§21. Deceleration Mechanism for Rotation of Instability with Minor Collapse in LHD

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Core plasma pressure sharply drops when radial magnetic fluctuation amplitude rapidly increases in LHD[1]. This drop is called minor collapse. The rotational frequency of the instability is changed with decrease of magnetic shear during the discharge[2]. The instability is divided into three parts by the activity of the frequency. The instability rotates at a constant speed in part 1, the rotation slows down in part 2, and it stops in part 3. The magnetic fluctuation amplitude is constant in part 1 but the amplitude increases with the decrease of the frequency in part 2. Then the flattening of pressure profile occurs near the resonant surface of the instability and its width also expands. The amplitude rapidly increases, the flattening width further grows, and the minor collapse takes place in part 3. Locked mode, which is one of key instabilities observed in tokamaks, is a similar character to the above instability, and it is known that locked mode causes collapse due to the stopping of its rotation[3]. Therefore, the deceleration mechanism for the rotation of the instability in part 2 needs to be clarified. According to works on physical mechanism for rotation of resistive interchange instability rotated at a constant speed, its rotational frequency is consistent with the sum f_{drift} of E×B drift frequency and electron diamagnetic drift frequency[4]. The goal of this study is that the deceleration mechanism for the rotation of the instability in part 2 is clear by comparison of the rotation with plasma rotation. Waveform in a typical discharge where the instability occurs is shown in Figure 1. Here magnetic configuration is set to be R_{ax}=3.60 m, B_{t}=-1.375 T, γ=1.18, B_{q}=100%. Co-NBI is used in order to produce and hold the plasma, and apply increased plasma current in Co-direction which decreases magnetic shear. The instability rotates with the frequency of 1 kHz in electron diamagnetic direction at t=4.7 s, but the rotational frequency continues to decrease with the increase of the plasma current in Co-direction until t=5.18 s. When the f_{drift} at the resonant surface is evaluated, the f_{drift} decreases with the rotational frequency of the instability. This is consistent with the result in paper 4. The radial location of the resonant surface is defined as the center of the flattening observed in part 2 because both locations are estimated to be almost the same. The electron diamagnetic drift frequency is set to be zero because the diamagnetic effect at the resonant surface is estimated to be so small because the flattening of pressure profile occurs. The time evolution of the radial profile of the f_{drift} as shown in Figure 2 indicates that the f_{drift} is close to zero in smaller R. The radial location of the resonant surface R_{res} is also plotted in Figure 2. Figure 2 indicates f_{drift} decreases due to the resonant surface moving to inward. In Figure 3, f_{drift} has linear relationship with $v_{\mathrm{p}}/R_{\mathrm{res}}$, where v_{p} is the poloidal carbon flow at R_{res}. This relationship shows that the main component of f_{drift} is v_{p}. Here the rate of change of R_{res} is within 5%. According to these results, one reason for the deceleration of the instability's rotation is the decrease of v_{p} at the resonant surface moving to core region.

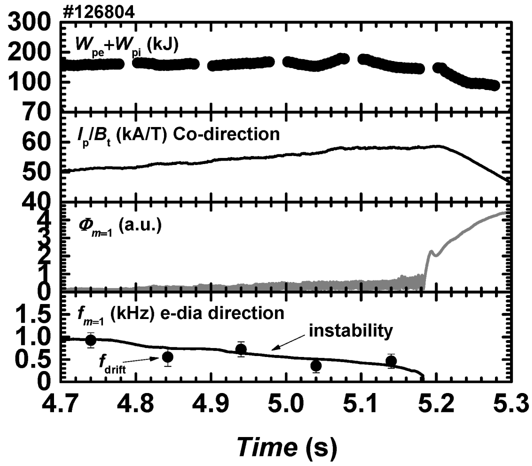

Fig. 1. Waveform in part 2 and part 3 of the instability with minor collapse in LHD.

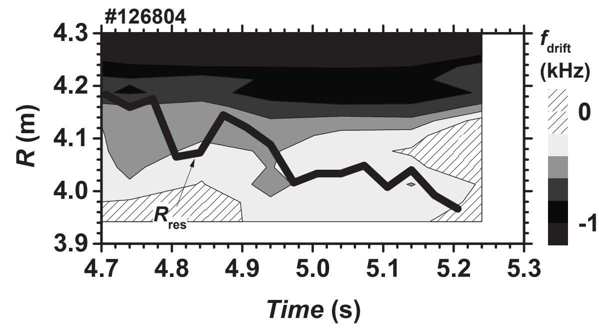

Fig. 2. Time evolution of the radial profile of f_{drift} and the radial location of the resonant surface of the instability.

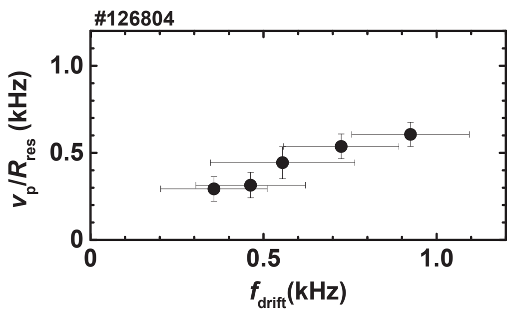

Fig. 3. Relationship between f_{drift} and $v_{\mathrm{p}}/R_{\mathrm{res}}$.

1) Sakakibara, S.: Fusion Sci. Technol. **58** (2010) 176.
2) Takemura, Y.: Nucl. Fusion **52** (2012) 102001.
3) Nave, M.F.F.: Nucl. Fusion **30** (1990) 2575.
4) Takemura, Y.: Plasma and Fusion Res. **8** (2013) 1402123.