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Analysis of velocity distribution of D-D fusion products driving ion cyclotron emission on JT-60U

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Non-thermal ions can drive waves in ion cyclotron range of frequency (ICRF). Excitation of ICRF waves has been observed in several tokamaks and stellarators when fast ions are produced. This emission is called ion cyclotron emission (ICE). A possible driving source for ICE is the ion velocity distribution having significant non-thermal components, such as a bump-on-tail structure and strong anisotropy. Such a non-thermal distribution can be formed near the outer midplane edge due to the magnetic drift. Identifying characteristics of the ion distribution driving ICE is important to understand its emission mechanism. On JT-60U, ICEs thought to be driven by deuterium-deuterium (D-D) fusion produced ^{3}He ions [ICE(^{3}He)], H ions (protons) [ICE(H)] and T ions (tritons) were detected, and their toroidal wavenumbers were quantitatively measured. Here, ICE(H) was identified by not only comparing its measured frequency with H ion cyclotron frequency, but also comparing its measured toroidal wavenumber with that of 2nd harmonic deuterium ICE [1]. ICE(H) was observed mainly in weak and reversed magnetic shear plasmas. In the previous study [2], fast ^{3}He ion velocity distribution driving ICE(^{3}He) is first evaluated under realistic condition by using OFMC code. In this simulation, birth spatial and velocity distribution of fusion produced ^{3}He ions is evaluated from orbit calculations of fast D ions injected by neutral beams. As the results, it was found that fast ^{3}He ions on the bump-on-tail structure can resonate with waves in the same frequency as the ICE(^{3}He). In addition, the emission condition for the ICE(^{3}He) strongly depends on the bump-on-tail structure in the distribution at the outer midplane edge. On the other hand, necessary characteristics of the fast H ion distribution to drive ICE(H) are not understood since the distribution was not evaluated under such realistic conditions so far.
The purpose of this study is to identify the characteristics of the D-D fusion produced ion distributions driving ICE. Fast H ion velocity distributions have been evaluated under the realistic conditions for the first time by using OFMC code. As the results, it was found that the evaluated fast H ion velocity distribution at the outer midplane edge has the pitch-angle anisotropy and the bump-on-tail structure in the coordinate of the energy. In addition, this bump-on-tail structure is formed only near the outer midplane edge. The ICE(H) would be excited locally in the major radius direction since its observed frequency spectrum width is very narrow (< 1 MHz). Hence, the localization of the formation of the bump-on-tail structure is reasonable. There is a possibility that the emission mechanism for the ICE(H) can be explained by destabilization of ICRF waves by the bump-on-tail structure as well as ICE(^{3}He).

[1] S. Sato et al., Plasma Fusion Res. **5**, S2067 (2010).
[2] S. Sumida et al., Plasma Phys. Control. Fusion **61**, 025014 (2019).

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