§16. Potential Turbulence in JIPP T-IIU Tokamak Plasmas Measured by a Heavy Ion Beam Probe

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The heavy ion beam probe (HIBP) is particularly suited for the local study of the turbulence of tokamak plasmas because of the potentiality for density and potential measurement. It is, however, difficult to measure by HIBP potential fluctuations due to the microintability in the tokamak plasmas, since the fluctuating potential is smaller than the acceleration voltage of a probing beam by many orders. Therefore, the measurement of the potential turbulence in the core region of the tokamak plasma by HIBP tends to have a low signal-to-noise ratio (SNR) and only a few results were published so far [1].To tackle these difficulties we enhanced the sensitivity of the measurement by increasing the beam current and by the employment of a multiple-detector system. By these improvements we are now able to obtain the wavenumber/frequency spectra $S(k,\omega)$ of the density and potential turbulence, and the wavenumber-resolved fluctuation-driven particle flux in the high temperature region of JIPP T-IIU tokamak plasma [2].

Figure 1 shows the contours of two-dimensional (wavenumber/frequency) spectra of the density $S_{n_e}(k,\omega) = \langle |n_e(k,\omega)|^2 \rangle$, (a), potential $S_{\Phi}(k,\omega) = \langle |\Phi(k,\omega)|^2 \rangle$, (b)), and the quantity proportional to the turbulent- driven particle flux, $\mathrm{real}[\langle n_e(k,\omega)\, E(k,\omega)\rangle]$, (c), at the position of about $r/a_p = 0.5$ and $\theta=0$ (weaker B_t field side). The particle flux <nv> driven by the turbulent electric field is proportional to <nE> through E/B particle drift. $S_{\Phi}(k,\omega)$ is noisy but similar to $S_{ne}(k,\omega)$. Fig. 1(c) and detailed analysis shows that the oscillations around 150 kHz mostly cause the turbulence-driven particle flux. This flux is outwards and its magnitude corresponds to the particle confinement time of about 5 ms under the assumption of the uniformity of the flux on the magnetic surface.

The instantaneus particle flux can also be calculated in addition to be the averaged particle flix. The ratio of the instantaneous flux to the average flux is so large (about 100) and the polarity of the instantaneous flux is always changing. This ratio of the quasi-steady flux may be understood, since the main density turbulence has the correlation time of a few microseconds, and the quasi-steady flux can be observed with the averaging time of a few hundred microseconds. We may call these signals as sporadic or intermittent behaviour.

Reference

[1] Forster, J. C., et al., Trans. Plasma Sci. **22** (1994) 359.
[2] HAMADA, Y., et al., Nucl. Fusion **36** (1996) 515 , 1047, **37** (1997) 999.

Figure 1. Contours of the two-dimensional (space/time) Fourie spectra of density and potential turbulence (a), (b). and <nE> proportional to the particle flux driven by the turbulence, (c). L_d = 2.5 cm.