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Numerical Investigation of the Transverse Instability in Radiation Pressure Acceleration

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Abstract : The Radiation Pressure Acceleration (RPA) mechanism is very promising in laser-driven ion acceleration because of high laser-ion energy conversion efficiency. Although some experiments have shown the characteristics of RPA, the energy of ions is quite limited. The ion energy obtained in experiments is only several MeV/u, which is much lower than theoretical prediction. One possible limiting factor is the transverse instability incited in the RPA process. The transverse instability is basically considered as the Rayleigh-Taylor (RT) instability, which is a kind of interfacial instability and occurs when a light fluid pushes against a heavy fluid. Multi-dimensional particle-in-cell (PIC) simulations show that the onset of transverse instability will destroy the acceleration process and broaden the energy spectrum of fast ions during the RPA dominant ion acceleration processes. The evidence of the RT instability driven by radiation pressure has been observed in a laser-foil interaction experiment in a typical RPA regime, and the dominant scale of RT instability is close to the laser wavelength. The development of transverse instability in the radiation-pressure-acceleration dominant laser-foil interaction is numerically examined by two-dimensional particle-in-cell simulations. When a laser interacts with a foil with modulated surface, the internal instability is quickly incited and it develops. The linear growth and saturation of the transverse instability are observed, and the growth rate is numerically diagnosed. In order to optimize interaction parameters, a method of information entropy is put forward to describe the chaotic degree of the transverse instability. With moderate modulation, the transverse instability shows a low chaotic degree and a quasi-monoenergetic proton beam is produced.

Keywords : information entropy, radiation pressure acceleration, Rayleigh-Taylor instability, transverse instability
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