§35. Physics of Plasma Production by Higher Harmonic ECH

Nagasaki, K., Mizuuchi, T., Kobayashi, S. (IAE, Kyoto Univ.), Idei, H. (Kyushu Univ.), Cappa, A., Fernandez, A., Castejon, F. (CIEMAT), Mutoh, T., Shimozuma, T., Kubo, S., Yoshimura, Y., Inagaki, S., Igami, H., Shoji, M., Notake, T.

High power electron cyclotron waves of fundamental and second harmonic resonance frequencies are routinely used for reliable plasma start-up in helical systems. Few systematic studies have been performed on the breakdown physics in helical systems as compared to tokamaks. This may be because plasma start-up was easily achieved with any kind of wave launching regardless of wave polarization or wave beam focusing, as long as the EC resonance was located inside the last closed magnetic surface. The fundamental plasma breakdown can be explained simply by a linear theory. On the other hand, the physics is not so simple for the second harmonic plasma breakdown. The second harmonic plasma breakdown requires consideration of nonlinear wave-particle interactions, since the linear energy increment of seed electrons is proportional to the gyroradius squared, which is practically zero at the initial phase. According to the nonlinear theory, the accelerated electrons should be confined well for causing electron avalanche until they collide with neutrals.

Recent study on plasma production by the second harmonic ECH has been studied in Heliotron J (Kyoto Univ.) [1], TJ-II (CIEMAT) [2] and CHS (NIFS) [3] has clarified the importance of the electric field and polarization of injection beam and the interaction region. In this research, we have experimentally investigated the second harmonic plasma production by using 84 GHz ECH in LHD in order to understand the physics mechanism of high harmonic plasma production commonly observed in helical systems. EC beams are injected so as to pass through the magnetic axis. Figure 1 shows a 2-D CCD camera measurement. The plasma rises up around the magnetic axis, and the initial plasma moves as the magnetic axis is shifted, indicating that the plasma is produced at good confinement regions and expands toward the edge region. Figure 2 shows the dependence of the delay time of the H_α signal reflecting the plasma production time on the magnetic axis position. Although the dependence on gas puffing condition should be taken into account, the plasma production tends to be delayed as the magnetic axis is shifted inwardly. The dependence on magnetic axis shift will be investigated in the future, which may be related to the confinement of trapped particles.

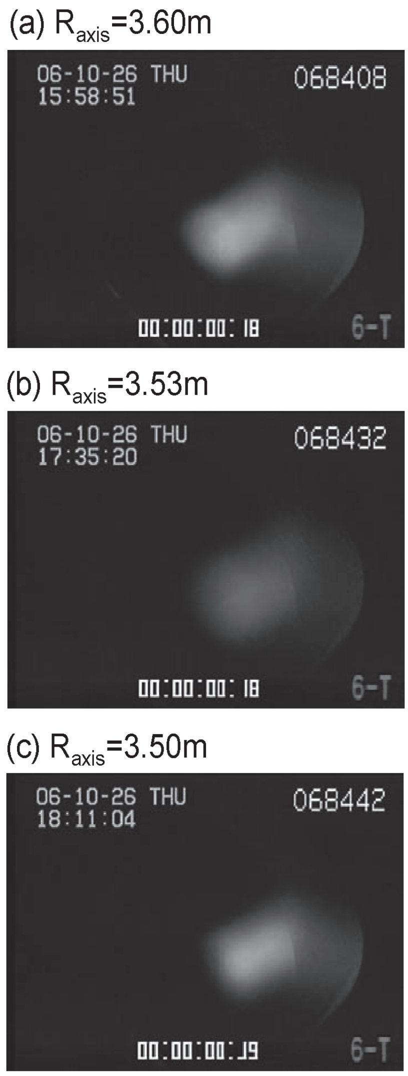

Fig. 1. Tangential view of CCD camera. The shift of initial plasma can be seen.

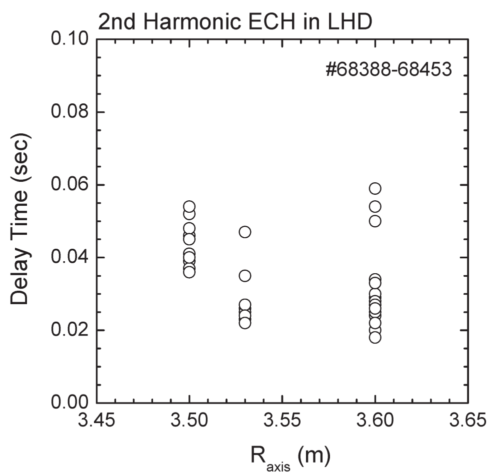

Fig. 2. Dependence of delay time of H_α signal on magnetic axis position

References
[1] Nagasaki, K., et al., Nucl. Fusion 45 (2005) 13
[2] Cappa, A., et al., Nucl. Fusion 41 (2001) 363
[3] Nagasaki, K., et al., J. Korean Phys. Soc. 49 (2006) 18