A Simple Scheme for GeV Ion Acceleration: Crossing Two Ultra-Intense Laser Pulses in Relativistic Transparent Plasma

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Laser-driven plasma-based ion acceleration has been an active research area for decades since it promises to deliver compact high energy ion sources. Recently, with the deployment of petawatt laser systems in more and more laboratories, ion acceleration in the so-called relativistically transparent regime has attracted much attention, where the plasma can be prepared from foams, aerogels, or laser-heated high-density targets. A petawatt laser pulse can drive a comoving snowplow field in relativistically transparent plasma with the field strength of one teravolt per centimeter. Ions trapped in it can be accelerated to energies of multi-giga-electron-volts in tens of microns. However, trapping ions in the snowplow field is challenging experimentally. Various schemes have been proposed in dealing with the trapping issue, however, so far, it is still a challenge. Here we show that this challenge can be well dealt with by simply crossing two laser pulses in relativistically transparent plasma [1]. One laser excites a radial shock and preaccelerates some of the background ions along the laser radial direction. Then the snowplow field driven by another laser can trap some of the preaccelerated ions. It is so simple that the ion dynamics can be well described by a one-dimensional Hamiltonian that developed from an ion wave model [2]. This simple scheme turns the requirement of target design into the requirement of adding an additional laser, which happens to be the development trend of high-power laser plasma physics. Therefore, this scheme is robust and promising in relativistic ion acceleration.

References

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