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Intermittent fluctuations in the Alcator C-Mod scrape-off layer[1]

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Cross-field transport of particles and heat in the scrape-off layer (SOL) of magnetically confined plasmas is dominated by radial motion of blob-like structures. The average radial particle and heat fluxes caused by such filaments depend on their amplitude distribution and frequency of occurrence. The statistical properties of plasma fluctuations in the SOL are thus crucial for development of a first-principles description of transport and main-chamber interactions. Plasma fluctuations in the Alcator C-Mod SOL have been investigated by analysis of long data time series from Langmuir probe measurements and gas puff imaging at the outboard mid-plane region in Ohmically heated discharges. This reveals frequent occurrence of large amplitude bursts with a fast rise and slow decay. The waiting times between burst events and the burst amplitudes are both found to be exponentially distributed. This implies that large amplitude bursts occur randomly at a constant average rate in the far SOL and are uncorrelated. Based on these properties, a novel stochastic model for the intermittent SOL plasma fluctuations has been constructed. Its input parameters are the burst duration and the waiting time and amplitude distributions. The role of these quantities for large SOL plasma densities and fluctuation levels is elucidated. As a direct consequence of this simple model, the mean plasma density is shown to be proportional to the average burst amplitude and the ratio of the burst duration and average waiting time. An additional consequence is that there must be a parabolic relation between the skewness and kurtosis moments. For exponentially distributed burst waiting times and amplitudes, the stochastic model reveals that the probability density function (PDF) for the plasma fluctuations is a Gamma distribution. This distribution can be rewritten solely in terms of the mean and rms values of the plasma density. Accordingly, it does not involve any fit parameters when compared to experimental measurements. The PDF changes from a normal distribution for small relative fluctuation levels, typical for the near SOL, to an exponential distribution for relative fluctuations of order unity, typical for the far SOL. These predictions of the stochastic model are shown to compare well with the experimental measurements.

[1]Work in collaboration with the Alcator C-Mod Group