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Three Dimensional Structure of Streamer in Drift Wave Fluctuations

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Meso-scale structures such as streamers and zonal flows are produced by nonlinear interaction between microscopic drift wave turbulence, and play important roles for transport in plasma turbulence. Therefore, to study the generation and suppression of these structures is one of the hot topics in plasma physics, fusion reactors, astrophysical phenomena, and so on [1]. While zonal flows have been widely studied both theoretically and experimentally [2], there are only few experimental studies for streamers; only signatures are found in toroidal plasmas [3]. Owing to the low temperature property, linear plasmas are well used for basic study of plasma turbulence. 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 [4]. The mediator mode is the trigger for the streamer generation, and nonlinearly couples with the carrier drift waves to create the streamer structure.

In the previous studies, our group clarified the cross-sectional structures of the streamer, its mediator mode, and carrier drift waves [5]. Several Langmuir probes including the 64-channel poloidal probe array [6] and bi-phase analysis were used to observe the phase structures. The results were well compared with theoretical [7] and numerical [8] works. While the streamer structure and carrier drift waves were radially elongated, the mediator mode had a node in the radial direction. However, their axial structures have not been yet confirmed, although the structures have been treated with assuming the axial uniformity. Therefore, the axial structures, additionally to the cross-sectional structures, of the streamer, mediator mode, and carrier drift waves were analyzed in this study.

The 64-channel poloidal probe array and several single probes arranged in the axial direction were used for observing the axial structures. Bi-phase analysis was used for determining the phase structure of streamer. In addition, the envelopes of the streamer structure at different axial positions were derived from Hilbert transport and were compared with each other to confirm the results (Fig. 1). As a result, while the carrier drift waves, which form the streamer structure by nonlinear interaction, 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 [9]. The relationship of these axial mode numbers is well explained by the matching condition of the nonlinear interaction between the carrier drift waves and mediator.

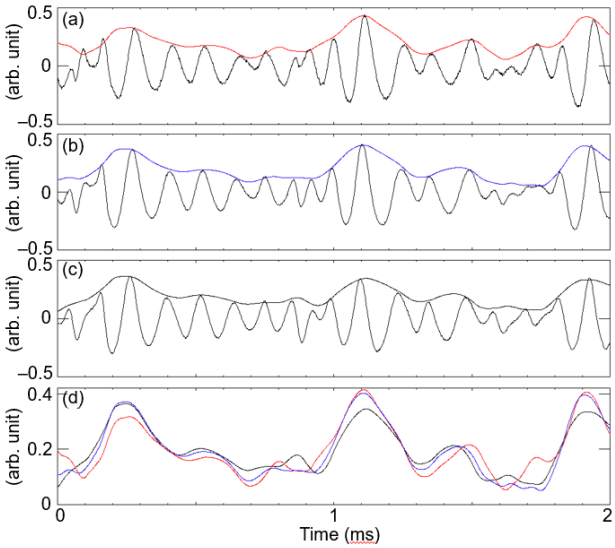

Figure 1. Time evolutions of the density fluctuation (components > 2.7 kHz) and their envelopes measured at the axial positions (a) 1.375 m, (b) 1.625 m, and (c) 1.885 m. Envelopes of (a)–(c) are over plotted in (d).

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