Universality in one-dimensional models displaying self-organized criticality

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Abstract

Throughout the years, the concept of self-organized criticality has established itself as one of the most promising explanations of the occurrence of self-similar fractal structures and complexity in nature. In this thesis, we will first give a short reminder of criticality in second-order phase transitions, after which the concept of self-organized criticality is introduced and a brief overview of self-organized criticality in one dimension is given. We then proceed by analysing various one-dimensional, slowly driven sandpile models, all of which are governed by different stochastic toppling rules. Under these dynamical rules, which are defined as either being local or nonlocal, and limited or unlimited, the models quickly evolve towards a steady state which is characterized by the occurrence of avalanches of varying size. These avalanches do not necessarily have a characteristic scale, and possibly display power-law behaviour in the frequency of their occurrence. Indeed, we find that three of our models exhibit critical behaviour in the form of distributions of avalanches following a power-law, all of which are characterized by different scaling exponents. Furthermore, we find certain critical properties intrinsic to the steady state of both the local-, and nonlocal-unlimited model. Lastly, we investigate whether the critical behaviour emerging through the dynamics of our models is universal between a class of different models. This is done by introducing a flow-parameter, with which we flow from one model to the other. We find that the critical behaviour emerging in the nonlocal-limited model is indeed universal between a class of different models, where the universality class to which these models belong can be characterized by a set of four critical exponents.