

Identification of core ion cyclotron instabilities on HL-2A

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Ion cyclotron emission (ICE) is the electromagnetic instability in multiples of ion cyclotron frequency (f_{ci}) range, excited by energetic particles (EPs). Assessment of ICE for diagnosing lost and barely confined fast ions [1,2] has become a critical topic in the International Tokamak Physics Activity (ITPA) EP physics topical group. The ICE spectrum provides detailed information about the contributions of EP driving across the velocity space.

Dedicated HL-2A experiments have been performed to investigate the physics mechanism of ion cyclotron emission (ICE), including its driven mechanism, frequency dependence, and spectrum feature. We found that the detected ICE frequencies match f_{ci} in deuterium plasma and scale with Alfvén velocity (v_A), providing the first evidence that ICE is a fast Alfvén wave. Secondly, it has been demonstrated that lower-frequency ICE modes are generated through the coupling of higher-frequency ICE modes. The experiment reveals that the wave-wave coupling processes have the potential to broaden the frequency bandwidth of ICE, resulting in a redistribution of ICE energy and a wider range of wave-particle interactions. Furthermore, the stability boundary of ICE has been directly observed, showing that ICE is stabilized with decreasing pedestal pressure gradient. This study provides valuable insights for the understanding of ICE and the development of ICE as a reliable diagnostic tool for studying energetic particles in fusion plasmas.

References

- [1] K. G. McClements et al., Nuclear Fusion 55, 043013 (2015).
 [2] N. N. Gorelenkov, Plasma Physics Reports 42, 430 (2016).

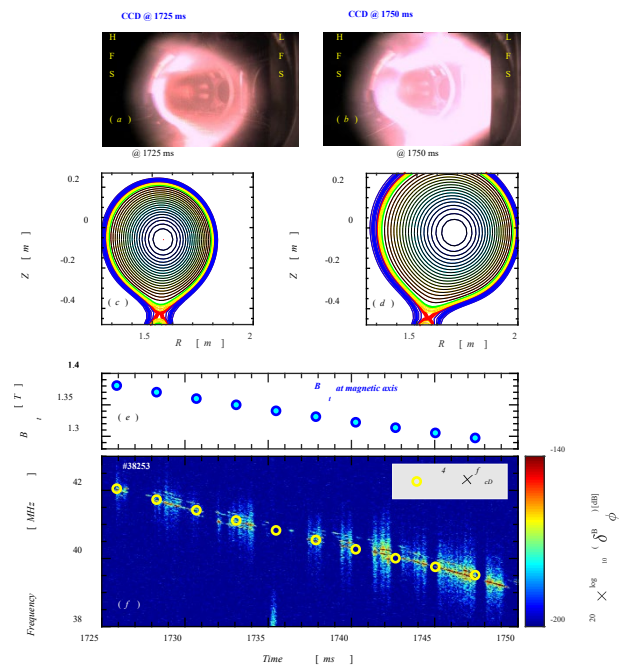


Figure. The detected frequency of ICE mainly depends on the magnetic field. (a) the CCD image at 1725 ms; (b) the CCD image at 1750ms; (c) the poloidal magnetic topology at 1725 ms calculated by EFIT; (d) the poloidal magnetic topology at 1750 ms calculated by EFIT; (e) the evolution of magnetic field at magnetic axis; (e) frequency spectrum of 4th ICE, the yellow circles stand for the calculated 4th harmonic of the core f_{cD} .