A general description of phase transitions under entropy production trademarks.

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Phase transitions in nonequilibrium systems can be typified in a similar way to equilibrium systems, for instance, by the use of the order parameter and its associated momentum. However, this characterization hides the irreversible character of the dynamics, as well as its influence on the phase transition properties. Some works have suggested that entropy production may be an important amount for filling this gap, since it vanishes identically for equilibrium systems and is strictly positive for nonequilibrium systems. Based on general arguments, the characterization of phase transitions through the entropy production is presented in this work [1]. Our study considers discontinuous phase transitions, both in regular and complex networks, through the mean field approach and beyond the mean field. Continuous phase transitions have also been considered.

On the other hand, we know that the order parameter and variance obey scale relationships, characterized by the critical exponents β and γ, respectively. In our work, we propose a similar relationship for the entropy production, whose its first derivative with respect to the order parameter is associated to α critical exponent. We verify that the scale relation $\alpha + 2\beta + \gamma = 2$ is satisfied beyond the mean field.

Our phenomenological theory reveals that a phase transition, whether critical ou discontinuous can be characterized by a specific and well defined entropy production trademark. We exemplify our predictions in the simpler non-equilibrium model that presents a order-disorder phase transition and spontaneous symmetry breaking: the majority vote model. Several numerical simulations were made using the Monte Carlo method, both for different network typologies and for different system sizes. We believe that our work paves the way to a systematic description and classification of nonequilibrium phase transitions through a key indicator of system irreversibility.

Bibliography

[1] C. E. Fernández Noa, Pedro E. Harunari, M. J. de Oliveira, and C. E. Fiore, Phys. Rev. E **100**, 012104 (2019).