IPI Letters

ISSN 2976 - 730X
IPI Letters 2025,Vol 3 (3):N1-N5
https://doi.org/10.59973/ipil.212

Received: 2025-05-28
Accepted: 2025-05-29
Published: 2025-05-30

News and Views

Response to Sabine Hossenfelder's Commentary on Vopson's Paper:

Is gravity evidence of a computational universe? AIP Advances 15, 045035 (2025)
`https://doi.org/10.1063/5.0264945`

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Abstract - On April 25, 2025, Melvin M. Vopson published a theoretical study proposing a novel derivation of Newtonian gravity [1] from information-theoretic principles, through the lens of the second law of infodynamics [2,3]. Shortly thereafter, on May 28, Sabine Hossenfelder released a video commentary critiquing the paper [4]. For maximum transparency, we extracted the full transcript of her video and we included it for our readers in the Appendix of this article. In her video, Sabine Hossenfelder criticizes Vopson's article, suggesting that it contains mathematical errors, contradicts established principles like entropy, and misinterprets the concept of information. She concludes that the paper "*makes no sense at all*" and "*shouldn't have been published*." While constructive critique is essential for scientific progress, we must hold it to the same standards of specificity and rigor that we expect of published papers. Hossenfelder's video provides no explicit mathematical rebuttal, specific citations, or reproducible counter-examples beyond verbal critiques and high-level subjective objections. In this report, we address the key issues she raises and offer detailed responses grounded in the content and logic of the original paper.

Keywords - Infodynamics; Entropic Gravity; Second law of infodynamics.

1 Claims of mathematical error

Dr. Hossenfelder claims:

"This paper has multiple mathematical problems..."

Unfortunately, she does not identify any specific equations or derivations as erroneous. Vopson's reconstruction of Newtonian gravity is grounded in Shannon entropy, the second law of infodynamics, and the Mass-Energy-Information (M/E/I) equivalence principle. In particular, Newton's law of gravity, Equation (15) in the paper, is derived rigorously from an entropic framework based on information compression. If there is disagreement with this approach, it should be supported by direct engagement with the mathematics, not general assertions.

Moreover, Hossenfelder references ”bit swapping” as a potential flaw. While entropy under Shannon’s theory is symmetric under relabeling (e.g., exchanging 1s and 0s), Vopson’s model is spatially grounded - the spatial distribution of mass is tied to entropy values.
Vopson explicitly shows entropy differences in distributions of 0s and 1s in Eq. (1) and the resulting ΔS from merging particles. Swapping the bits is clearly possible, but once a data encoding scheme and semantics are fixed, bit values acquire physical meaning. To illustrate this, Table 1 shows how swapping bits in a binary-encoded string corrupts the original message:

Message	Binary ASCII encoding	Swap 1s and 0s	New Message ISO/IEC 8859-1 (Latin-1) encoding
S	01010011	10101100	¬
A	01000001	10111110	þ
B	01000010	10111101	ý
I	01001001	10110110	¶
N	01001110	10110001	±
E	01000101	10111010	º

Table 1: Binary encoding of a message and example of corruption when swapping bits in a binary-encoded string message.

The semantic meaning of the message is lost once the bit encoding protocol is altered, showing that entropy is not just a statistical measure but context-dependent.

2 Entropy argument mischaracterization

Hossenfelder argues:

> *”The entropy is maximal if there are approximately the same numbers of zero and ones, and in this case the information is minimal...therefore matter should spread out.”*

This interpretation conflates thermodynamic entropy with Shannon information entropy. In Shannon theory, maximum entropy corresponds to maximum uncertainty, i.e., maximum average information per symbol, not minimum information.

Here is an example of a sequence of 10 characters, 0101010101, which has maximum Shannon information entropy of 1 bit per character and a total information content of 10 bits.
Another example of a sequence of 10 characters, 0000000000, has minimum Shannon information entropy of 0 bits per character and a total information entropy content of 0 bits.

Vopson interprets information entropy as a measure of computational complexity: the number of bits required to encode the state of a system. Clustering matter reduces the number of ”1” states and therefore reduces entropy under his definition. This is analogous to data compression. The notion of minimizing entropy here is about reducing the complexity of storing and processing data in a simulated universe, not maximizing randomness.

Furthermore, it is unclear what she means by “*matter should spread out*”. We assume that Hossenfelder thinks that an alternative process resulting in reduction of information entropy is when matter spreads out. This is because matter spreading out would create more 0s states, while maintaining the 1s constant. This is again incorrect. Creating a larger and larger imbalance of 1s and 0s in the system, by moving matter objects away from each other, or by expanding the space, would indeed result in a slow asymptotic decrease of the information entropy. However, this would never reach the reduction / optimization obtained by the proposed process of clustering together via an entropic attraction. Moreover, Hossenfelder's assertion that matter dispersing would lead to minimizing entropy is not supported by energy-based arguments, i.e. the system would consume more energy in dispersing than clustering, while achieving a less favorable outcome in terms of information compression in a discretized space.

3 Dismissal of Vopson's extension of Verlinde's work

Hossenfelder states:

"Verlinde's idea made sense, this one doesn't."

This simplification overlooks Vopson's careful acknowledgment of his theory as an extension of Verlinde's work [5] (see sec. 5 of the paper). Whereas Verlinde considers gravity as an entropic force increasing entropy on a holographic screen, Vopson introduces a framework in which entropy decreases in information space, following a new law of information dynamics. Both are valid within their assumptions, but Vopson's formulation adds a novel computational perspective. Importantly, Vopson does not refute Verlinde's model, but proposes a parallel mechanism rooted in discrete information theory, computational mechanics, and infodynamics. This is consistent with contemporary debates on gravitational entropy and holographic data minimization.

4 The Simulation Argument

The opening remark of Hossenfelder's video:

"Wouldn't bad programming explain a lot?"

is clearly satirical and frames the entire discussion in a dismissive tone.
Vopson is not arguing for bad programming but proposing that known physical laws (like gravity) may arise naturally in a simulation / computational universe governed by information theory principles. This is a legitimate hypothesis, similar to how the holographic principle or digital physics are discussed in foundational physics. It is exactly the same as the principle behind Wolfram's *cellular automata* concept [6], which is well known to Hossenfelder.
Moreover, Vopson explicitly acknowledges the speculative nature of the paper, including in the title itself, which poses a question rather than a claim. He also states in the conclusion:

"Whether the universe is indeed a computational construct remains an open question... Future research should focus on refining this framework."

5 Conclusion

Hossenfelder's commentary appears to be more opinionated than analytical. It frames the work as pseudoscience without a fair, specific, or technical rebuttal. Her critique is largely rhetorical and does not offer constructive or reproducible scientific counterarguments. In contrast, Vopson's paper builds on a well-defined set of assumptions, leverages established principles in information theory, and presents a novel extension of entropic gravity models. Vopson's work may be speculative, but it is methodically derived and contributes to the growing discourse on information-based physics. Blanket statements of mathematical invalidity without citation or analysis do not advance the conversation. Vopson acknowledges that the paper has some weaknesses and a meaningful critique would be justified in relation to the use of the Mass-Energy-Information equivalence principle [7], which has no empirical validation yet. He also acknowledges that:

"Future research should focus on refining this framework, exploring its applicability in relativistic and quantum gravitational contexts, and investigating possible experimental validations."

In the spirit of academic dialogue, critiques of theoretical frameworks should aim to engage with equations, logic, and assumptions rather than broad subjective generalizations.

Appendix: Full transcript of Hossenfelder's video commentary

`https://youtu.be/ArUTSOZcn0E`

"Imagine we live inside a computer simulation. Wouldn't bad programming explain a lot? This "simulation hypothesis" has been discussed in physics and philosophy for a few decades and it's annoyingly hard to get rid of. It's not entirely untestable either. You'd expect clues hidden in the way nature works, because only some laws of nature can be run as computer simulations. In a recent paper, a physicist has now claimed that one such clue is gravity. Yes, gravity might be a computer simulation. Really? I've had a look.

In the new paper, the author, Melvin Vopson, argues that gravity can be explained by the idea that the universe is built up of discrete units, like a computer, and that information distributed over these units decreases. That is the opposite of the second law of thermodynamics, which says that entropy can at best stay constant, but normally it increases. The author calls his idea that information decreases, the second law of infodynamics. He suggests that quote, "gravitational attraction manifests as a requirement to reduce the information entropy of matter objects in space." In other words, objects fall toward each other because that's what would happen in a system that's trying to minimize the complexity of the information it has to store.

He goes on to derive Newton's law of gravity for a point mass. Newton's law is, of course, strictly speaking wrong, in that we know gravity needs general relativity, but then again Newtonian gravity is a good approximation in many cases, so one could see this derivation as a start.

The idea seems closely related to Eric Verlinde's 2011 idea that gravity is an entropic force. That is, gravity is just a consequence of the increase of entropy. Verlinde too only looked at Newtonian gravity. When Verlinde's paper came out, I spent quite some time on trying to make sense of it, and eventually concluded that it's mathematically correct. You can reformulate gravity so that it resembles the statistical description of an ensemble of something with entropy. However, it doesn't tell you what the microscopic underlying thing is. Verlinde seems to have had strings in mind.

Vopson says he knows how the underlying microscopic theory looks like, all you have to do is to assume that, well, the universe is a computer, basically, Space is made up of discrete chunks like pixels and everything below the scale of the pixels can no longer be resolved. So, in his idea, if you compress things, information decreases.

He explains the basic idea as follows. Imagine space as made of discrete Planck-sized cells, each capable of storing a single bit: either "0" for empty or "1" for occupied by matter.

He now distributes these particles across space and uses his equation to calculate what he calls the information entropy. He claims that this information entropy is smaller the fewer "1" bits there are. So assuming that information entropy decreases, therefore, explains why the bits, which are the matter clump. That sounds reasonable at first, but think about it somewhat more and it makes no sense at all.

For one thing, you should get the same entropy or information if you swap out the ones and zeros so you could take that to also argue that matter wants to spread out. Neither of these is correct. Because we know how to calculate the entropy and information for the distribution of bits. And it's simply not how the author claims. The entropy is maximal if there are approximately the same numbers of zero and ones, and in this case the information is minimal. This is because in this case there is the largest number of possible microstates.

Thus, if you would postulate that information decreases you'd expect matter to spread out, up to some point. Which is simply not what we see. This incidentally is totally unsurprising, because gravity indeed gives the appearance of decreasing entropy. The way that physicists normally resolve this is by assigning entropy to gravity itself. That is, if matter clusters, that decreases the entropy of the matter and increases information, but it increases the entropy of gravity, so thermodynamics checks out. This paper has multiple mathematical problems and I think it shouldn't have been published. That said, let's not throw out the baby with the bathwater. Just because this particular idea for how to get gravity as an entropic force doesn't work doesn't mean it can't work. But I am afraid it means that we can't blame a programmer that the paper was published. Thanks for watching, see you tomorrow."

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