Laser Wakefield Acceleration with Two Collinear Laser Pulses

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Resonant excitation of plasma waves by consecutive laser pulses delayed by roughly one plasma period is a well-known technique to enhance the wakefield amplitude [1,2,3]. This would allow the efficient acceleration of electron bunches over a shorter distance, within several Rayleigh lengths of the driving laser pulse. However, generating aligned multiple pulses with controlled delay is technologically challenging and controlled electron injection becomes a difficult problem far behind the first driving pulse. Recently a theoretical investigation [4] has shown that by using two pulses with optimized delay not only the acceleration is enhanced, but the guiding of the second pulse naturally occurs due to the self-consistent evolution of the plasma density profile.

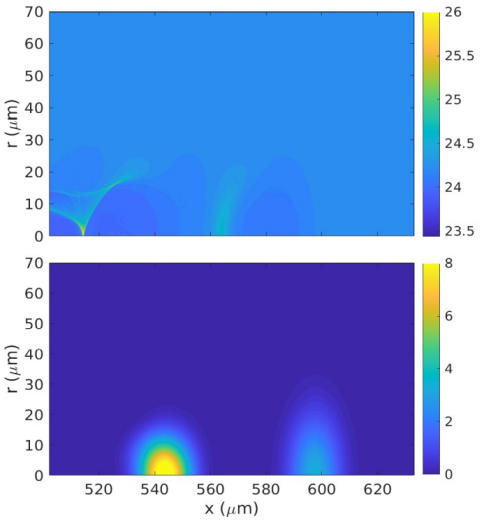

Figure 1: Plasma density (log scale, m^{-3}) distribution (upper) and normalized intensity distribution (lower) of the two pulses.

In our work we investigate the propagation of two pulses (Fig 1) with different spot radii, where the second pulse is frequency doubled and it is delayed by more than one plasma period, in contrast to Ref [4], where the optimal delay was found to be 85% of the plasma wavelength. In our scheme relativistic self-focusing of the second pulse does not occur, which allows the excitation of a strong wakefield without large variations in the phase velocity. Our simulations (using SMILEI [5]) show that the second laser pulse can be guided over 10 Rayleigh lengths with a slowly varying spot radius. Final electron spectra for different laser and plasma parameters will be presented.

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