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Experimental research on the nonlinear dynamics of plasma turbulence in magnetize devices

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Understanding the mechanisms of turbulent fluctuation-driven anomalous transport is crucial in magnetically confined plasmas. The turbulent fluctuations in magnetized plasmas, governed by nonlinear interactions across disparate scales, remains a complex and challenging area of study. Despite decades of the research, fundamental questions persist regarding the nonlinear dynamics of plasma turbulence, including the asymmetry of structures and their localization on magnetic flux surfaces. To address these challenges, a novel three-dimensional (3D) tomographic imaging system has been developed, enabling comprehensive investigations into the dynamics of plasma turbulent fluctuations.

This presentation elucidates the intriguing findings from the study of nonlinear interactions between fluctuations across disparate scales, derived from the Qt-Upgrade linear device at Tohoku University. Additionally, it introduces preliminary experimental results obtained from the 3D tomographic system deployed in the PANTA (Plasma Assembly for Nonlinear Turbulence Analysis) plasmas at Kyushu University, Japan.

Significantly, the results of the Qt-Upgrade linear device highlight the enhanced multiscale nonlinear interactions between high-frequency electron gyro scale instabilities and low-frequency ion gyro scale instabilities, particularly when electron temperature gradients exceed critical thresholds [1-3]. Moreover, recent experimental findings underscore the pivotal role of nonlinear processes in mitigating microscale turbulence in the magnetized plasmas [4].

On the other hand, the tomographic imaging system provides significant insights [5], such as the radial structure of normalized fluctuations exhibits asymmetry, with notable variations along the z-axis. This suggests non-uniform stationary plasma fluctuations along the magnetic field direction. Additionally, strong cross-coherence between tomographic emission plasma fluctuations and ion saturation current fluctuations has been observed, offering direct insights into the axial wavelength characteristics of low-frequency fluctuations through 3D tomography diagnostics.

In summary, this research highlights the critical role of advanced diagnostic tools in elucidating the complex dynamics of plasma turbulence, providing novel insights into anomalous transport mechanisms in magnetized plasmas.

References

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