Numerical Study on Hollow Cathode Discharge of IEC Fusion

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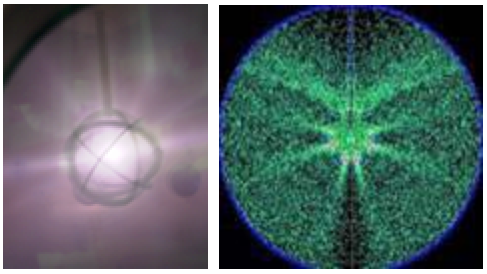
An inertial electrostatic confinement (IEC) fusion device is possibly used for the neutron sources that produce the neutrons of 1.8 x 10^8n/s by the use of the glow discharge under the conditions of about 0.5 Pa deuterium gas pressure and the applied voltage of 180kV[1)]. Since gas pressure in the most of IEC device, is so high that most nuclear fusion occurs between ion beam and neutral gas. The conditions of the high voltage and the low pressure are preferable, because the energy which beam ions possess is used for the fusion reaction more efficiently. It, however, is difficult to keep the robust operation because the glow discharge at the low-pressure is not stable.

We make the two-dimensional Monte Carlo PIC code in order to investigate the discharge characteristics in the IEC. The code includes 12 kinds of atomic processes and elastic collisions among electrons, D+ ions, D2+ ions and D3+ ions as well as the effects of the electric field deformed by the existence of the current feed through and the cathode structure. The code is initialed by the seed electrons existing between electrodes. The motions of each particle are traced by the Runge-Kutta method. During tracing the particles, atomic collisions are taken into account and new ions and electrons are generated by the collisions. The time behaviors of number of ion and electrons are observed. When the particles continue to increase, we identify that the glow discharge occurs.

We have the following results from the computations.

1. The relations between the gas pressure and the discharge voltage are consistent with those of the experiment.
2. The charged particle multiplication is proceeded dominantly by the ionizations of D_2 by fast D_2^+ ions and fast D_2 neutrals.
3. The fact that the discharge at a low pressure is unstable is explained by a less multiplication rate of ions
4. The ionization is rare in the region near the feed-through and its extension and lot of molecules are ionized near the hollow cathode.
5. We can reproduce the glow discharge pattern with several light spokes called “star mode” as shown in Fig. 1.



(a) (b)

Fig.1. “Star mode” (a) Experiment. (b) Simulation

1) G. L. Kulcinski, et al. “6th US-Japan Workshop on Inertial Electrostatic Confinement Fusion” Tokyo Institute of Technology Yokohama, Japan Oct.20-21, 2003.