations of the expected yield of reactions and possible ways of creation of a photon source with requested parameters.
The spatial separation of the photon-photon interaction zone seems to be the best way for the detection of the BW pairs emitted in the preferential direction. Thank with MeV photon source [3] and based on numerical simulations with QED effect more than 10^4 Breit-Wheeler pairs per shot can be acheived [4]. Results from Monte-Carlo simulations will be pressented to proposed a robust experimental design. Moreover, the noise level due to other pair process creation is estimated.

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Summary

Direct production of electron–positron pairs in two photons collision by Breit–Wheeler process is one of the basic processes in the Universe. However, this process has never been observed in laboratory up to now. Laser induced synchrotron sources of γ-rays may open for the first time a way to observe it. We study the feasibility of an experimental set-up using a MeV photon source aiming to produce more than 10^4 pairs per shot. We compare several γ–ray sources, estimate the photon background for our proposed scheme with analytical model and numerical simulations including quantum electrodynamic effects.

Author: RIBEYRE, Xavier (Université de Bordeaux 1)

Co-authors: Dr D'HUMIÈRES, Emmanuel (Université de Bordeaux 1); Dr LOBET, Mathieu (CEA/DAM); Dr JANSEN, Oliver (Université Bordeaux 1); Dr JEQUIER, Sophie (Université Bordeaux 1); Prof. TIKHONCHUK, Vladimir (Université Bordeaux 1)

Presenter: RIBEYRE, Xavier (Université de Bordeaux 1)

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