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Wave number analysis of meso-scale structures in linear plasmas

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Meso-scale structures such as streamers and zonal flows are produced by nonlinear interaction between microscopic drift wave turbulence in fusion plasmas. Zonal flows suppress the radial transport and are well studied these days. In other hand, although streamers enhance the radial transport, to study the generation and suppression of the streamer structures is important in plasma physics and fusion reactors.

By using the linear plasma device, LMD-U in Kyushu University, our group succeeded in finding the streamer structure and its mediator mode for the first time [1]. Owing to the low temperature property, linear plasmas are well used for basic study of plasma turbulence. In the previous studies, our group clarified the cross-sectional structures of the streamer, its mediator mode, and carrier drift waves [2]. The mediator mode is the trigger for the streamer generation, and nonlinearly couples with the carrier drift waves to create the streamer structure. Several Langmuir probes arranged in the axial direction including the 64-channel poloidal probe array, and bi-spectral and bi-phase analyses were used to observe the three-dimensional phase structures. The results were well compared with theoretical [3] and numerical [4] works. While the streamer structure and carrier drift waves were radially elongated, the mediator mode had a node in the radial direction. Additionally, the axial dimensional research revealed that while the carrier drift waves had an axial mode number one (propagation direction from the end to the source), the streamer and mediator were revealed to have an axial mode number zero [5].

To compare the observed meso-scale structures with theoretical and numerical studies more precisely in the phase space, local information of the wave number is required. In this study, we tried to observe the local wave number of plasma turbulence for phase space analysis. By applying a window function to the observed data array of 64-channel poloidal probe array before the Fourier analysis, nearly local information of the wave number of which the window function is open can be derived. Figure 1 shows the result. Time evolution of the amplitude of poloidal mode number three when a streamer structure was observed is shown in the figure. The windows are phase shifted for –π/2, –π, –3π/2, compared to the top figure. The streamer is a bunch of waves in the poloidal direction and poloidally rotates with frequency of 1.2 kHz in our linear plasma. In the figure, we can clearly see that the amplitude of mode number three is poloidally localized, and the localized region is rotating in the poloidal direction with the frequency of 1.2 kHz.

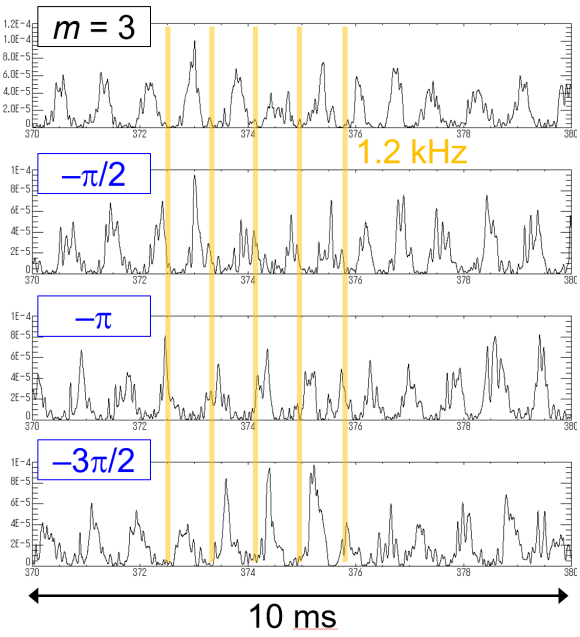

Figure 1. Time evolution of the amplitude of poloidal mode number 3. Window function is applied in the poloidal direction. The windows are phase shifted for –π/2, –π, –3π/2, compared to the top figure.

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