Experimental study of electron scale density fluctuation on HT-7 Tokamak

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1, HT-7 CO2 collective scattering system

\[ \lambda = 10.6 \mu m \]
\[ \omega = 28 THz \gg \omega_{ce} \approx 100 Hz \] (refractive effects are negligible)
\[ \theta_i < 0.48 \times \theta_{chord} \] averaged
K-matching \( k_s = k_i + k \)
Bragg condition: \( k_s = 2 k \sin (\theta / 2) \)
K-space resolution: \( \Delta k = 2 \pi a = 2.5 cm^{-1} \)
Homodyne detection

2, Fluctuation level of different \( k \) related to q profile

The anomalous particle pinch is observed in absence of toroidal electric field and of central particle source.

In most of the tokamak plasmas, the curvature pinch term is more important than the thermodiffusion term, and the curvature term is proportional to magnetic shear when the TEMs dominate.

\[ \gamma = 0 \]
\[ \Gamma = \sum \left( D_0 V_n + V_n^* \right) = 0 \]
\[ \Gamma = \left[ D_0 (V_n^+ + V_n^*) + C \left( V_n^+ + V_n^* \right) \right] \]

Both the fluctuation level of the modes in channel \( k = 12 cm^{-1} \) and \( k = 20 cm^{-1} \) are related with plasma current profile.

3, Enhanced fluctuations observed in high-Te plasma

• When the lower hybrid power exceeded 500kW, the ohmic normalized fluctuation level in channel \( k = 12 cm^{-1} \) dropped to a low level. The ohmic normalized fluctuation level in channel \( k = 24 cm^{-1} \) was still increasing.
• The frequency spectrum of density fluctuation was obviously changed in channel \( k = 24 cm^{-1} \).
• These turbulent fluctuations (frequency spectrum of channel \( k = 24 cm^{-1} \) peaked at about 200kHz) appear to be related to the electron temperature gradient.
• Channel \( k = 12 cm^{-1} \) dropped to a low level seem to be the stabilization of the TEM for a flatten magnetic shear.

4, Self-consistent profile of normalized pressure without transport barriers

The self-consistent pressure profile links with plasma equilibrium.

• Particle and thermal pinches are used by plasma for \( p_N(r) \) regulation.

5, K-spectra Compare with different plasma B

• The power spectra follows power laws from \( \sim B = 3.15 \) to \( \sim B = 4.37 \), all the power spectra monotonically decrease. (\( B > 2 \))

6, Discussion

• Both the fluctuation level of the modes in channel \( k = 12 cm^{-1} \) and \( k = 20 cm^{-1} \) are related with plasma current.

• \( P(\theta) \) may become larger because of the increasing electron temperature profile, These turbulent fluctuations (frequency spectrum of channel \( k = 24 cm^{-1} \) peaked at about 200kHz) appear to be related to the electron temperature gradient.

• \( P(\theta) \) may be independent on the plasma ICRF heating.

• Density spectra tend to be anisotropic at higher k and exhibit a flat region or modified power laws when \( B \), is lower.