Extended self-similarity of intermittent turbulence in edge magnetized plasmas

V.P. Budaev[1], N. Ohno[2], S.Takamura[3], S. Masuzaki[4]

[1]*Nuclear Fusion Institute, RRC Kurchatov Institute, 123182, Kurchatov Sq.1, Moscow, Russia*
[2]*Eco Topia Science Institute, Nagoya University, Nagoya 464-8603, Japan*
[3]*Department of Energy Engineering and Science, Graduate School of Engineering, Nagoya University, Nagoya 464-8603, Japan*
[4]*National Institute for Fusion Science, Oroshi 322-6, Toki, Gifu 509-5292, Japan*

A lot of experimental evidences have been observed now in fusion devices that the edge plasma turbulence is highly intermittent. Experimental investigations have highlighted slight deviations (due to strong intermittency) from Kolmogorov prediction of the scaling ($\zeta(q)=q/3$) of the velocity increments moments $S(q,l) \sim \langle|\upsilon(x+l)-\upsilon(x)|^q\rangle \sim l^{\zeta(q)}$, , within the inertial range $\eta \ll l \ll L$ at high Reynolds numbers, L is the integral scale of motion and η is the dissipation scale. This means that the second order moments such as Fourier power spectra do not completely describe the wavefield and hence the higher order moments must be investigated. The scaling properties in plasma turbulence should not be investigated as a function of l, the resolution scale, but rather as a function of the generalized scale $\xi(l,\eta,L,\ldots)$. It may be reminiscent critical phenomena in finite size systems with a scaling , which depends on the size of the system and the correlation function diverged at critical points. The scaling of higher order moments has been interpreted in terms of a multifractal processes. The multifractality is related to an underlying multiplicative cascading process. Scaling properties of the turbulence can be extended up to dissipative range (referred as extended self-similarity) even at moderate Reynolds number. In this work, Langmuir probe data from the T-10 and the Hybtok-II tokamaks, NAGDIS-II plasma device, the LHD and other data have been analyzed. To characterize the intermittency, higher order moments of the data at different scales are considered. Turbulent fluctuations in fusion plasmas at turbulent boundary layer demonstrate multifractal statistics, i.e. the scaling behaviour of absolute moments is described by a convex function $\zeta(q)$. Using wavelet based technique, we have computed the scaling exponent $\zeta(q)$. More robust criteria can be obtained by invoking the extended self-similarity (ESS) hypothesis, which states that the scaling of the type $S(q,l) \sim S(3,l)^{\zeta(q)/\zeta(3)}$ should hold for long ranges of delays $l \geq 5\eta$. It reflects generalized scale invariance of developed turbulence. The ESS is observed for: all data that were analyzed.