Study the characters of WCM in I-mode plasma on EAST

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The I-mode is a tokamak plasma operational mode that combines high heat confinement with low particle confinement. This lower pressure gradient compared to that in H-mode prevents the I-mode pedestal from reaching the peeling-ballooning mode instability region, thereby avoiding the Edge Localized Modes (ELMs) naturally. Most I-mode discharges are accompanied with the Weakly Coherent Mode (WCM), an instability that is considered to play a significant role in preventing the formation of a density pedestal structure during the I-mode phase.

This work conducts a comprehensive study of the latest experimental data on WCM in I-mode discharges from the EAST tokamak device and existing database. Statistical analysis of the WCM in the database reveals a wide range of central frequencies, from 40kHz to 110kHz. Statistical analysis unveiled an inverse relationship between the central frequency of WCM and q_{95}. However, linear simulation results showed that the real frequency of instability is directly proportional to q_{95}, which contradicts the trend observed in statistical data. This suggests that neither the current nor the safety factor are the true factors affecting the WCM frequency. Comparing density profiles from low, medium, and high-frequency results within the statistical data reveals that higher frequencies correspond to steeper density gradients. It is speculated that I_p might merely be a superficial factor, and other parameters could be the actual influences of WCM frequency. Further investigation using simulation methods are conducted to modify density and temperature gradients to compare mode frequencies and validate this hypothesis.

Moreover, the WCM was recently observed for the first time in conventional reflectometer on EAST, and successfully determined its poloidal wavenumber range. During the transition from L-mode to I-mode, the line-averaged density remained nearly unchanged while a significant change was observed in the Electron Cyclotron Emission (ECE) signals at the boundary. The difference between the signals for two channels at the edge increased, coinciding with the appearance of WCM and a simultaneous rise in boundary electron temperature. Simulation results provided additional insights, demonstrating that the simulated 'WCM' in the density fluctuations aligns with experimental data in terms of center frequency. Additionally, the radial distribution of this simulated 'WCM' closely corresponds to regions with the strongest electron temperature gradients. Finally, through cross-correlation analysis of the simulated fluctuations, the following phase relationship for wavenumber range of 'WCM' was observed: $\alpha_{Te} > \alpha_{ne} \sim \alpha_{\phi} > \alpha_{Ti}$.