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Experimental signatures of the quantum nature of radiation reaction in the field of an ultra-intense laser

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The description of the dynamics of an electron in an external electromagnetic field of arbitrary intensity is one of the most fundamental outstanding problems in electrodynamics. Remarkably, to date there is no unanimously accepted theoretical solution for ultra-high intensities and little or no experimental data. The basic challenge is the inclusion of the self-interaction of the electron with the field emitted by the electron itself, the so-called radiation reaction force. We report here [1,2] on the experimental evidence of strong radiation reaction, in an all-optical experiment, during the propagation of highly relativistic electrons (maximum energy exceeding 2 GeV) through the field of an ultra-intense laser (dimensionless intensity $a_0 \sim 10$). In their own rest frame, the highest energy electrons experience an electric field as high as one quarter of the critical field of quantum electrodynamics and are seen to lose up to 30% of their kinetic energy during the propagation through the laser field. The experimental data show signatures of quantum effects in the electron dynamics in the external laser field, potentially showing departures from the constant cross field approximation.

[1] K. Poder et al., submitted to Phys. Rev. X (2018). ArXiv: 1709.01861

[2] J. M. Cole et al., Phys. Rev. X 8, 011020 (2018)