Radiation-Dominated Plasma Dynamics in the Interaction of Super-Intense Circularly Polarized Pulses with Thick Targets

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We present a self-consistent theory describing the interaction of superintense (with intensities about 10^{23} W/cm^2 and higher) circularly polarized electromagnetic pulses with thick plasmas of overcritical density. In contrast to the case of thin plasma slabs, thick targets are known to provide an interaction regime with extremely high radiation losses, because a high plasma surface density prevents longitudinal acceleration of electrons. Relying on our previous work [1] and on the model suggested in 1975 by Zeldovich [2], we developed an analytic theory which predicts that the combined effect of the radiation reaction force and of the charge separation in the plasma leads to the self-limited (although high) radiation losses, making a classical picture of radiation fairly accurate up to the intensity 10^{25} W/cm^2, which is currently at the edge of capabilities expected from the Extreme Light Infrastructure pillars [3]. We expect that at these ultrahigh but nevertheless foreseen in the near future intensities the radiation losses saturated at a roughly 50% energy conversion from the laser pulse to high-energy photons. As a result of this conversion, a quasi-static magnetic field with the magnitude up to 30 gigagauss can be generated. Our theoretical predictions are supported by results of relativistic 3D particle-in-cell simulations.

References

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