A new scenario design for enhanced magnetic vortex ion acceleration

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Laser-based ion accelerator has been considered to be a compact and cost-saving alternative to the conventional radio-frequency accelerators. While relentless experiments have been performed based on various models, the generation of high-flux and well-defined monoenergetic ion beams is still facing formidable challenges. Magnetic vortex acceleration[1] is a model proposed to generate collimated energetic ion beams by the time-varying magnetic dipole vortex at the rear of near-critical/underdense plasmas. However, both the numerical studies[1, 2] and experiments[3, 4] indicate that the resultant ion beams from such acceleration have low particle number with an exponentially decaying spectrum.

In our study, the magnetic vortex acceleration driven by intense laser pulses is theoretically analyzed, which reveals that both the accelerating field and the ion energy in such acceleration have strong scalings with the laser and plasma parameters. But this effective acceleration will break down and the ion beam quality will as well be degraded along with the depletion of electron density in the interaction channel[5]. A new ion acceleration scenario, in which the intense laser directly interacts with a cone-like dense hollow tube, is proposed to achieve a sustained high density plasma and realize an enhanced and stable magnetic vortex structure at the rear side. Such magnetic fields induce a strong and stable electric field which produces high-flux and more energetic ion beam with a well-defined monoenergetic spectrum. This new and robust acceleration scenario is verified by 3-dimensional particle-in-cell (PIC) simulations.

References

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