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Universality of intermittent fluctuations in the Alcator C-Mod scrape-off layer

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A first-principles understanding of scrape-off layer (SOL) transport is needed in order to anticipate plasma-wall interaction conditions in a reactor-scale device. A stochastic model that describes SOL fluctuations and transport as a super-position of uncorrelated pulses is found to accurately reproduce many of the features seen in the experiments. We report on gas puff imaging (GPI) and mirror Langmuir probe (MLP) measurements on Alcator C-Mod compared to a stochastic model that describes electron density, temperature and electric potential fluctuations as arising from a super-position of uncorrelated pulses attributed to blob-like filaments propagating radially outwards. The statistical properties have been unambiguously established by measurement time series of approximately one second duration under stationary plasma conditions. The GPI fluctuation probability density function is found to change from nearly Gaussian at the separatrix to a strongly skewed and flattened Gamma distribution in the far-SOL. Despite this, the frequency power spectrum is identical for all radial positions in the SOL and for a large range of line-averaged densities. This suggests that both the near- and the far-SOL fluctuations are due to uncorrelated exponential pulses but with much more pulse overlap close to the separatrix. These observations run contrary to the ideas that the shape of the power spectrum arises from the interaction of turbulent eddies or self-similar processes. The fluctuation statistics are shown to be the same in both Ohmic plasmas and high confinement modes. Electron density and temperature fluctuations measured by the MLP system are strongly intermittent with large relative fluctuation levels. The fluctuation-induced radial heat flux has significant contributions from both the convective and conductive components. The model parameters are estimated from the data time series and their variation with the line-averaged density is elucidated.

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