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Physics of Inference[1]

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Jayness maximum entropy method provides a family of principled models that allow the prediction of a systems properties as constrained by empirical data (observables). However, their use is often hindered by the degeneracy problem characterized by spontaneous symmetry breaking, where predictions fail. Here we show that degeneracy appears when the corresponding density of states function is not log-concave, which is typically the consequence of nonlinear relationships between the constraining observables. We illustrate this phenomenon on several examples, including from complex networks, combinatorics and classical spin systems (e.g., Blume-Emery-Griffiths lattice-spin models). Exploiting these nonlinear relationships we then propose a solution to the degeneracy problem for a large class of systems via transformations that render the density of states function log-concave. The effectiveness of the method is demonstrated on real-world network data. Finally, we discuss the implications of these findings on the relationship between the geometrical properties of the density of states function and phase transitions in spin systems.

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