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Numerical Simulation of Collective Ion Acceleration in the Laser Controlled Collective Accelerator,* R. L. Yao, C. D. Striffler, and W. W. Destler, University of Maryland, College Park, MD 20742. — In the Laser Controlled Collective Accelerator, an intense electron beam is injected at a current above the vacuum space charge limit into an initially evacuated drift tube. A plasma channel, produced by time-sequenced, multiple laser beam ionization of a solid target on the drift tube wall, provides the necessary neutralization to allow for effective beam propagation. By controlling the rate of production of the plasma channel as a function of time down the drift tube, control of the electron beamfront can be achieved. Initial experiments[1] have demonstrated the controlled acceleration of protons at a rate of 40 MeV/m over a distance of 50 cm, in good agreement with experimental design values.

In order to understand and to optimize ion acceleration in this system, we have developed the 1D electrostatic PIC code CIA. Simulations performed with this code give the following general picture for the initial phase of the acceleration process. Soon after the electron beam is injected into the drift tube, a virtual cathode forms near the injection plane. Ionization of the neutral gas causes the virtual cathode to move downstream to the end of the gas cloud. During this movement of the virtual cathode, ions produced by ionization of the neutral gas are accelerated to energies several times the injected electron-beam energy. For example, for a 1 MeV, 20 kA electron beam injected into a cloud of hydrogen gas at 500 mTorr, the maximum ion energy is about 3 MeV when the gas cloud is 3-4 cm wide.

Following the initial phase of ion acceleration, the ions are further accelerated during the propagation of the electron beam front down the plasma channel. In the PIC code we model this process by assuming that the laser produces a space-charge neutralizing channel which sweeps down the drift tube at a rate controlled by the laser. Initial results with the model agree with the experimental results as regards rate of sequencing for enhanced acceleration, and peak enhanced ion energy. In addition, the code demonstrates the erosion of the strong beam front electric field as well as the decrease in the number of ions accelerated over the channel length. Limits on this process obtained from the PIC code will be discussed.

[1]P.G. O'Shea, W.W. Destler, J. Rodgers, and Z. Segalov, Appl. Phys. Lett. 49, 1696 (1986).
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