§3. Plasmoid Motion in Helical Plasmas

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Injecting small pellets of frozen hydrogen into torus plasmas is a proven method of fueling [1]. Since a plasmoid induced by pellet ablation drifts to the lower field side, the pellet fueling to make the plasmoid approach the core plasma has succeeded by injecting the pellet from the high field side in tokamak. On the other hand, such a good performance has not been obtained yet in the planar axis heliotron; Large Helical Device (LHD) experiments, even if a pellet has been injected from the high field side [2]. The purpose of the study is to clarify the difference on the motion of the plasmoid between tokamak and helical plasmas.

The motion of the plasmoid is investigated in the LHD plasma by using the pellet ablation code (CAP) [3] in four cases A, B, C and D that the plasmoids are initially located at the inner and outer sides of the torus on the vertical and horizontal elongated poloidal cross sections as shown in Figure 1. The peak values of density and temperature of the plasmoid are 1000 times as large as density and 1/1000 times as large as temperature of the bulk plasma, respectively. The plasmoid, whose half width is 0.03, encounters the electrons with fixed temperature 2 keV and number density 10^{20} m^{-3}. An equilibrium obtained by the HINT code [4] is used as the bulk plasma.

Figure 2 shows the temporal evolution of the averaged density and averaged mass flow on the flux surfaces. The plasmoids A, B and C drift to the lower field sides due to a tire tube force and a magnetic force induced by the magnetic field with curvature similarly to tokamak [5]. However, it is found that the plasmoid C drifts in the negative direction of the major radius and subsequently drifts in the positive direction of it. Since the plasmoid C is initially located in the region where the gradient of the magnetic pressure is positive in the direction of the major radius as shown in Fig. 1(b), it is reasonable that the plasmoid drifts in the negative direction of the major radius at $t = 2\tau_A$. On the other hand, the plasma beta of the plasmoid becomes ~ 1 because the magnetic well is induced by the extremely large pressure of the plasmoid. Therefore, it is considered that the plasmoid drifts in the positive direction of the major radius at $t = 10\ \tau_A$ due to the change of the magnetic pressure and curvature induced by such a high beta. The detail will be clarified in the future work.

It is verified by simulations using the CAP code that the plasmoid with a high pressure induced by heat flux drifts to the lower field side for several Alfvén transit times in the LHD plasma. Such a drift is due to a tire tube force and a magnetic force induced by an extremely large pressure of the plasmoid similarly to tokamak. However, it is found that the drift direction is reversed in the case that an initial location of the plasmoid is the inner side of the torus on the horizontal elongated poloidal cross section. That fact is considered to be caused by the change of the magnetic pressure and curvature induced by the high beta, but the detail analysis will be required to clarify the physics mechanism.

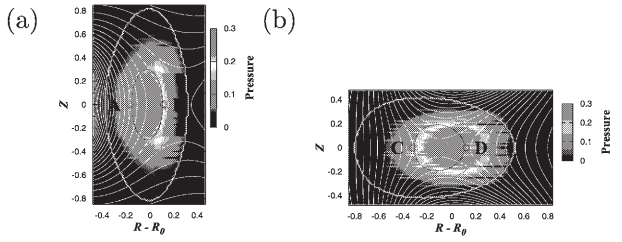

Fig. 1: Four initial locations of the plasmoids in the LHD plasma with the geometrical center of the poloidal cross section, $R_0 = 3.82$. The colors show the pressure contours in the poloidal cross sections at (a) $\phi = 0$ (vertical elongated one) and (b) $\phi = 2\pi/20$ (horizontal elongated one). The last closed surfaces are defined by the contour lines of 0.5% of the maximum pressure. The yellow lines show the contour of the magnetic pressure. The plasmoids denoted by circles A, B, C and D are located on the same flux surface.

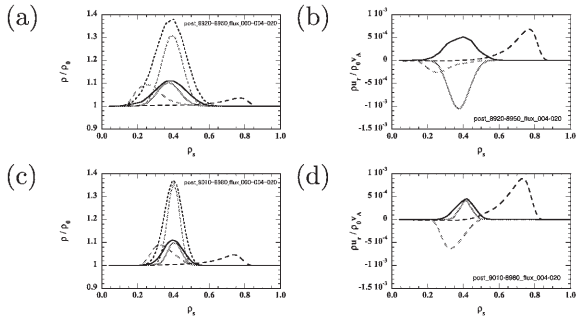

Fig. 2: (a)(c) The normalized averaged density, ρ/ρ_0 and (b)(d) the normalized averaged mass flow, $\rho u_r/\rho_0 v_A$ on the flux surfaces as a function of the normalized minor radius, ρ_s. (a)(b) The plasmoids A and B are shown by red and blue lines, respectively. Dotted, solid and dashed lines show ones at $t = 0$, 2 and $10\tau_A$, respectively. (c)(d) The plasmoids C and D are similar.

1) Y. W. Muller et al. Nucl. Fusion, **42**, 301 (2002).

2) R. Sakamoto et al. *in proceedings of 29th EPS conference on Plasma Phys. and Control. Fusion.*

3) R. Ishizaki et al. Phys. Plasmas, **11**, 4064 (2004).

4) K. Harafuji et al. J. Comp. Phys., **81**, 169 (1989).

5) R. Ishizaki et al. IAEA-CN-149/TH/P3-6 (2006).