Intermittent fluctuations in the scrape-off layer of tokamak plasmas

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Fluctuations in the far scrape-off layer (SOL) of magnetically confined plasmas are universally found to have large amplitudes and to be strongly intermittent. This is attributed to radially outwards motion of blob-like plasma filaments, which contain excess particles and heat compared to the ambient plasma. As a result, the probability density function (PDF) is strongly skewed and flattened, with an exponential tail towards large values.

Recently, the statistical properties of the intermittent fluctuations have been revealed by exceptionally long data time series from numerous tokamak experiments. The large fluctuation level in the far-SOL may significantly enhance plasma interactions with main chamber walls in the next generation high duty cycle fusion experiments. In the vicinity of the last closed magnetic flux surface, the fluctuations are moderate and nearly normally distributed.

In this presentation, a stochastic model is presented, describing the fluctuations as a super-position of uncorrelated exponential pulses. The underlying assumptions as well as the predictions of this model are in excellent agreement with experimental measurements. When pulses overlap significantly, the resulting signal resembles random noise with normally distributed fluctuation amplitudes. In the case of weak pulse overlap, the signal is strongly intermittent and dominated by large-amplitude bursts.

The frequency power spectrum is demonstrated to be independent of the degree of pulse overlap. The spectrum is determined solely by the shape of the underlying pulses. The predictions of this model describe the variety of auto-correlation functions and power spectral densities reported from experimental measurements in the scrape-off layer of magnetically confined plasmas for all radial positions in the SOL.

Implications of such fluctuations for the average radial SOL profile as well as the rate at which the signal crosses a given threshold level are also discussed.