An Empirical Model for the Interaction of Ultra-Intense Laser Pulses with Fully Ionized Plasmas Including Electrostatic Effects

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Abstract

The radial electrostatic field grows to an amplitude that exceeds the peak laser fields because they are not confined sufficiently long to experience the ponderomotive force and, therefore, serves to confine the remaining electrons. In this case, very small net charge density exists in the forward direction. This modeling predicts some collimation, but not enough to meet the requirements of fast ignition. The electrons escape predominantly in the normal direction, and with low spread and high energy. Without the electrostatic field, the electrons emerge with high spread and low energy. The electrons escape in the forward direction with substantial collimation. With the electrostatic field, the electrons emerge collimated and energetic electron beams are formed, indicating that free electrons cannot extract enough energy transfer occurs, which is consistent with previous work. For 0.2-ps pulses, electrons are rapidly depleted from the laser region leading to a large electrostatic field. The simulations used a high-intensity, ultra-pulse Gaussian beam.

1. Without Electrostatic Field

The electron escape is in the forward direction with substantial collimation. The electrons are strongly relativistic. The escape angle is close to the plane-wave predictions. The electron escape is predominately in the radial direction.

2. With Electrostatic Field

The electron escape is perpendicular to the laser beam. The electrons are not relativistic. The escape angle is close to the plane-wave predictions. The electrons escape predominantly in the normal direction, and with low spread and high energy. Without the electrostatic field, the electrons emerge with high spread and low energy. The electrons escape predominantly in the normal direction. The electron escape is predominately in the radial direction.

Simulations have been carried out for a variety of conditions, with and without a radial electrostatic field. Self-consistent electrostatic fields make a significant difference to the electron orbits in ultra-intense laser fields. For 0.2-ps pulses, electrons are rapidly depleted from the laser region leading to a large electrostatic field. In this case, very small net charge density exists in the forward direction. This modeling predicts some collimation, but not enough to meet the requirements of fast ignition.

The simulations used a high-intensity, ultra-pulse Gaussian beam. The radial electrostatic field grows to an amplitude that exceeds the peak laser fields because they are not confined sufficiently long to experience the ponderomotive force and, therefore, serves to confine the remaining electrons. For 0.2-ps pulses, electrons are rapidly depleted from the laser region leading to a large electrostatic field. The simulations used a high-intensity, ultra-pulse Gaussian beam. The simulations used a high-intensity, ultra-pulse Gaussian beam. The simulations used a high-intensity, ultra-pulse Gaussian beam. The simulations used a high-intensity, ultra-pulse Gaussian beam.

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