§12. Motion of Ablation Cloud in Torus Plasmas

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Injecting small pellets of frozen hydrogen into torus plasmas is a proven method of fueling. Experimentally, it is known that the density distribution, after the pellet ablates by encountering the high temperature in plasmas, is not consistent with the distribution inferred from assuming that the ablated material remains on the flux surfaces where the ablation occurred. The subsequent redistribution of mass is considered to be due to $E \times B$ drift induced by toroidal drift [1] It is this phenomenon which we seek to investigate.

In this research, the basic equations are MHD equations. They are solved in a cylindrical geometry (R, ϕ, z) with a rectangular cross-section as shown in Fig. 1, where R and ϕ are a major radius and toroidal angle, respectively. R-z plane is a poloidal surface. The cubic interpolated pseudo-particle (CIP) method is used in the code [2]. An initial magnetic field is a vacuum one proportional to $1/R$. An initial pressure and mass density are assumed to be uniform. In this paper, all variables are expressed in a normalized form. The particle supplement due to a pellet ablation is expressed by an artificial point source located at $(R, \phi, z) = (1, 0, 0)$. Those conditions are not realistic, but the results obtained give some useful understanding on drift of the ablation cloud across the flux surfaces.

Temporal evolutions are obtained by using ideal MHD equations here. Figure 2(a) and (b) show density contours on the mid-plane $z = 0$ at $t = 1$ and 10, respectively, where the time is normalized by an Alfven transit time. A high density cloud is found to be quickly expanded along B-field compared with the displacement perpendicular to B-field. Figure 3 shows vertical electric field E_z. Dashed and solid lines show E_z at $t = 1$ and 10, respectively. That is a negative value within the cloud due to the opposite ∇B and curvature drifts of the ions and electrons. Then, it is clear that the cloud is moved to the low field side due to $E \times B$ drift. A peak value of the drift velocity becomes 3×10^4 m/s at 5 μs corresponding to $t = 10$. Actually, the drift velocity is considered to be less than that peak value because a parallel current flowing along the field lines reduces the electric charge developing the vertical electric field E_z.

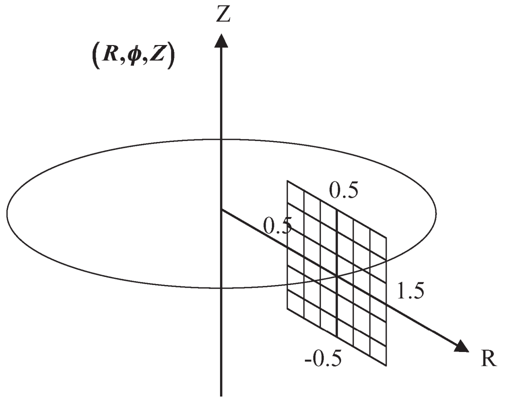

FIG. 1: Coordinate system of numerical code.

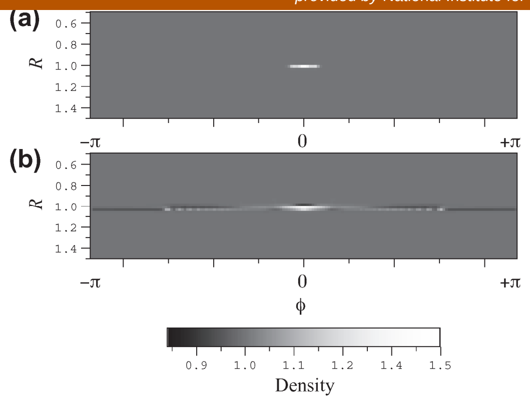

FIG. 2: Density contours on the mid-plane $z = 0$. A horizontal line is a toroidal angle ϕ and a vertical line is a major radius R. (a) and (b) show those at $t = 1$ and 10, respectively.

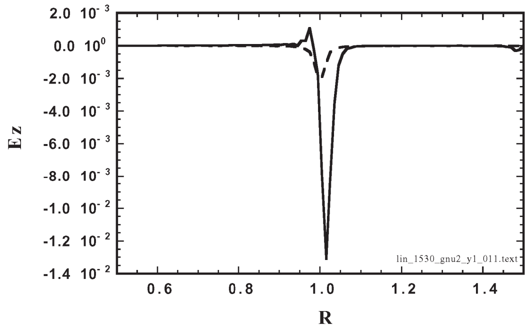

FIG. 3: Major radial profiles of E_z at $\phi = 0$ and $z = 0$. Dashed and solid lines show those at $t = 1$ and 10, respectively.

The motion of the ablation cloud in a vacuum field is investigated by solving the ideal MHD equations. A vertical electric field is induced due to a toloidal drift in the cloud and in result the cloud has a $E \times B$ drift velocity toward the low field side across the flux surfaces.

REFERENCES

[1] P. B. Parks et al., Phys. Plasmas **7**, 1968 (2000).
[2] T. Yabe and P. Y. Wang, J. Phys. Soc. Jpn **60**, 2105 (1991).