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Radiation reaction in laser-electron beam interactions

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Charged particles accelerated by electromagnetic fields emit radiation, which must, by the conservation of momentum, exert a recoil on the emitting particle. The force of this recoil, known as radiation reaction, strongly affects the dynamics of ultrarelativistic electrons in intense electromagnetic fields. Such environments are found astrophysically, e.g. in neutron star magnetospheres, and will be created in laser-matter experiments in the next generation of high-intensity laser facilities. Not only is radiation reaction important here, but so are quantum effects, as the energy of an individual photon of the radiation becomes comparable to the energy of the emitting particle.

The same physics can be explored with existing laser facilities, using electrons that are pre-accelerated to high energy to probe laser pulses with intensity > 10^{20} Wcm^{-2}. In this way the laser fields are boosted to critical strength in the rest frame of the electron, and radiation reaction and quantum effects enhanced. In this talk we will review theoretical[1,2] and experimental[3,4] progress towards understanding quantum radiation reaction. In particular, we will discuss experimental signatures in the electron and photon energy spectra, the approach to a cascade of photon emission and electron-positron pair creation[5], and how well the widely-adopted “QED-PIC” simulation method[6,7] compares against the results of exact QED[8].

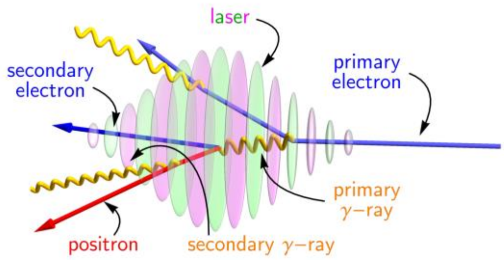

Figure 1: An ultrarelativistic electron collides with a laser pulse, losing energy through the emission of gamma rays. At very high intensity, gamma rays produce electron-positron pairs that also lose energy to radiation.

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