Tree-code simulations of proton acceleration from laser-irradiated wire targets

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which appear to radically alter the field distribution in the vicinity of the laser-irradiated region.[19]

Rewriting Eq. ~2! in terms of the normalized variables ~1!, we find

$$\tilde{m}_i \frac{d\tilde{\mathbf{u}}_i}{} \quad \frac{{}_p e^2 \nu_p}{m\ c^3} \tilde{q}_i \Big(\frac{\tilde{q}_j \tilde{\mathbf{r}}_{ij}}{\tilde{r}_{ij}^3},$$

which after adding an external field $\mathbf{E}^p$ and making use of the plasma frequency definition, $\nu_p^2 = 4p\ {}^2 n_e / m_e$ for electron density n

The end result, arrived at after a few plasma periods, is a

$$C = 4a_0^2 X^2(x) R(r) T(t), \qquad (11)$$

$$X(x) = \begin{cases} \sin x, & x < 0, \\ \sin f \exp(-x) \end{cases}$$

parison, a fully electromagnetic *two*-dimensional PIC simulation using the OSIRIS code

off the rear side due to hot electrons ~not shown! circulating behind and around the wire. This last effect is the familiar rear-surface acceleration mechanism, but in cylindrical geometry, ultimately leading to a disclike fast ion emission.

From Fig. 6 one might expect that rear-surface protons will dominate the emission spectrum here, yet this is only part of the picture. Inspection of the ion phase space (p_x-x) for Run C in Fig. 7~a! indicates that front-side ions are also accelerated significantly via the ponderomotively driven shock, some of which have already emerged from the rear surface ~at $x=50$) as a beamlet in the forward direction. The onset of a double-disk structure is apparent in the p_z-x plot of Fig. 7~b!: the rear-side ions ($x>100$) are beginning to fork at an angle of $5°-10°$ to the laser axis. At this point these ions have energies of >6 MeV, and are still being accelerated. Also evident from Fig. 7~b! are the significant

of a 1/2 wire vertical slice—Fig. 10. Superimposed on these plots are slices of the instantaneous electron temperature, showing that while the laser is incident, the hottest electrons are actually confined to the shock region (a,b). At the same time, there is also a strong circulation of hot electrons around the wire.

The most striking feature of this simulation is that the entire mid section of the wire is pushed out by the laser; the beamlet visible in Fig. 10˜d! has detached itself completely from the wire and continues to propagate away, spreading as it does so. This is reminiscent of three-dimensional PIC