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Application of Rank-Ordered Multifractal Analyses (ROMA) to intermittent magnetic fluctuations in the Earth's magnetospheric cusp and in the high-speed solar wind.

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The Rank-Ordered Multifractal Analysis (ROMA) developed by Chang & Wu (2008) is a powerful technique that provides a physically meaningful and a quantitatively accurate description of intermittency in space plasmas. The ROMA method offers a natural connection between the one-parameter monofractal scaling idea and the multifractal phenomenon of intermittency. The key-element in ROMA is to find s(Y), the spectrum of the scaling exponents, and Ps(Y), the scaled Probability Distribution Function (PDFs), from the raw PDFs of the variable X at various scales τ, P(δX,τ), with the following scaling:

P(δX,τ)$\tau^{s(Y)}$=Ps(Y) with Y= δX/$\tau^{s(Y)}$

The first (direct) method is to use range-limited structure functions in a sufficiently small range of the scaled variable Y and search for the value of monofroctal exponent s(Y). A drawback of this approach is that the range of Y must be large enough to ensure that the statistics is meaningful. As a consequence, some cross-over behavior between fluctuations with different monofractal exponents can lead to an ambiguity with several solutions s(Y) for some ranges of Y. To overcome this ambiguity, Wu & Chang (2011) have recently suggested a second approach where a value of the parameter s is assumed and the corresponding value of Y ensuring a collapse of the raw PDFs is searched for. The advantage of this latter approach is that s(Y) and Ps(Y) can be obtained for single values of Y and solves the previous ambiguity.

We apply the direct ROMA method to two sets of magnetic field data: (a) intermittent magnetic fluctuations detected by the four Cluster spacecraft in the Earth's magnetospheric cusps and (b) magnetic field data from Ulysses in the high-speed solar wind at high heliographic latitudes. The ROMA spectrum of both data sets reveals a cross-over behavior for some ranges of Y. Therefore we apply the second method to consistently choose the correct solution s(Y).

T. Chang and C.C. Wu, Rank-Ordered Multifractal Spectrum for Intermittent Fluctuations, Phys. Rev. E77, 045401(R), 2008

CC. Wu and T. Chang, Application of rank-ordered multifractal analysis (ROMA) to intermittent fluctuations in 3D turbulent flows, 2D MHD simulation and solar wind data, to be submitted to the special issue "Multifractals and Intermittent Turbulence in the Solar-Terrestrial System", Nonlinear Processes in Geophysics, 2011.