Vacuum laser acceleration of super-ponderomotive electrons using relativistic transparency injection

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Table-top petawatt-class lasers can accelerate electrons to near-light speed over a very short distance. These compact accelerators have potential applications in fast ignition, high energy physics, radiography, and secondary ion/neutron sources. One of the existing schemes of laser-based electron acceleration is called "Vacuum Laser Acceleration" (VLA) where the injected electrons are directly accelerated by the intense laser field (> 10 TV/m). The VLA requires injected electron to be pre-accelerated close to the speed of light such that it remains within a given half cycle of the laser wave and sees a unipolar field for continuous acceleration. Recently, a breakthrough was made in VLA using a plasma mirror injector [1] accelerating electrons to relativistic energies around 10 MeV. The present work demonstrates VLA of electrons up to 20 MeV using a qualitatively different injection method that exploits the plasma relativistic transparency (RT) effect – where dense opaque plasma becomes transparent to the driving laser due to relativistic electron mass increase by driving a thin solid foil at normal laser incidence[2]. When the laser interacts with a thin foil, super-ponderomotive electrons can be generated from VLA by using the novel RT effect as the injector. The experimental results show 20 MeV super-ponderomotive electrons from thin plastic foils (5 nm thick) undergoing RT injection and subsequent VLA [3]. It is possible to further optimize the electron injection/acceleration by manipulating the laser polarization, incident angle, and temporal pulse shaping. Our result sheds new light on the fundamental relativistic transparency process, crucial for producing secondary particles and light sources.

References:

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