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# Theoretical study of laser energy absorption in near-critical density plasmas at ultra-high intensity

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At the interaction of an ultra-high intensity laser pulse (I ≥ 1018W/cm2) with a plasma, the plasma constituents will absorb a significant part of the laser energy and will be accelerated up to relativistic velocities for electrons. The most predominant mechanisms of energy transfer from the laser pulse to the plasma constituents are collisionless in this regime, being done by collective effects in plasma. The absorption of laser energy depends on the initial laser and target parameters [1, 2, 3]. The target transparency or opacity depends on the interaction process itself: a slightly over dense target can absorb or reflect the laser energy according to the laser amplitude [4].

Our main goal is to describe and model the energy transfer from laser to particles, from the transparent to less transparent regime of laser-plasma interaction in the ultra-high intensity regime, and using the results obtained to optimize the ion acceleration. We propose a theoretical model of energy transfer, assuming that most of the laser energy will be transferred to hot electrons. The model proposed is further tested and corrected through 2D particle-in-cell (PIC) simulations performed with SMILEI (Simulating Matter Irradiated by Light at Extreme Intensities) [5]. Varying the target density and thickness, we studied the optimal parameters for the maximum conversion efficiency of the laser energy to particles. We investigate a model for a near-critical density plasma between 0.5 −20 nc (where nc ≈ 1.1·1021 cm-3 is the critical density) driven by a laser pulse of intensity in the range 1018 −1023 W/cm2 and the pulse duration in the range 10 −100 fs.

The laser absorption mechanisms determine the characteristics of the accelerated particles. Theoretical modelling of the predominant laser-plasma interaction mechanisms predicts the particle energy and conversion efficiency optimization [6]. The transition from the opaque to the transparent regime can lead to an enhancement of the ion acceleration process [7]. Our studies led to an optimization of the target areal density for maximizing proton acceleration for a laser intensity of 1022 W/cm2, which is in good agreement with [8].

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