CONF-800208--3

Title: EXPERIMENTAL INVESTIGATIONS OF HIGH CURRENT LINEAR ION ACCELERATORS*

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ABSTRACT Experiments on high current pulsed linear ion accelerators are described. A five-stage device, Pulselac B, has produced 4 kA of C+ at 700 keV for a 0.5 microsecond pulse.

*This work was supported by the U. S. Department of Energy under Contract DE-AC04-76-DP00789.

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SUMMARY The Pulselac Program at Sandia Laboratories is centered on the study of high current linear ion accelerators, with emphasis on their use as inertial fusion drivers. Beam currents of 1 - 10 kA for submicrosecond pulses are of immediate interest. The accelerators use classical ion acceleration combined with neutralized transport principles to produce ion fluxes far in excess of bare beam limits. The major novelty is the introduction of electrons into the beam volume to provide almost complete neutralization of space charge. These electrons are controlled by weak magnetic fields to prevent backflow in the acceleration gaps and allow effective neutralization. The physics of these accelerators shares much in common with high current light ion diode devices. By alleviating space charge restrictions, the neutralized transport approach would provide a simple and inexpensive alternative for inertial fusion when compared to heavy ion proposals.

A series of experiments have been performed at Sandia Laboratories during the past year to understand the physics of high current beams and to demonstrate the technological feasibility of intense ion accelerators. Considerable effort has been devoted to the development of multi-kiloampere injectors of intermediate mass ions. These injectors use a magnetically insulated gap[1,2] in conjunction with ion production by an array of plasma guns. Typical output parameters are 3 kA of C+ at 100 keV. A number of advances have been made in intense ion diode technology. The injectors are the first practical sources of non-hydrogenous ions using plasma guns decoupled from the diode. They operate at current densities more than an order of magnitude higher than the Child-Langmuir limit, with the ion flux regulated by plasma injection. The ability to control the optics of the emerging beams has also been demonstrated.

An extensive experimental run was performed with a two gap accelerator. Observations of beam neutralization in the drift spaces showed good agreement with computer simulations.[3] An upper limit on space charge imbalance of 0.2 percent was found. Over 2 kA of carbon ions passed through the second gap, which was pulsed to 200 kV. The ion energy was given by the sum of voltages on the two gaps. The magnetic fields in the second gap were curved to shape the equipotential surfaces determined by the electron distributions. When the accelerating field was applied, the ions were focused by the transverse electric field components. The observed foci were in agreement with predictions based on the virtual electrode concept, and indicated that the accelerating fields could be used for transverse beam confinement.

The two gap results were used to design a five stage accelerator, Pulselac B. This device has recently been completed and operated successfully. Excellent transport was achieved through the five gaps and drift spaces. Output beams of 4 kA of C+ at over 500 keV were achieved. Ultimately, an output current of 6 kA at 700 keV for 0.5 microseconds is expected. A number of improvements are being incorporated on Pulselac B, including a puffed gas plasma gun array. This will allow study of a wide variety of ion species and permit operation for hundreds of shots without opening the vacuum system. When optimized. Pulselac B will be used experiments on neutralization and the propagation of intense ion beams in vacuum and plasma.

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1. S. Humphries, Jr. and G. W. Kuswa, Appl. Phys. Lett 35, 13 (1979).
2. S. Humphries, Jr., C. W. Mendel, Jr., G. W. Kuswa, and Steven A. Goldstein, Rev. Sci. Instrum. 50, 993 (1979).
3. J. W. Poukey and S. Humphries, Jr., Appl. Phys. Lett. 33, 122 (1978).