Enhanced betatron-radiation energy using two collinear laser pulses

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A new self-injection scheme is proposed for the laser wakefield accelerator in the nonlinear (bubble) regime using a pair of matched, copropagating laser pulses which yields a pC electron bunch. By tuning their relative delay and intensity, the subsequent betatron radiation energy can be considerably (3 fold) enhanced compared to the single pulse scheme for the same total energy. A new condition for the optimal bubble size is derived and verified by particle-in-cell simulations, further demonstrating the advantages of the double-pulse scheme for self-injection.

Bubble regime of electron acceleration [1] is the highly non-linear regime of laser wake field acceleration, evolving a plasma wave following the laser pulse. The condition is that laser pulse intensity is high enough to create a cavity, free from background plasma electrons, and that the pulse duration is the order of plasma wavelength. Some electrons get trapped in the cavity, are accelerated and start to wiggle around the laser pulse propagation axis. This results in betatron radiation. In this work we propose an improved, double-pulse scheme in the bubble regime with significantly improved electron beam and radiation properties, *c.f.* figure 1. Based on the simulation results, the optimum condition is that the energy of first pulse to be high enough to meet the bubble condition. Allocating the remaining energy to the second pulse and positioning it at the rear of first bubble leads to increased electron beam energy and higher betatron energy yield than for a single-pulse with the same total energy [2].

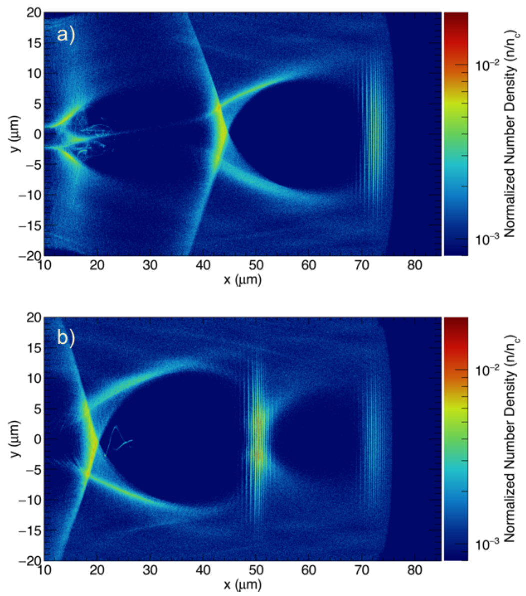

Figure 1: 2D snapshot of the electron number density distribution at t=1500 fs, with the target being irradiated by a laser of $a_0 = 3.85$, for a) the double pulse scheme with the optimum condition, b) the single pulse scheme. The total pulse energy is 2 J and is the same in both cases. The double pulse scheme yields an improved electron beam.

References

[1] A. Pukhov and J. Meyer-ter Vehn, Applied Physics B - Lasers and Optics, **74** (4-5):355-361, 2002.

[2] Z. Chitgar *et al.*, Enhanced betatron-radiation energy from plasma self-injection using two collinear laser pulses, (submitted for publication, 2018).