Physical Mechanism of the Intrinsic Transverse Instability in Laser Pressure Ion Acceleration

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With the rapid progress of ultraintense lasers, strong interests have been aroused on “light sail” and “flying mirror” concept driven by laser pressure, which may lead to useful applications such as laser pressure driven ion acceleration (RPA). However, many simulations indicated that such “light sail/flying mirrors” may suffer instabilities that can break up their surfaces. With intense research for more than a decade, the physical mechanism behind these instabilities has not been clarified. In this work, a theoretical model has been developed to decipher this mystery. It turns out that the ripples on the foil surface are mainly induced by the coupling between the transverse oscillating electrons and the quasi-static ions. The predictions of the mode structure and the growth rates from the theory agree well with the results obtained from the PIC simulations in a wide range of parameters, indicating the model contains the essence of the underlying physics of the transverse breakup of the foil. Based on the above analysis, a new ion acceleration scheme and companied 2/3D simulations are also presented to avoid this big problem and achieve high quality high energy ion beams, which may open up a new route for compact laser trigger ion sources.