Review of: "Measuring Complexity using Information"

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Potential competing interests: No potential competing interests to declare.

I have never heard about the *Qeios* journal before, but I received an email asking to review the paper by Dr. Klaus Jaffe, “Measuring Complexity using Information.” I would like to thank the author for the opportunity to read his paper.

Complexity is quite an elusive property that is not equivalent to information, entropy, or symmetry. A completely disordered (random) system has zero complexity. However, at the opposite end, a completely ordered pattern or system also possesses zero complexity due to being predictable [1]. Complexity can be treated from the information-theoretical perspective, or it can be considered from the perspective of dynamical systems.

Among quantitative measures of complexity are the Kolmogorov algorithmic complexity, "Martin-Loef" randomness, and other approaches which may be based on algorithms needed to create the system, on the system's dynamics, or on a measure of the system's orderliness such as the Shannon entropy.

Speaking of the paper by Dr. Jaffe, it is a nice attempt to write a review of various ways to measure complexity using information. Several points still may be improved.

- ***Taxonomic Complexity***: *The simplest way of measuring complexity is by counting the parts or components of a system. The examples given in the table include the Standard Model of particle physics. This model is a descriptor of the complexity of the quantum world, enumerating all known subatomic particles. These 16+ particles, explaining 3 fundamental forces of physics, allow us to express quantitatively the complexity of the results of interactions between one or more of these subatomic particles.*"

I do not think that this statement is accurate. It is the Lagrangian of the interaction between the particles that explains the fundamental forces, and not just listing or enumerating these particles. Also, the Standard Model (SM) has nothing to do with the complexity of the quantum world. The SM and Quantum Mechanics (QM) are two different theories.

- “*Useful Information* ***Φ*** *as the one producing Free Energy* ***F*** *and thus work. Free Energy and Work are thermodynamic concepts so that* ***F = E – S*** *, where* ***E*** *is total energy and* ***S*** *is the thermodynamic entropy due to energetic processes.”*

The unit of energy is Joules (J), whereas the units of entropy are Joules divided by degrees Kelvin (J/K). Therefore, one cannot subtract thermodynamic entropy S [J/K] from the total energy E [J].

- To make the discussion more understandable, it is recommended to include examples (with particular values of parameters and variables) of how the formulas can be used.

- Given that the relation between thermodynamics and information is discussed, it may be beneficial to mention the Landauer principle[2][3].
- A relation to the continuous measures of symmetry[4] may be discussed.
- For the Network Science part of the article, I would strongly recommend using an example with values. For instance, the Table 1. below, I copied from our paper [5].

Table 1. Number of neurons, synapses, and corresponding information content of some organisms (based on Ref.[5])

Organism	Neurons, N	Synapses, k	Bits Per Neuron, $k \cdot \log_2(N)$	Bits Per Connectome, $kN \cdot \log_2(N)$	Transcription Factors, T	Transcription Factors Information, $N \cdot T$
C. elegans	302	6398	3818	$1.3 \cdot 10^6$	934	$2.8 \cdot 10^5$
Drosophila fruit fly	10^5	10^7	$2.3 \cdot 10^6$	$2.3 \cdot 10^{11}$	627	$6.3 \cdot 10^7$
Mouse	$7.1 \cdot 10^6$	$1.3 \cdot 10^{11}$	$2.6 \cdot 10^8$	$1.9 \cdot 10^{15}$	1457	$1.0 \cdot 10^{10}$
Cat	$7.6 \cdot 10^8$	$6.1 \cdot 10^{12}$	$3.2 \cdot 10^{10}$	$2.5 \cdot 10^{19}$	887	$6.7 \cdot 10^{11}$
Human	$8.1 \cdot 10^9$	$1.6 \cdot 10^{14}$	$3.8 \cdot 10^{11}$	$3.1 \cdot 10^{21}$	1391	$1.1 \cdot 10^{13}$

- I would suggest also mentioning some applications. Many examples of complexity are found in the study of clusters. Thus, the applicability of the mathematical *ADE*-classification or the so-called simply laced Dynkin diagrams to levitating droplet clusters (Fig 1) has been suggested [6].

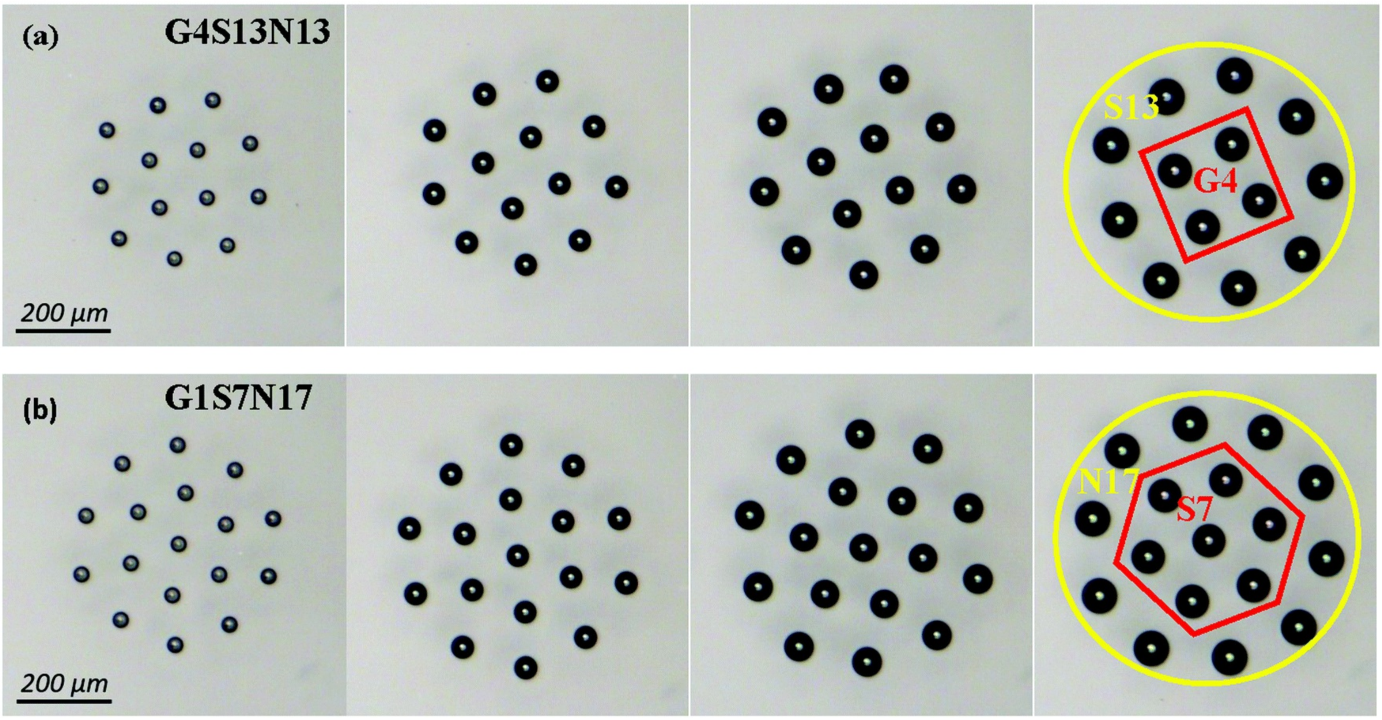

Fig. 1. Symmetry of small clusters of levitating water droplets[6].

Again, thanks to Dr. Jaffe for his inspiring article.

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