2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

# Focusing and Up-shift of Ultra-high Intensity Lasers Reflected by Relativisitic Flying Mirrors

James K. Koga[1], Sergei V. Bulanov[2], Timur Zh. Esirkepov, Masaki Kando[1], Stepan S. Bulanov[3], Alexander S. Pirozhkov[1], Andreas Bierwage[4] and Petr Valenta[2,5]

[1] Kansai Photon Science Institute, QST, [2] Institute of Physics ASCR, v.v.i. (FZU), ELI BEAMLINES, [3] Lawrence Berkeley National Laboratory, [4] Rokkasho Fusion Institute, QST, [5] Czech Technical University in Prague

e-mail (speaker):koga.james@qst.go.jp

Due to the advent of 10 PW petawatt (PW) [1,2], and even the possibility of 100 PW laser systems [3] there has been a strong interest in studying nonlinear quantum electrodynamics using them [4]. We have shown that by upshifting laser light with mirrors moving at relativistic velocities photon-photon scattering induced by the vacuum could be measured with these types of lasers [5]. Theoretically [6], numerically [7], and experimentally [8-11] relativistic flying mirrors based on the breaking plasma wave properties have been shown to be able to up-shift laser light via the double Doppler effect. We have shown that even laser pulses having near relativistic intensities can be reflected and up-shifted by relativistic flying mirrors formed by breaking wake waves in underdense plasma [12]. Here we continue this investigation looking at the focusing of the reflected light. We do this with 2D particle-in-cell simulations using the EPOCH code [13].

In the simulations we start with a focusing laser pulse (driver) to generate the relativistic mirror and a de-focusing laser pulse (source) to be reflected. Two laser pulses one focusing and one defocusing having wavelengths of $\lambda$=1 μm, initial intensities of $1.25\times10^{19}$ W/cm$^2$ and pulse durations of 4 μm (FWHM) collide in a plasma. We choose a density of $n_e=1.75\times10^{19}$ cm$^{-3}$. The simulation domain is chosen to be 40 μm x 60 μm in the x and y directions, respectively. The resolutions are $\Delta_x=\lambda/2048$ and $\Delta_y=\lambda/128$ in the x and y directions, respectively. The results show that at even at these intensities there is an up-shift of the de-focusing pulse and focusing of the reflected pulse.

We will present details of this along with the prospects for measuring photon-photon scattering with a combination of such up-shifted laser pulses.

This work was supported by JSPS KAKENHI Grant Number JP16K05639 and by the project High Field Initiative (CZ.02.1.01/0.0/0.0/15_003/0000449) from European Regional Development Fund.

References

1. B. L. Garrec, et al, in: Proc.SPIE, Vol. 8962, 8962 (2014).
2. S. Gales et al., Reports on Progress in Physics 81 (9), 094301 (2018).
3. B. Shen et al., Plasma Phys. Control. Fusion 60, 044002 (2018).
4. A. Di Piazza et al., Rev. Mod. Phys. 84, 1177 (2012).
5. J. K. Koga, S. V. Bulanov, T. Zh. Esirkepov, A. S. Pirozhkov, M. Kando and N. N. Rosanov, Phys. Rev. A 86, 053823 (2012).
6. S. V. Bulanov, I. N. Inovenkov,V. I. Kirsanov, N. M. Naumova and A. S. Sakharov, Sov. Phys.—Lebedev Inst. Rep. 6, 9 (1991)
7. S. V. Bulanov, T. Zh. Esirkepov and T. Tajima, Phys. Rev. Lett. 91, 085001 (2003)
8. M. Kando et al, Phys. Rev. Lett. 99 135001 (2007)
9. A. S. Pirozhkov et al, Phys. Plasmas 14, 123106 (2007)
10. M. Kando et al., Phys. Rev. Lett. 103, 235003 (2009)
11. A. S. Pirozhkov et al., AIP Conf. Proc. 1153, 274 (2009)
12. J. K. Koga, et al., Plasma Phys. Control. Fusion 60 074007 (2018); Corrigendum, Plasma Phys. Control. Fusion 60 074007 (2018).
13. T. D. Arber et al., Plasma Phys. Control. Fusion 57 113001 (2015).