Collective electron dynamics in relativistically transparent laser-foil interactions

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Understanding the collective response of charged particles to intense laser radiation is both of fundamental interest and important to the development of laser-driven accelerators. For sufficiently high laser intensities and thin foil targets, relativistic induced transparency occurs in ultra-thin foils due to a combination of thermal expansion of the local target electron population and an increase in the critical density due to the relativistic correction to the electron mass with increasing laser intensity.

We report on an experimental demonstration of asymmetry in the collective electron response to the radial ponderomotive force during transparency, as manifested in the formation of lobe structures in the beam of electrons accelerated. The beam profile changes from an ellipse aligned along the laser polarization direction in the case of limited transparency, to a double-lobe structure aligned perpendicular to it, when a significant fraction of the laser pulse co-propagates with the electrons. The temporally resolved dynamics of the interaction are investigated via PIC simulations. The implications of the onset of relativistic induced transparency, and the resulting collective electron dynamics, for laser-driven ion acceleration are also explored.

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