High intensity physics and braided beam emissions in underdense plasmas

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Today, laser wakefield acceleration of electrons is a mature subject and one of the major applications of high-power laser systems [1]. The weakly nonlinear regime of LWFA is known to be the optimal for reaching the highest possible electron energies, while the capabilities of upcoming large laser systems will provide the possibility of running highly nonlinear regimes of laser pulse propagation in underdense or near-critical plasmas. We show that such regimes can be implemented with external guiding for a relatively long distance of propagation and allow for the stable transformation of laser energy into other types of energy, including the kinetic energy of a large number of high energy electrons and their incoherent emission of photons. This is despite the fact that the high intensity of the laser pulse triggers a number of new mechanisms of energy depletion, which we investigate systematically. Notably, the production of pairs in these systems is very small even at very high intensities, and only becomes notable at extreme intensities (around 10^{26} W/cm^2) [3].

Apart from the intensity parameter, one may also play with the geometry of the wakefield setup. In particular, if allowed to interact, two such wakefield systems will generate a rich dynamics, where its characteristics depend on, e.g., the collision angle [**?**]. Here, we do a full parameter scan of different collision angles between the wakefields. In particular, we are interested in the radiative properties of the interaction. We use analytics and 3D PIC simulations to investigate this as a means for controlling and tuning the radiation emission from such systems. Two main regimes are compared: large angle collisions with the transverse acceleration due to the laser fields and small angle collisions with the transverse acceleration due to plasma fields. The latter provide a mechanism for generating soft x-rays. Moreover, for small angle collisions, the electron bunches oscillate behind the laser pulses in a braided pattern, extending the interaction time beyond the normal dephasing length and giving a tunable radiation source.

References

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