Laser-driven ion acceleration with ultra-thin graphene target

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Laser-driven ion acceleration has been extensively studied to realize the high energy ion sources for wide applications including cancer therapy [1], high-resolution radiography [2] and fast ignition-fusion [3]. Recent experiments have reported the energy around 100 MeV protons with different acceleration mechanisms [4-6]. Kim *et al*. [5] have reported the 93 MeV protons accelerated by the radiation pressure acceleration (RPA) with circularly polarized laser pulse, using the ultra-thin (15 nm) polymer target. The efficient RPA requires the optimum thickness which is given by the condition of $a_0 \simeq (n_0/n_c)D/\lambda$ [7], where a_0, λ, D, n_0 and n_c are the normalized laser amplitude, the laser wavelength in vacuum, the target thickness, the plasma density, and the critical density of the incident laser pulse, respectively. When the target is much thinner than the optimum thickness for RPA $a_0 >> (n_0/n_c)D/\lambda$, this is Coulomb Explosion (CE) regime, where electrons blow out from the foil and ions are accelerated by the repulsive electrostatic field due to the excess of positive charge [8].

Khasanash *et al*. [9] manufactured the ultra-thin graphene films of thickness 1.0 nm at the National Central University (NCU). This is the thinnest target ever found, and the target thickness can be controlled with high-resolution. Our research group plans to conduct the experiment using this target on the 100TW laser system at NCU. According to the optimum thickness condition, the ions are expected to be accelerated efficiently by the RPA at low laser intensity with ultra-thin target (< 5 nm). To support this experiment, based on the dimensionless parameters a_0 and σ, the optimum conditions of the laser intensity and the graphene target thickness are investigated by VORPAL PIC code [10]. The ion acceleration mechanisms of RPA and CE are also investigated in detail.

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