Review of: "On the Statistical Arrow of Time"

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I read this article with genuine interest and I must say that, apart from a small correction in my opinion necessary, which I will discuss shortly, it seems to me to be well argued and well written. However, I disagree conceptually with the author's views, and with the conclusions he draws from his reasoning.

Let us first consider the small correction. In the Introduction it is stated that: "When the gas has spread out evenly in the room, the room is in thermal equilibrium with the gas molecules. Thus, it seems to be the case that systems, which are left to themselves, tend to evolve in time in such a way that they reach thermal equilibrium. From the statistical mechanical point of view, thermal equilibrium happens when all possible microstates are equally probable." Actually, the assumption underlying the definition of entropy represented by Equation (23) is that all microstates have the same prior probability. This hypothesis, called the "molecular chaos", is different from the state of thermal equilibrium. It is possible to realize this by considering the simple case of a gas in equilibrium at a certain temperature, subjected to the action of a homogeneous and constant gravitational field (so-called "barometric" equilibrium). The gas is in thermal equilibrium, because a homogeneous temperature is defined over the entire column of gas. However, the condition of molecular chaos is not respected because different positions along the column correspond to different a priori probabilities of finding molecules, given that the acceleration of gravity pushes them downwards. So the system is not in thermodynamic equilibrium, although it is in thermal equilibrium. Only sufficiently small cells at a specific height can be considered in thermodynamic equilibrium. Only for each single cell can therefore be defined an entropy conforming to Equation (23). In other words, entropy is a function of height and there is no single value of entropy for the entire gas.

For the same reason, it is wrong to understand the second law in the sense that, starting from a given initial state arbitrarily chosen, the system evolves towards the condition of thermodynamic equilibrium. If we consider the Sun-Earth pair as an isolated system, the Earth's atmosphere evolves towards a barometric equilibrium and not towards a thermodynamic equilibrium (here we neglect the problem of the depletion of hydrogen as a source of solar energy). In general and in a statistical sense, the evolution will be towards the condition of maximum entropy compatible with the internal conditions of the system. Once this condition is reached, the production of information by the system ceases, in the sense that the flows become static or stationary. It is therefore the cessation of the PRODUCTION OF INFORMATION that is physically relevant, NOT the loss of the initial information.

Apart from these clarifications, which are perhaps pedantic but which I consider useful to clear the ground of false problems, my disagreement with the author is of a philosophical nature. It is true that the concepts of entropy and information have a double value: subjective (knowledge that the observer has of the system) and objective (function of state of the system). It is also true that thermodynamic states, defined by particular values of macroscopic variables (temperature, pressure, volume, etc.), are epistemic states. However, what is not considered in the article is the fundamental fact that such states are defined by the experimental setup (let's say, in a broad sense, the "vessel" of the system), which is completely objective. If a gaseous mass occupies a given volume it is because it interacts with the walls of the container which delimit that given volume. If this mass is at a certain temperature, this is due to the heat exchange with the outside mediated by those walls, and so on.

The subjective side of the thermodynamic state, and therefore of state quantities such as entropy, is simply the reflection, on a cognitive level, of the fact that the experimenter acts on the system by defining the experimental setup and, THROUGH IT, the value of those quantities. The observer's ignorance regarding microstates simply derives from the fact that there are many microstates compatible with the values of the thermodynamic quantities relative to the state achieved with that setup. Many microstates will give the value of pressure actually experienced by the vessel walls, etc.

In other words, the meaning of the thermodynamic state and its functions (such as entropy) is completely objective. The state is epistemic, but defined on a phenomenological basis.