§2. MHD Simulation on Pellet Plasmoids

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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. Such a good performance, however, has not been obtained yet in Large Helical Device (LHD) experiments. In order to clarify the motion of the pellet plasmoids, MHD simulation has been carried out.

Figure 1 shows the initial location dependence of the plasmoid motion. (a), (b) and (c) show the horizontally, vertically and obliquely elongated poloidal cross sections, respectively. Red circles show the initial locations for the plasmoids drifting to the core center, and black circles show the initial locations for the other plasmoids. The red circles are distributed at the slightly inboard side of the core center. The force acting on the plasmoid in the major radius direction is shown by $F_R = \boldsymbol{B^{eq}} \cdot \nabla B_R^{pl} - B_\varphi^{eq} B_\varphi^{pl}/R$, where B^{eq} is the equilibrium magnetic field, B^{pl} is the perturbation of the magnetic field induced by the plasmoid [1)], and the cylindrical coordinate (R, φ, Z) is used. The first term of F_R means the restoring force due to the magnetic tension, and the second term means $1/R$ force due to the toroidal magnetic field. When the connection length is short, $L_c \ll R$, the first term is greater than the second term. In other words, since the connection length is long at the outboard side, the second term is dominant in the plasmoid motion. Since B_φ^{pl} has the opposite sign of B_φ^{eq} due to the diamagnetic effect, the second term is always positive. Then, the plasmoids located at the outboard side drift in the major radius direction. On the other hand, the plasmoids located at the inboard side drift in the negative direction of the major radius by the first term which is dominant at the inboard side because the connection length is short. The magnetic pressure at the plasmoid on the mid-plane is a local minimum value along the field line on the horizontally elongated poloidal cross section shown in Fig. 1(a). When the plasmoid is elongated along the field line, the plasmoid flows to the higher field side. Since the flow of the plasmoid along the field line is inhibited by the higher magnetic pressure, the flow is narrowed and the magnetic field is also narrowed. Since the first term restores the field line which is narrowed, the force acts on the plasmoid in the negative direction of the major radius. On the other hand, the magnetic pressure at the plasmoid on the mid-plane is a local maximum value along the field line on the vertically elongated poloidal cross section shown in Fig. 1(b) When the plasmoid is elongated along the field line, the plasmoid flows to the lower field side. Then, the flow of the plasmoid along the field line becomes broad and the magnetic field also becomes broad. Since the first term restores the magnetic field, the force acts on the plasmoid in the negative direction of the major radius. In other words, the plasmoid located at the inboard side drifts to the higher field side on the vertically elongated poloidal cross section. Similarly, the plasmoid located at the inboard side drifts in the direction of the major radius on the obliquely elongated poloidal cross section as shown in Fig. 1(c). Since the effective connection lengths are short at the plasmoid locations shown by the red circles, the second term becomes dominant and the plasmoids drift in the major radius direction, namely to the core center. The future work is to clarify the suitable condition that the pellet can reach the region shown by the red circles.

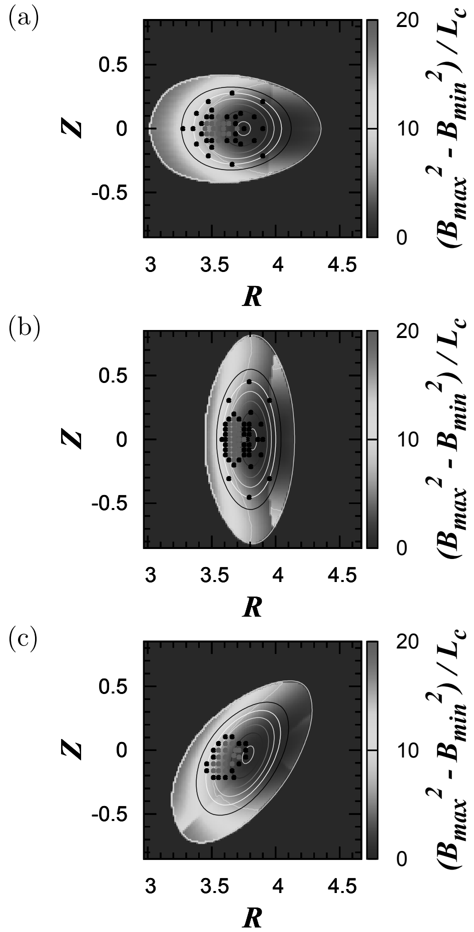

Fig. 1: Initial location dependence of the plasmoid motion. (a), (b) and (c) show the horizontally, vertically and obliquely elongated poloidal cross sections, respectively. Red circles show the initial locations for the plasmoids drifting to the core center, and black circles show the initial locations for the other plasmoids. Contours show $(B_{max}^2 - B_{min}^2)/L_c$, where B_{max}^2 and B_{min}^2 are the maximum and minimum values of the magnetic pressure along the field line through the initial location, and L_c is the connection length.

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