§6. Intermittent Transport of Particle and Heat in Scrape-off Layer of Limiter and Divertor Configurations on CHS

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Electrostatic fluctuation associated with non-diffusive convective plasma transport like zonal flow and plasma blobs have been intensively investigated in the edge plasmas of several fusion devices[1,2], which could play a key role for cross-field plasma transport. The fluctuation property shows self-similarity[3-5]. The self-similarity parameter varies little from one device to another, suggesting the universality of self-similarity properties in edge of magnetically confined plasmas We report statistical analysis of the intermittent edge plasma fluctuation of ion saturation currents I_{sat} measured with a probe array in the CHS device.

In order to investigate characteristic timescales of the fluctuation of I_{sat}, we define

$$\delta I = I_{sat}(t) - I_{sat}(t - l),$$

where l is delayed time. When a time trace would obey a Poisson process having fully random process, the PDF of δI becomes a Gaussian profile for any l. The figure in the left hand side of Fig. 1 shows the PDFs of δI, by varying l from 4 μs to 1024 μs. As increasing l, the PDF is getting closer to a Gaussian distribution.

Skeweness of the δI's PDF is plotted as a function of l in the right hand side of Fig.1. For small l, the value of skewness is positive. At l is larger than lc =100 μs, the skewness becomes almost zero, indicating that the PDF is changed to a Gaussian profile. The time lc corresponds an integral correlation time scale of the fluctuation, and can be interpreted as an inertial-range timescale discussed in fluid dynamics.

The I_{sat} measured in the CHS device was also analyzed in terms of multifractal formalism revisited with wavelets. When $I(t)$ is the time evolution of ion saturation current, a trajectory in a q-dimensional space can be reconstructed with embedding method. Then, we can obtain a series of q-dimensional vectors $\vec{r}_i$, representing the phase portrait of the dynamical system:

$$\vec{r}_i = \{I[t_i], I[t_i+\tau], \ldots, I[t_i+(q-1)\tau]\} \quad i = 1,2,3,\ldots,m \tag{1}$$

where τ is appropriate delay time.
The multifractality can be described by following formula:

$$M(r) = \left\langle \left|\vec{r}_i - \vec{r}_j\right|^q \right\rangle \approx r^{\zeta(q)}, \tag{2}$$

$$\zeta(q) = qH - \lambda^2 q^2 \ . \tag{3}$$

λ^2 means multifractality parameter. When $\lambda^2 = 0$, the system is mono-fractal,

We can obtain $\zeta(q)$ and λ^2 is determined by Eq. (3). Apparently, both λ^2's are finite value, which means that the fluctuation in the CHS can be characterized by multifractality. Multifractality factor defined in multiplicative cascade model, could be relevant parameter to characterize the edge plasma turbulence. To find whether the parameters of multifractality observed in this analysis, have a more universal validity, it would be interesting to extend multifractal analysis to a broader set of turbulent data from edge plasmas.

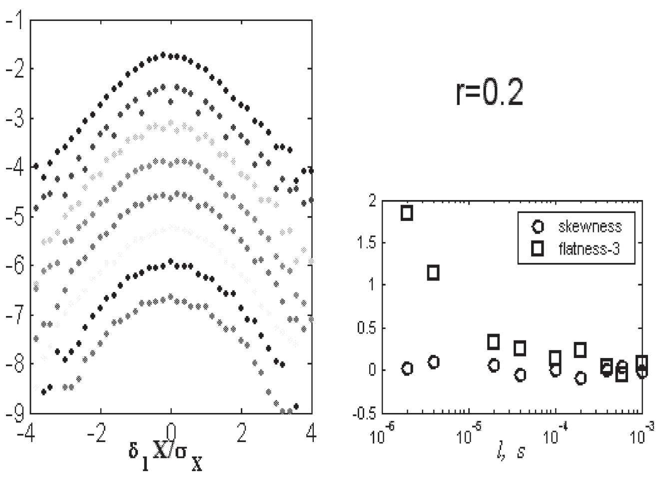

FIG. 1 (left) Log-linear plots of probability distribution function (PDF) for $\delta I = I_{sat}(t) - I_{sat}(t - l)$ as a parameter of delayed time l. (right) Skewness of δI's PDF as a function of l.

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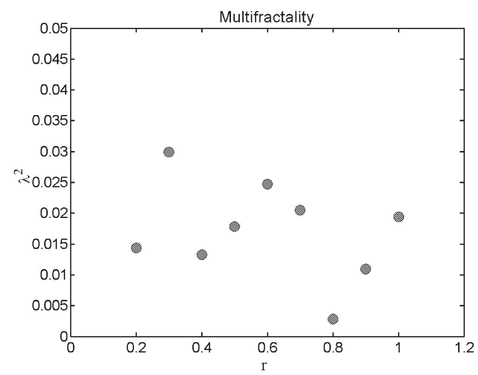

FIG. 2 Multifractality parameter as a function of normalized radial position.