Fast-ion Driven Alfvén Eigenmodes during ICRF Heated High β_p Plasmas on EAST

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Fast-ion driven Alfvén Eigenmodes (AEs) are observed during ICRF heated high-β_p plasmas on EAST since AEs quiescence was discussed in [1]. Multiple high frequency modes are observed for shot 112670 at f_{TAE1} ~ 145 kHz, n = 3, $\delta B/B$ ~ 4×10^{-4} and f_{TAE2} ~ 175 kHz, n = 4, $\delta B/B$ ~ 1.2×10^{-5} measured by high-frequency mirnov coil, at B_0 ~ 2.45T, I_p ~ 350kA, n ~ ramp-up from 3.5×10^{19}m^{-3} to ~ 4×10^{19}m^{-3} at P_{ECRH} ~ 2 MW, P_{LHW} ~ 2 MW, and P_{ICRH} ~ 2.1 MW. Here, 37MHz ICRF minority hydrogen heating scheme, located at plasma core, creates fast ion population which drives TAEs unstable from TRANSP+TORIC. In the experiment, it is observed that the evolution of mode frequency depends on electron density, following the theoretical TAE frequency characteristic $f_{th} = V_A/(4\pi qR) \propto (n_e)^{1/2}$ [2]. As the electron density increases, the amplitude of the AE mode progressively diminishes. At higher plasma densities, the slowing-down time of fast ions is decreased, reduce the ICRF absorption power, and weaken the high-energy ion tail, thereby it reduces fast-ion beta β_f. According to reflectometer diagnostic, both TAE modes are located at a radial position at approximately ρ ~ 0.2. The gyro-fluid code FAR3d[3] are applied to study the properties of these instabilities, including the effect of the acoustic modes, EP finite Larmor radius damping effects. The simulation indicates a narrow TAE gap in the inner plasma region around ρ ~ 0.2. The simulation indicates a narrow TAE gap in the inner plasma region around ρ ~ 0.2, showing a consistence between the measurements and the frequency range of the dominant modes. It is also found that the linear growth rate of the n = 4 TAE is higher than that of the n = 3 TAE. The result shows the characteristic of β_f profile, as the main driver of AE instability, is peaked at ρ ~ 0.2 which is the location of ICRF power deposited.

The threshold of ICRF power to excite AEs is studied in the experiments attributing to enough β_f to drive TAE instability. A further study for the impact of ICRF resonance layer position shows that when B_t is increased from 2.51T to 2.56T, TAE activities gradually disappear, attributed to the reduced β_f with the ICRF power deposited outwards. In addition, to investigate the impact of the synergetic effect between NBI and ICRF on ICRF driven TAEs, the experiment shows a stabilizing effect of beam ions that TAE activity are mitigated. The changes in kinetic profiles and fast-ion velocity distribution can impact ICRF tail and TAEs.

References

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