

Emergence of modulated cycles in critical dynamics

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In complex systems, the existence of critical fluctuations, either near a nonequilibrium phase transition or a self-organized criticality attractor in dynamical systems driven out of equilibrium, indicate the states where the emergence of new features at a larger scale can occur. These stationary states are characterized by long-range spatiotemporal correlations and collective avalanching dynamics in response to endogenous or external forces. A closer inspection of state variables reveals a tendency towards cyclical trends in their temporal fluctuations, which can be related to the gradual accumulation and release of energy through a cascade of avalanches of different sizes, for example, in sandpile automata. Here, we investigate such cycles in two types of critical states, particularly near a jamming transition in traffic on complex networks [1] and in self-organized critical states observed in the empirical data of emotional messages in online social networks [2]. Even though their origins differ, our results show that the emergent cycles in both cases are irregular and modulated by the collective critical dynamics; they attain higher harmonics that can be appropriately described by multifractal analysis. The observed variations in the corresponding singularity spectra correlate with the nature of collective dynamics.

References

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- [2] B. Tadić, M. Mitrović Dankulov, R. Melnik, Cycles and self-organized criticality in social dynamics, in review (2023).