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Light Interferometer for Measurement of the Gravitational Behavior of Antimatter

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The QUPLAS (QUantum interferometry and gravitation with Positrons and LASers) experiment aims to test fundamental physical laws with antimatter by measuring the Positronium (Ps) fall in the Earth's gravitational field. Such measurement would represent a test of the Einstein Equivalence Principle and the CPT symmetry and is further motivated by the lack of information on antimatter behavior in the gravitational field.
The setup and techniques of the experiment involve three phases of production, preparation, and interference of the positronium beam. I will discuss the design, simulation and optimization of the Single Photon Large Momentum Transfer (LMT) Mach-Zehnder interferometer [1] composed by 23 laser pulses and used in the final stage of the experiment to reveal the influence of the Earth's gravitational field through the relationship that binds the phase shift of the wave function of Ps to the gravitational acceleration: $\Delta\phi = k_{eff}\ gT^2$. By simulating the interferometer, it was possible to estimate its efficiency, contrast and signal acquisition times as well as determining fundamental operating parameters such as the size, shape and power of the laser pulses and the divergence requirements on the positronium beam. These results will be shown in the exhibition.

[1] G. Vinelli et al., arXiv:2303.11798 [physics.atom-ph].

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