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Peer Review

Review of: "The Information Theory of Self-Organization Phenomena in Thermal Systems"

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The manuscript entitled **"The Information Theory of Self-Organization Phenomena in Thermal Systems"** by Hongzheng Liu et al. presents three main correlated axes: Brownian motion, Information Theory, and Thermodynamics through the SPBM model. The local randomness and global distributions have been explored by the authors. The paper is well theoretically tailored, but there is a huge lack of empirical validation. However, that would pave the way for experimental realization.

- The part on the one-dimensional random walk deals with how prior information and constraints are related to each other. For better representation, I suggest: Keep the way you write variables and conditions robust; for example, always write $X(t \pm \Delta x)$ the same way. Besides, explain what each symbol (like Δx, Δt, and X) means the first time you use them, making them more accessible to readers.
- The manuscript shows that prior information and constraints are equivalent using the concepts of necessity and sufficiency. For clarity, I suggested separating the necessity and sufficiency explanations into different sections and clearly stating any assumptions.
- The local dynamics are easily described by the equivalence theorem. However, a main question is raised: How does this equivalence affect simulations or the practical real world?

The authors focus on the local and global behaviors that interact in the SPBM model and present how they influence each other. This interaction leads to strong, random processes and briefly connects entropy with mutual information. I would like to point out that while the analysis of Brownian motion is prominent, it could be improved by explaining how the 'adjacent displacement principle' generates a localized and uneven probability distribution over time. I would like to highlight that the section on

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entropy and its changes needs to be clearer in demonstrating the connection between local entropy and global mutual information.

The manuscript needs to be refined more, for example, by making the mathematical part clearer. Present a short summary for each part that would help to be widely reached by readers. To make the study more coherent, I suggest that the authors perform numerical computations and analyses to spotlight the experimental realization. Besides, delving into the realm of stochastic modeling would be a prominent factor for technological applications. By addressing all the previous comments, the paper would be an increment to the Qieos journal.

Declarations

Potential competing interests: No potential competing interests to declare.