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A Renormalization-Group Interpretation of the Connection between Criticality and Multifractals

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Turbulent fluctuations in space plasmas beget phenomena of dynamic complexity. It is known that dynamic renormalization group (DRG) may be employed to understand the concept of forced and/or self-organized criticality (FSOC), which seems to describe certain scaling features of space plasma turbulence. But, it may be argued that dynamic complexity is not just a phenomenon of criticality. It is therefore of interest to inquire if DRG may be employed to study complexity phenomena that are distinctly more complicated than dynamic criticality. Power law scaling generally comes about when the DRG trajectory is attracted to the vicinity of a fixed point in the phase space of the relevant dynamic plasma parameters. What happens if the trajectory lies within a domain influenced by more than one single fixed point or more generally if the transformation underlying the DRG is fully nonlinear? The global invariants of the group under such situations (if they exist) are generally not power laws. Nevertheless, as we shall argue, it may still be possible to talk about local invariants that are power laws with the nonlinearity of transformation prescribing a specific phenomenon as crossovers. It is with such concept in mind that we may provide a connection between the properties of dynamic criticality and multifractals from the point of view of DRG (T. Chang, Chapter VII, “An Introduction to Space Plasma Complexity”, Cambridge University Press, 2014).
An example in terms of the concepts of finite-size scaling (FSS) and rank-ordered multifractal analysis (ROMA) of a toy model shall be provided.

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