Fermionic Signal of Vacuum Polarization in Strong Laser Fields

Y-N Dai[1], K Z Hatsagortsyan[2], C H Keitel[2], and Y-Y Chen[1]

[1] *Department of Physics, Shanghai Normal University, Shanghai, China*
[2] *Theoretical Quantum Dynamics and Quantum Electrodynamics, Max-Planck Institute for Nuclear Physics, 69117 Heidelberg, Germany*
Contact Email: yueyuechen@shnu.edu.cn

Vacuum polarization (VP) is investigated for the interaction of a polarized γ-ray beam of GeV photons with a counterpropagating ultraintense laser pulse. In a conventional setup of a vacuum birefringence measurement, a VP signal is the emerging small circular (linear) polarization of the initially linearly (circularly) polarized probe photons. The pair production *via* the nonlinear Breit-Wheeler process in such a high-energy environment eliminates part of the γ-photons in the outgoing γ-beam, increasing the statistical error and decreasing the accuracy of this VP signal. In contrast, we investigate the conversion of the emerging circular polarization of γ-photons into longitudinal polarization of the created positrons, considering the latter as the main VP signal [1]. To study the VP effects in the highly nonlinear regime, where the Euler-Heisenberg effective Lagrangian method breaks down, we have developed a Monte-Carlo simulation method, incorporating vacuum birefringence and dichroism *via* the one-loop QED probabilities in the locally constant field approximation. Our Monte Carlo method will enable the study of VP effects in strong fields of arbitrary configuration. With 10 PW laser systems, we demonstrate the feasibility of detecting the fermionic signal of the VP effect at the 5σ confidence level with a few hours of measurement time.

References

[1] Y-N Dai, K Z Hatsagortsyan, C H Keitel and Y-Y Chen, arXiv:2401.11168 (2024)