Radiation friction induced enhancement of laser-driven longitudinal fields for pushing the ion acceleration limit

E.G. Gelfer[1,2], A.M. Fedotov[2], S. Weber[1]

[1] *ELI Beamlines, Institute of Physics of the ASCR, Dolni Brezany, Czech Republic*

[2] *National Research Nuclear University "MEPhI", Moscow, Russia*

Due to the construction of high power laser facilities, ELI Beamlines [1] and alike, a pressing challenge is the search for novel regimes of laser-plasma interactions at the next intensity levels, in particular uncovering the role of radiation friction [2]. We consider the generation of longitudinal waves due to the propagation of a strong laser pulse through an underdense plasmas with account for radiation friction. Our goal is an analytical model of the process capable for estimating and optimizing the parameters of the wave [3]. In particular, we prove that both the amplitude and the period of the generated waves are essentially enhanced by radiation friction under the condition

$$\left(\frac{I}{10^{22}\,\mathrm{W/cm^2}}\right)^{2/3}\cdot\left(\frac{n}{10^{19}\,\mathrm{cm^{-3}}}\right)^{1/6}\cdot\left(\frac{t_{pulse}}{100\,\mathrm{fs}}\right)^{5/6}\cdot\left(\frac{\lambda}{1\,\mu\mathrm{m}}\right)^{1/3}\gtrsim 1.$$

Our findings are confirmed by 1D and 2D PIC simulations. The resulting charge separation field can be so high that ions gain relativistic energies, hence the discovered effect can be applied to laser-plasma acceleration. We also demonstrate that radiation friction notably enhances longitudinal field generation under the conditions realizable at ELI Beamlines [1], see Fig. 1.

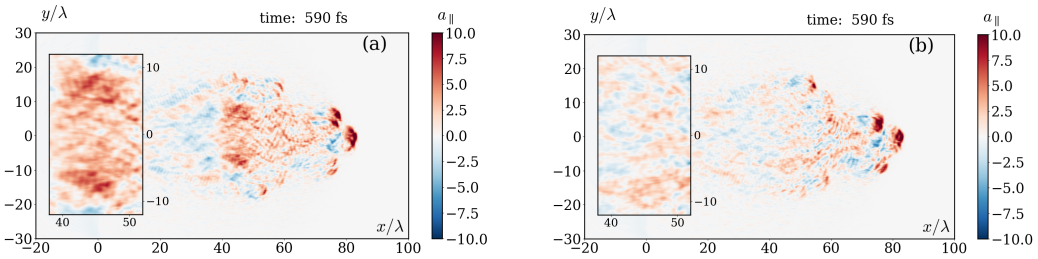

Figure 1: 2D simulation of the longitudinal field distributions created by a tightly focused 10 PW laser pulse of FWHM duration $t_{pulse} = 150$ fs, propagating in a plasma (a) with and (b) without friction.

References

[1] http://www.eli-beams.eu.

[2] A. Di Piazza, C. Muller, K.Z. Hatsagortsyan, and C.H. Keitel, Rev. Mod. Phys. **84**, 1177 (2012).

[3] E.G. Gelfer, N.V. Elkina and A.M. Fedotov, arXiv:1710.09253 (2017); E.G. Gelfer, A.M. Fedotov and S. Weber, arXiv:1801.03795 (2018).