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All-optical radiation reaction in head-on laser electron interaction

MARIJA VRANIC, THOMAS GRISMAYER, JOANA L. MARTINS, RICARDO A. FONSECA, LUIS O. SILVA, GoLP/IPFN, Instituto Superior Tecnico, Universidade de Lisboa, 1049-001 Lisbon, Portugal — Radiation reaction (RR) accounts for the slowdown of a charged particle that occurs when a significant fraction of its kinetic energy is emitted as radiation. Here we show that this effect could be measured in an all-optical setup using a laser wakefield accelerated electron beam colliding with an intense laser pulse. We employ full-scale 3D PIC simulations to show that one can enter a radiation reaction dominated regime with a GeV electron beam and a 30 fs laser of $I = 10^{21} \text{W/cm}^2$. The electrons can lose up to 40% of their initial energy, which can be used as an experimental signature in the spectra. Our results indicate that modern laser facilities provide an exciting opportunity to explore classical RR and the near-future laser facilities can be employed to study the RR beyond classical description. By using higher laser intensities (10^{22} - 10^{23}W/cm^2), quantum effects such as Compton scattering and Breit-Wheeler pair production become relevant. We have included these quantum effects in our PIC code OSIRIS through a Monte Carlo module, and performed a detailed numerical study of the transition from classical to quantum RR dominated regime. We identified the distinct features in the electron distribution function that could serve as signatures of quantum radiation reaction, and showed that large-scale infrastructures (e.g. NIF and ELI and next generation of PW-class lasers (e. g. CoReLS, Bella-i, Texas Petawatt, Apollon 10 PW) could be employed to test the physics in these extreme scenarios.

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