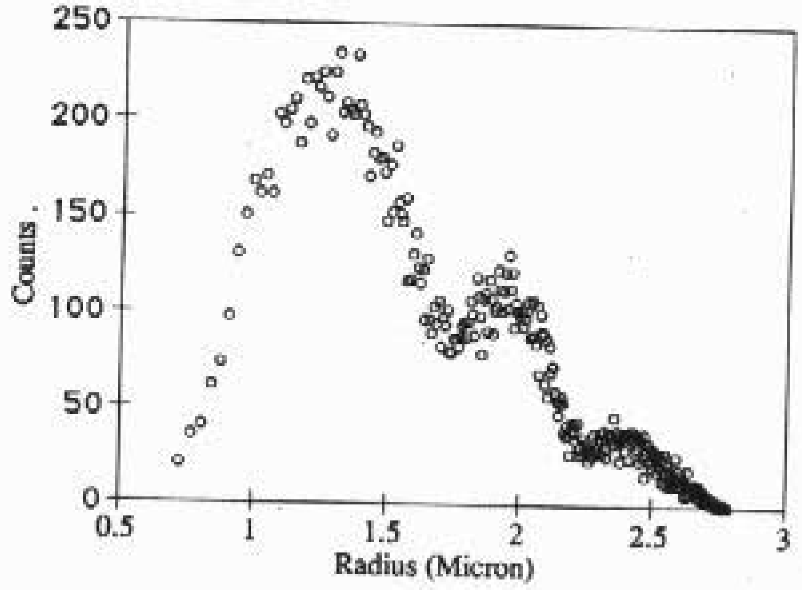

FIG. 4. The same as in Fig. 2 with the charge-to-mass ratio equal to 0.588 C/kg and the resolution of 1.5. This is the only data clearly showing the presence of three peaks although the resolution is very low.

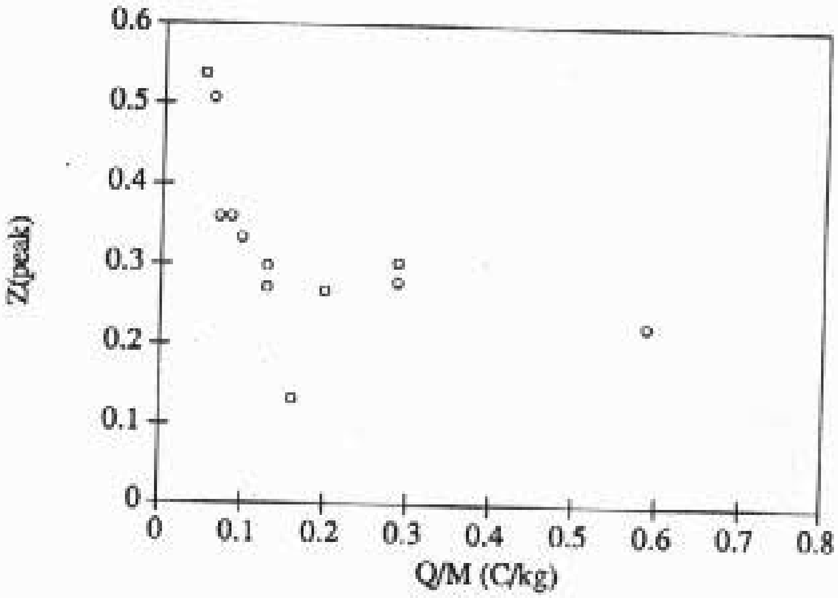

FIG. 6. Plot of relative charge level obtained by dividing observed charges by the Rayleigh limit as a function of charge-to-mass ratio. Note for small Q/M corresponding to large drop radius, data appear to split into two branches which is predicted by the maximum entropy theory.

entropy theory predicts a possibility of double and triple peaks for a given charge-to-mass ratio. The theory is, however, not easily applicable to real experiments as the theory is in a highly abstract form with more than three free parameters to adjust.

Shown in Fig. 4 is a rare example where three peaks are observed for the charge-to-mass ratio of 0.588 C/kg although the resolution in this case is very low. Repeated attempts to reproduce the triple peaks with a higher resolution have not been successful so far.

More than a few dozens runs were made since the machine started running. Some of the results are presented in this paper. The data are analyzed with regard to their size, charge, surface electric field and surface potential. They are currently being compared with the maximum entropy theory as it is the only theory available which predicts a presence of multiply peaked distribution. Shown in Fig. 5 is the comparison of the experimental data (open circles) with the Rayleigh limit and the minimum energy theory. Clearly the observed charging level is less than the Rayleigh limit by a factor of 3 to 4. For larger droplets, the minimum energy limit agrees well with the observed data.

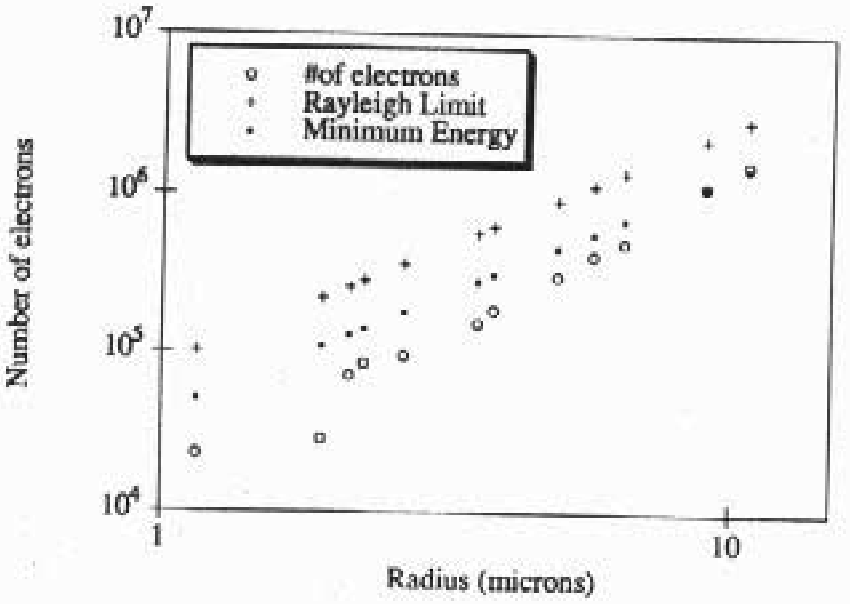

FIG. 5. Comparison of the Rayleigh limit and the minimum energy model with experimental data. The data are consistently smaller than the Rayleigh limit by a factor 3 to 4.

Shown in Fig. 6 is the same data shown differently using the charge-to-mass versus Z which is a relative charge level given by the ratio of the observed charging divided by the Rayleigh limit. For small droplets corresponding large Q/M, the relative charging remains flat at about 0.2–0.3 while for larger drops (smaller Q/M), there is a split of the charging level, one increases with radius and the other decreases with the radius. This trend qualitatively agrees with the prediction from the maximum entropy theory although quantitative comparison is not available yet.

V. NUMERICAL SIMULATION OF ELECTRON BEAM INJECTION INTO WATER VAPOR

A numerical simulation model has been developed in order to study injection of an electron beam into water vapor using a full three dimensional particle simulation model. The pressure of the water vapor is expected to be less than one atmospheric pressure as the swirling water jet removes the air out of the orifice. The results of the simulations are expected to shed light on the behavior of the charged particles in a water vapor thereby helping design a novel fire extinguishing nozzle using an electrostatic spray atomizer.

In the numerical simulation model, motion of the beam electrons injected into water vapor is followed in time in the presence of a self-consistent electrostatic field where collisions with water molecules are modeled by means of a Monte Carlo method. Both elastic and inelastic collisions between beam electrons and water molecules are considered. In the elastic collisions, the sum of the kinetic energies of the beam electrons and water molecules does not change. In the inelastic collisions, part of the beam energy is consumed in various atomic and chemical processes. These inelastic collisions considered in the present simulation model include the direct ionization of the water molecules and the dissociative ionization in which the water molecules dissociate into H, O and OH components before ionization. These dissociative ionizations have higher threshold energy than the direct