

Effect of impurity ions on turbulence-zonal flows dynamics in HL-2A plasmas

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Abstract:

It is well known and widely accepted that zonal flows plays a crucial role in regulating turbulence in magnetically confined plasmas [1]. Impurity injection, one of the external perturbation methods, was used to study the turbulent transport dynamics in fusion devices. The theoretical work [2] has indicated that both frequency and amplitude level of the geodesic acoustic mode (GAM) zonal flows would significantly reduce with the increase of low-Z impurity ions concentration, such as carbon. However, the physical mechanism for the interaction of turbulence and zonal flow cycles effected by impurity ions has not been fully understood yet in experiments.

In this work, we report the first observation of the effect of the carbon impurity on GAM zonal flows dynamics and the resulting turbulent transport in HL-2A tokamak [3]. The time trace of the impurity concentration f_c together with the GAM frequency and its amplitude are plotted in Fig. 1 (a)-(c). The result presented here clearly indicates that both the GAM frequency and its amplitude start to reduce from $t=360$ ms, which is qualitatively consistent with the numerical simulation result [2]. This is the direct evidence for the effect of the carbon impurity ions on the dynamics of GAM zonal flows involving the frequency and amplitude both as observed in our experiment. The results presented here can be explained as follows: as the impurity concentration is increased, the GAM frequency decreases due to the increase of polarization current, which makes more bulk ions to resonate with the GAM via the wave-particle interaction and thus increases the damping rate of the GAM. For elucidating the effect of impurity ions on the drive of GAM zonal flows, the time trace of the nonlinear energy transfer between the zonal flows and turbulence, the total bicoherence ($\sum b^2$) and the poloidal coherence length (L_θ) has presented in Fig. 1 (d)-(f). One can see that maximum correlation in Fig. 1 (d) appears at the negative time delay ($\Delta\tau = -15 \mu\text{s}$), indicating that the energy is mainly transferred from the turbulence to GAM zonal flows, and the decreased correlation after impurity injection reflecting that the less energy is transferred from turbulence to GAM zonal flows. The detailed

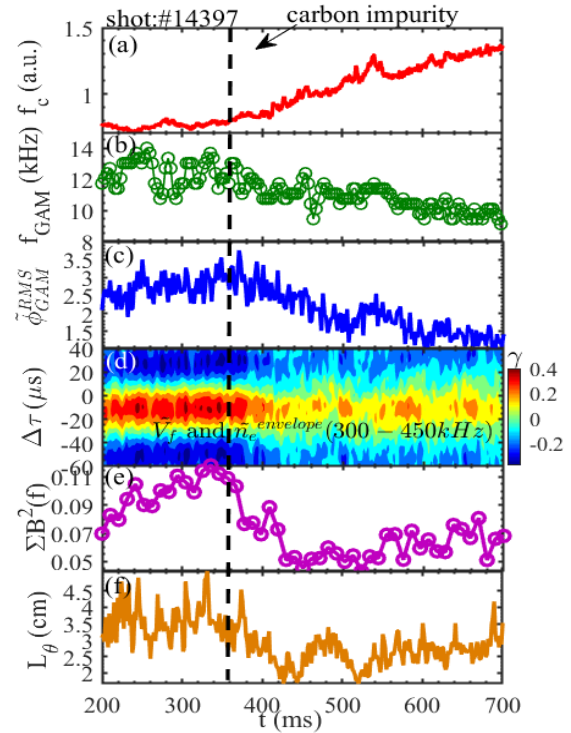


Fig. 1 The time traces of impurity concentration f_c (a), GAM frequency (b), the RMS of the floating potential fluctuations filtered in 8-15 kHz (c), the cross-coherence function (CCF) between the floating potential and the envelope of density fluctuations (d), the total bicoherence $\sum b^2(f)$ of the floating potential fluctuations (e) and the poloidal coherence length of turbulence vortex estimated with two floating potentials poloidally separated by 8 mm ($d_\theta = 8 \text{ mm}$) (f)

experimental results will be presented in this conference.

References

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