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Search for a light neutral boson in nuclear transitions

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In a recent series of papers the intriguing possibility was explored that the cosmic dark matter consists of new elementary particles with masses in the MeV range, which could be searched for in nuclear physics laboratories. Such particles are not excluded by any obvious laboratory measurements or astrophysical arguments. There are even some experimental indications for a light neutral boson with a mass of around 9 MeV/c2 [1,2]. The spectrometers used for the above studies were plastic telescopes, which are insufficient for the required precision. We have improved the setups already and got somewhat stronger indications, but the reliability of the results can still be questioned because of the large systematic errors [3,4].

The signature of the new particle is the very characteristic angular correlation of the e+e- pairs from their decay. Quantum electrodynamics predicts that the angular correlation between the e+e- pairs emitted in internal pair creation drops smoothly with the separation angle. In striking contrast, when the transition takes place by the emission of a short-lived neutral particle annihilating into an e^+e^- pair, the angular correlation becomes sharply peaked at large angles. In order to search for this signature with high confidence we need an internal pair spectrometer with much better specifications, which was ever built for studying nuclear transitions.

We started to build a Compact Orange type Positron Electron spectrometer (COPE) for precise studies of the e+e- pair creation in the energy range of 10-20 MeV with large solid angle, good energy (1\%) and angular (2 deg.) resolutions, using strong permanent magnets. The diameter of such a spectrometer will be about 30 cm, which is versatile and can be used at different laboratories. With the presently available tracking detectors, data-acquisition systems and computers we will be able to study the differential internal pair creation process more precisely than ever before, with a precision enaugh for confirming (or discarding with high confidence) the existence of such light neutral particles.

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Primary author: Prof. KRASZNAHORKAY, Attila (Inst. of Nucl. Res. of the Hung. Acad. of Sci. (ATOMKI), Head, Division of Nuclear Physics)

Presenter: Prof. KRASZNAHORKAY, Attila (Inst. of Nucl. Res. of the Hung. Acad. of Sci. (ATOMKI), Head, Division of Nuclear Physics)

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