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Key physics study of high quality laser driven ion acceleration

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For the past two decades, the interaction of ultra-intense lasers with over-critical plasma has been motivated by acceleration of proton/ions for radiobiological applications. Despite some progress, the realization of a stable high-charge narrow-energy-spread protons of hundreds MeV remains a challenge. One promising scheme is the “light sail”acceleration, where laser pressure directly pushes the whole target, providing a strong accelerating force. A major showstopper of such scheme is that it will suffer significant transverse instabilities that can break up the target, but the underlying mechanism has still not been clarified. Here we present a full three-dimensional theoretical model that clarifies the origin of this long-standing problem, and support it with 2/3D PIC simulations for a wide range of parameters. Based on this understanding, we propose several new concepts of high quality ion acceleration, which provide better scalings and indicate several hundreds of MeV protons can be produced by 100s TW to PW laser systems.

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