§3. MHD Simulation on Pellet Injection in LHD

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It is well known that an ablation cloud; a high density and low temperature plasmoid, drifts to the lower field side in tokamak plasmas, which leads to a good performance on fueling in tokamak [1]. Such a good performance, however, has not been obtained yet in Large Helical Device (LHD) experiments [2]. In order to obtain suitable conditions on pellet injection, MHD simulation on a plasmoid with an initial velocity has been carried out. It is found that the effect of the initial velocity is small in the plasmoid motion.

Plasmoid initial locations used are shown in Fig. 1, and their velocities used are $v_p = 0$ and 0.015 in the major radius direction. Figure 2 shows the displacements of the center of gravity, $< \Delta R_p > = \int (R - R_p)\rho dR / \int \rho dR$ for $v_p = 0$ and 0.015, respectively, where ρ is the plasmoid density. The plasmoid in case 1 drifts in the negative direction at first and subsequently drifts back and forth. The plasmoids in the other cases drift in the positive direction. Especially, the one in case 5 is accelerated very much. The leading force acting on the plasmoid is expressed by two forces, which are $1/R$ force by the magnetic field and the force by dipole field [3]. The former force induces the drift motion in the major radius directon. The latter force due to dipole field induced by diamagnetic effect of the plasmoid is approximately proportional to $1/L_c$, where L_c is connection length. In the LHD, the connection lengths depend on the locations. They are short in case 1 and long in case 5. Then, the connection length determines the leading force action on the plasmoid. The former force becomes dominant in case 5 and the latter force becomes dominant in case 1. Therefore, there is difference among the plasmoid motions in the cases. The plasmoids drifts in the positive direction in all cases by the initial velocity. However, the plasmoids are decelerated very much by magnetic field. Subsequently, the plasmoid drifts back and forth in case 1 and the plamoids drifts in the positive direction in the other cases. Especially, the plasmoid is accelerated in case 5 and its velocity becomes greater than the initial velocity. Figure 3 shows the displacement in all cases at $t = 15$. It is found that the effect of the initial velocity is small in all cases. Especially in case 1, the plasmoid hardly drifts to the core even if it has an initial velocity, $v_p = 0.015$ which is correspoinding 3.6×10^4m/s.

1) L. R. Baylor et al., Phys. Plasmas, **7**, 1878 (2000).

2) R. Sakamoto et al., *in proceedings of 29th EPS conference on Plasma Phys. and Contr. Fusion*, **26B**, P-1.074 (2002).

3) R. Ishizaki and N. Nakajima, Plasma Phys. Control. Fusion, **53**, 054009 (2011).

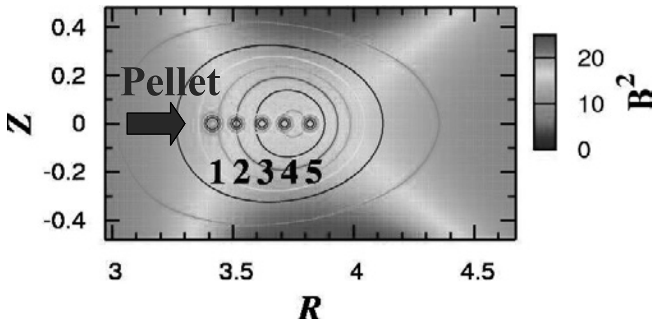

Fig. 1: Horizontally elongated poloidal cross section in the LHD. Colors and contours show the magnetic and plasma pressures, respectively. The outermost contour is corresponding to the last closed flux surface. Circles denoted by 1, 2, 3, 4 and 5 are initial plasmoids which have the velocity in the direction of an arrow.

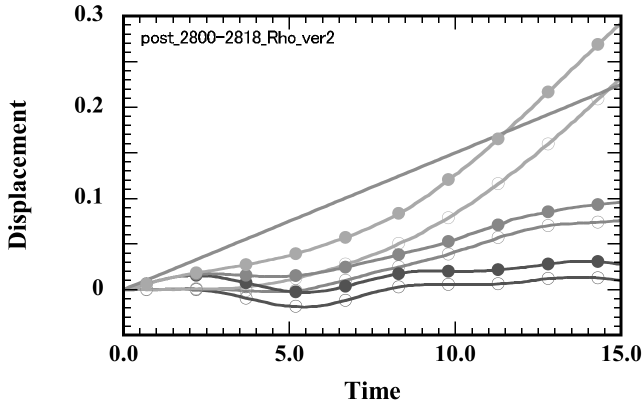

Fig. 2: Displacement of the center of gravity as a function of time for $v_p = 0$ (open circles) and 0.015 (closed circles). Red, green and sky blue lines show the displacements in cases 1, 2 and 5, respectively. Gray line shows the pellet trajectory.

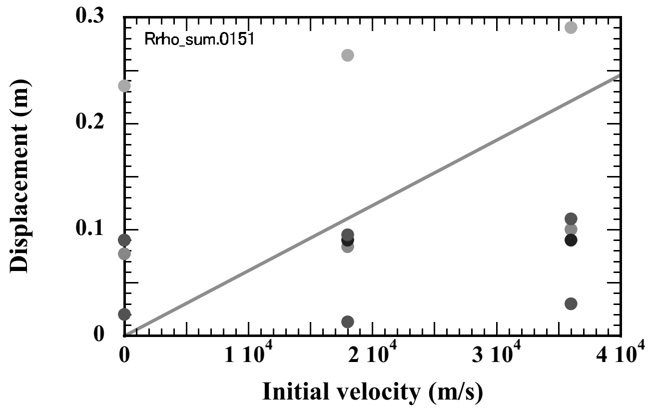

Fig. 3: Displacement of the center of gravity as a function of initial velocity at $t = 15$. Red, green, blue, pink and sky blue circles show the displacements in cases 1, 2, 3, 4 and 5, respectively. Gray line shows the displacement of the pellet.