# Review of: "On the statistical arrow of time"

Arto Annila[1]

1 University of Helsinki

Potential competing interests: No potential competing interests to declare.

I value the paper for questioning the commonly held belief among physicists that the flow of time relates to the increase of disorder, often but erroneously equated with entropy. Clearly, disorder, just like order, is not the cause but a consequence of attaining thermodynamic balance. Moreover, I find the subjectivity of entropy a correct conclusion. Clearly, a system gains balance with its surroundings, while another with its surroundings.

Indeed, as the Author remarks, the correct comprehension requires revisiting the foundations of statistical mechanics, the many-body theory underlying thermodynamics. The Author correctly reasons that only a system gaining energy from or losing energy to its surroundings evolves from one state to another, while a closed or isolated system may only revolve in phase space. Since entropy is merely a logarithm of a probability distribution multiplied by the Boltzmann constant, all inferences depend on probability.

The Author associates probability with information, while I derive probability from the atomistic axiom and arrive at the conclusion that the flow of time is the flow of quanta. A light quantum, for example, carries energy on its period of time. So, time, just like energy, is an attribute of quantum (Annila A. The matter of time. Entropy 2021 23, 943. doi: 10.3390/e23080943).

While one may question the Author's conclusion that the statistical arrow of time owes its existence to the ignorance of the observer, the Author provides balanced arguments and self-criticism. Thus, I believe many readers will welcome the Author’s objection of the indoctrinated belief that the arrow of time would relate to the increasing disorder. Also, the Author's insight into the subjective nature of thermodynamics is worth noting as it is in line with time being a relativistic concept. Clocks in different places run at different rates.