Modelling the effects of radiation reaction in the acceleration of over
dense ultra-thin foils

M. J. Duff\textsuperscript{1}, R. Capdessus\textsuperscript{1}, M. King\textsuperscript{1} and P. McKenna\textsuperscript{1}

\textsuperscript{1} SUPA, Department of Physics, University of Strathclyde, Glasgow, United Kingdom

Future multi-petawatt laser facilities will allow the experimental study of plasma interactions with ultra-high intensity laser pulses. The peak intensities of such systems will exceed $10^{23}$ Wcm$^{-2}$, subjecting the plasma dynamics to high field physics effects. Of particular interest is radiation reaction, a process by which a radiating electron experiences a recoil force due to photon emission.

We consider the interaction of an ultra-intense ($2 \times 10^{23}$ Wcm$^{-2}$, 60 fs FWHM duration) Gaussian pulse with solid-density aluminium targets with thickness in the range $l=50$-500 nm. Due to the high laser intensity, the targets are accelerated by radiation pressure in a regime similar to the light sail regime\cite{1}. We have shown in an initial numerical investigation of the plasma dynamics that radiation reaction plays a small but non-negligible role, allowing non-linear QED effects to be neglected. Previous investigations of radiation reaction effects in this regime have indicated that the most noticeable effects appear in the population of electrons which counter-propagate with respect to the laser\cite{2}. Radiative cooling of these electrons leads to an enhancement of the charge separation fields within the plasma, which subsequently affects the acceleration of ions\cite{3}. Here, we demonstrate that radiation reaction causes a decrease in the velocity of over dense targets irradiated with ultra-intense laser pulses. This decrease in the target velocity is modelled by modifying the equation of motion of an ultra-thin foil undergoing radiation pressure acceleration, to include the absorption of laser energy into photons of synchrotron radiation. The evolution of the target velocity throughout the interaction agrees well with 1D numerical simulations using a QED-particle-in-cell code\cite{4}. In addition, the changes in the target velocity, with and without radiation reaction, are related to changes in the average emission angle of the emitted synchrotron radiation. The effects predicted by this model could be tested experimentally in future multi-petawatt laser facilities.

References

\begin{itemize}
\item \cite{1} A. Macchi et al. New J. Phys. 12, 45013 (2010).
\item \cite{3} M. Tamburini et al. New J. Phys. 12, 12123005 (2010).
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