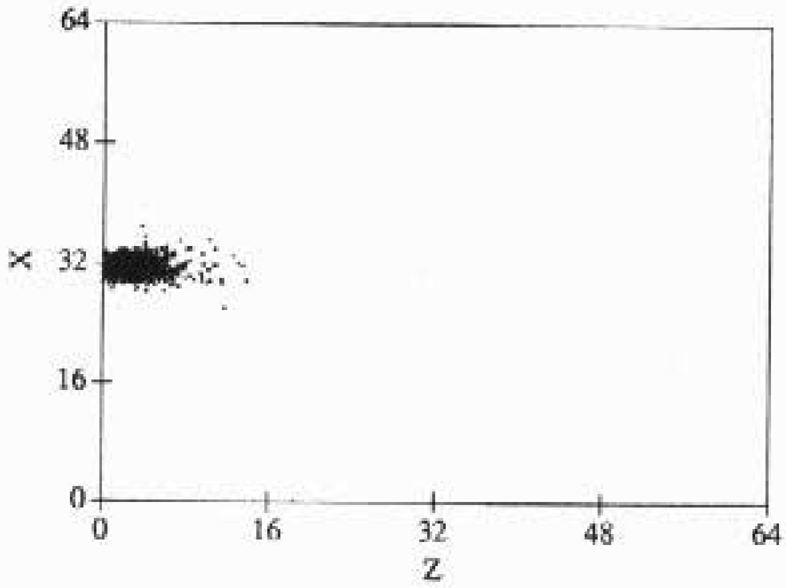

FIG. 8. Result of the simulation at t=0.27 μs after injection. Shown are 1024 OH^- ions slowly spreading toward the biased wall.

further injection of beam electrons after 0.27 μs as the computing became too large. The results are shown in Fig. 9 at t=22.5 μs and Fig. 10 at t=24.5 μs for OH^- ions. It is clearly seen that part of negative charges are pulled to the positive plate located at the right end. In the presence of continued beam injection, the core plasma will be maintained to produce negative charges which propagate away from the source region in front of the gun.

VI. CONCLUSION

Electrostatic Atomization Laboratory has been successfully established at PPPL in collaboration with Charged Injection Corporation. An electrostatic sprayer with the quadrupole mass spectrometer/charge detector was used to study fundamental properties of the electrostatic spray such as size and charge distribution using octoil. The experimental observations show that the observed charging level is smaller than the predicted level by the Rayleigh limit and the minimum energy theory. The observations, however, can be explained qualitatively in terms of the maximum entropy theory which is the only theory predicting a presence of multiple peaks as observed in our experiment. A particle simulation model was developed in order to study interaction of an electron beam injected into water vapor to help design a fire-fighting nozzle. Various numerical techniques have been tested to solve the real engineering problems. It was found that an electron beam at 20 keV energy can penetrate into one atmospheric pressure water vapor only about 1 mm for a short time scale, less than a few ns before excess negative charges are pulled toward the biased wall. Much more work is needed to refine and perfect the numerical model so that real experimental conditions can be simulated.

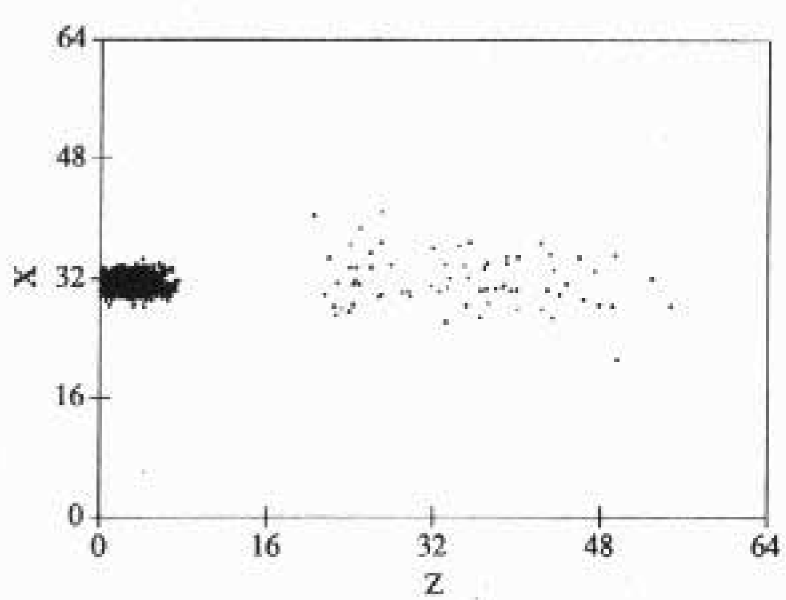

FIG. 9. 1024 OH^- ions at t=22.5 μs after injection. Part of the OH^- ions are detached from the main body flying toward the biased wall.

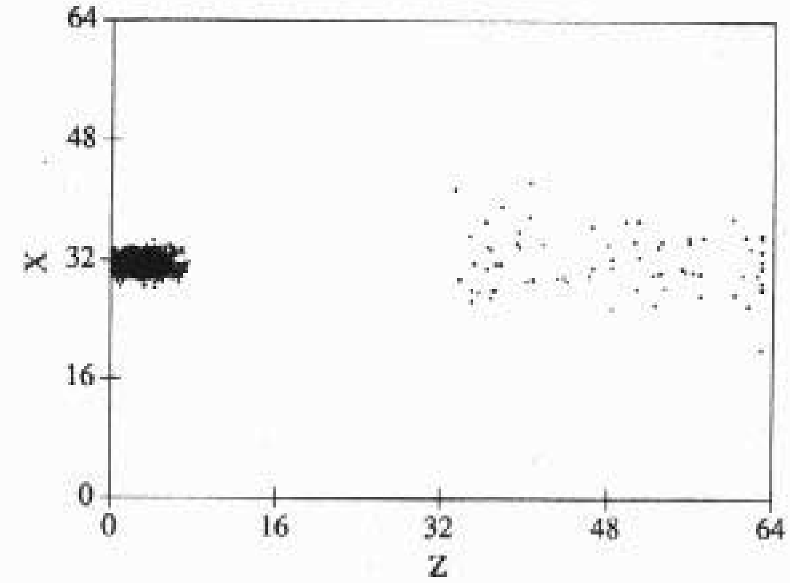

FIG. 10. Same as in Fig. 9 at t=24.5 μs after injection.

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[1]Lord Rayleigh, Philos. Mag. **14**, 184 (1882).
[2]C. D. Hendricks, J. Colloid. Sci. **17**, 249 (1962).
[3]A. J. Kelly, J. Appl. Phys. **47**, 5264 (1976); **49**, 2621 (1978).
[4]A. J. Kelly, J. Aerosol Sci. **25**, 1159 (1994).
[5]O. J. Orient and S. K. Srivastava, J. Phys. B Atom. Mol. Phys. **20**, 3921 (1987).
[6]*Electron-Moleculer Collisions*, edited by I. Shimamura and K. Takayanagi (Plenum, New York, 1984).
[7]C. E. Melton, J. Chem. Phys. **57**, 4218 (1972).
[8]H. Okuda and M. Ashour-Abdalla, J. Geophys. Res. **95**, 21307 (1990).