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Extremes and bursts in complex multi-scale plasmas

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Quantifying the spectrum of sizes and durations of large and/or long-lived fluctuations in complex, multi-scale, space plasmas is a topic of both theoretical and practical importance. The predictions of inherently multi-scale physical theories such as MHD turbulence have given one direct stimulus for its investigation. There are also space weather implications to an improved ability to assess the likelihood of an extreme fluctuation of a given size. Our intuition as scientists tends to be formed on the familiar Gaussian "normal" distribution, which has a very low likelihood of extreme fluctuations. Perhaps surprisingly, there is both theoretical and observational evidence that favours non-Gaussian, heavier-tailed, probability distributions for some space physics datasets. Additionally there is evidence for the existence of long-ranged memory between the values of fluctuations.

In this talk I will show how such properties can be captured in a preliminary way by a self-similar, fractal model. I will show how such a fractal model can be used to make predictions for experimental accessible quantities like the size and duration of a buurst (a sequence of values that exceed a given threshold), or the survival probability of a burst [c.f. preliminary results in Watkins et al, PRE, 2009].

In real-world time series scaling behaviour need not be "mild" enough to be captured by a single self-similarity exponent H, but might instead require a "wild" multifractal spectrum of scaling exponents [e.g. Rypdal and Rypdal, JGR, 2011; Moloney and Davidsen, JGR, 2011] to give a complete description. I will discuss preliminary work on extending the burst approach into the multifractal domain [see also Watkins et al, chapter in press for AGU Chapman Conference on Complexity and Extreme Events in the Geosciences, Hyderabad].