Ion Acceleration via "Stochastic Vacuum Heating"

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The interaction between high-intensity laser pulse and surface is crucially important for understanding physics underlying attractive applications including the generation of high-energy ions, high-order harmonics and coherent x-ray.

Under the condition of laser intensities ranging from 10^{18} to 10^{20} Wcm^{-1}, ions are accelerated by a strong charge-separation field induced by the motion of high energy electrons around target foils. Recently, it has been experimentally found [1] that energy of accelerated ions can be enhanced by using ultrathin foils irradiated with high contrast laser pulses that can preserve the steep boundary of the surface until the arrival of the pulse peak.

Several analytical models [2] described the generation of charge-separation field by solving Poisson equation and successfully reproduced the ion energy distributions obtained experimentally. However, these models do not directly involve the laser field that should be responsible for the electron acceleration and the charge-separation field generation, e. g. the ion energy dependence on the laser pulse polarization. There has been no model of ion acceleration describing the process of electron acceleration on the steep-gradient surface.

In this paper, we propose a novel model of ion acceleration involving the kinetic motions of electrons based on a purely nonlinear effect [3]. In our model, electrons quivered by the laser field are kicked-out by the steep potential boundary of the plasma and lose their phase information of the oscillating laser field. Some of the electrons successively ride on the acceleration phase of the field and obtain kinetic energy further higher than the quiver energy. Here, we term the mechanism as *Stochastic Vacuum Heating*. Our model well reproduces the maximum energy of protons obtained in the present and previous experiments. Especially, dependency on the angles of laser polarization and incidence is explained for the first time.

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