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Pulsative non-thermal emissions between ion cyclotron and electron cyclotron frequencies during external heating in magnetically confined experimental plasmas

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Pulsative intensity increase and decrease of the non-thermal emissions are observed in the harmonic frequency range of the ion cyclotron, lower hybrid, and electron cyclotron waves at helical devices.

In the large helical device (LHD), at the start-up phase of the plasma discharge initiated by tangential neutral beam and electron cyclotron wave, pulsative zebra-like pattern emissions are observed as shown in Fig. 1. The peak frequencies correspond to $f = n f_{LH} + m f_{IC}$, where f_{LH} is the lower hybrid and f_{IC} is the ion cyclotron frequency. It was previously suggested that when the lower hybrid frequency is close to the integer multiple of the ion cyclotron frequency, waves of harmonic ion cyclotron frequencies are excited with the existence of the high energy ions that have low pitch angle [1] and can be provided by tangential neutral beam injection. Here, the existence of waves of harmonic frequency range of the lower hybrid wave is reported. We have found that there are two specially separated double resonances "DBR1" and "DBR2" where the ion cyclotron resonance and the lower hybrid resonance overlap. At each double resonance, f_{LH} is approximately a multiple of f_{IC}. We have also found that $6f_{IC}$ at DBR1 corresponds to f_{LH} at DBR2.

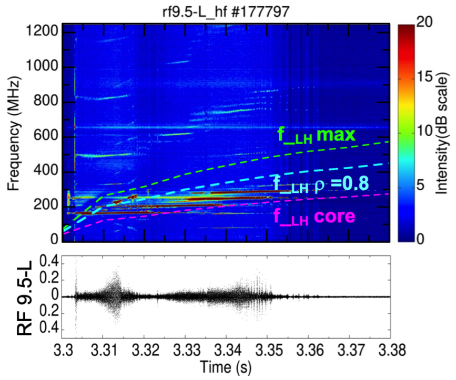

Fig.1：Time change of the frequency spectrum and signal intensity detected by RF probe at the initiation phase of the plasma discharge in LHD

The impact of the waves that propagate between DBR1 and DBR2 on the intensity of the waves excited at each double resonance via nonlinear wave-wave coupling will be investigated.

After the appearance of the emissions described above, pulsative intense non-thermal emissions are observed with chirping-up/ down of the frequency in the second harmonic electron cyclotron frequency range. In Heliotron J, similar emissions are also observed when the plasma is initiated only by 2nd electron cyclotron wave injected obliquely to the external magnetic field as shown in Fig. 2. The intense emission is observed under the 2nd ECRH frequency. This time change of frequency spectrum looks like the falling tone of the whistler-mode wave in the magnetosphere although the condition of $\omega_{pe}/\Omega_{ce} > 1$ is not satisfied in the experimental condition. Interaction between high energy electrons and existing waves will be investigated.

References

[1] M. Toida, H. Igami, et al, Plasma Fusion Res. 14, 3401112 (2019)

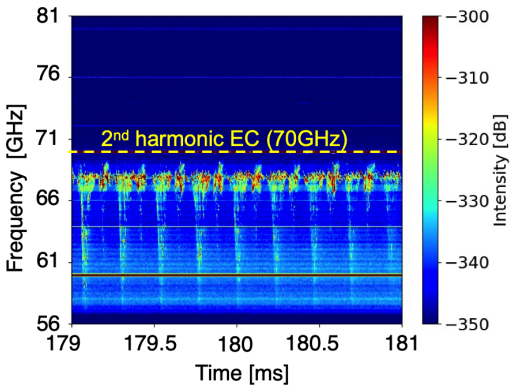

Fig.2：Time change of the frequency spectrum of 2nd electron cyclotron wave range at the initiation phase of the plasma discharge in Heiotron J