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On the use and abuse of *thermodynamic* entropy

physikalisches

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Ort: H34

Entropy is a buzzword that is used by all kinds of communities, covering biologists, economists, social scientists and even writers. One may speculate that the term “Entropy” acts to provide their profoundness of thinking an appropriate scientific aura. One of the reasons for the bewilderment of the term Entropy is the unheralded appearance is the superabundance of situations bearing this expression. Being so, using the term thus requires that one does respect its precise meaning without effusing unnecessarily its wild growth, adding only to confusion rather than to clarity.

The concept of entropy was originally introduced by Rudolf Clausius in 1865. He chose the symbol S for Entropy in honor of (Nicolas Léonard) Sadi Carnot, who laid the basis for the second law of thermodynamics. The celebrated Clausius relation; i.e., $dS = \delta Q/T$ identifies the inverse of the thermodynamic temperature T as the integrating factor for the second Law, with δQ denoting quasi-static and reversible infinitesimal heat exchange. After Clausius’ seminal paper it took about 30 more years until Gibbs, Einstein, Planck and others were able to connect firmly thermodynamics and statistical mechanics — and yet certain aspects of this connection have remained a subject of debate up to this day [1, 2].

Here I will discuss in more precise terms its physical role for various notions. In particular, I will address the proper choice of entropy as it depends on the interests of the individual, the particular situations under study (classical or quantum regime), the degree of precision available and the type and method of description. I further will address the notion of entropy for systems of finite size and those situations of relevance in nanoscience, i.e. when the system under study is strongly interacting with its environment [3].

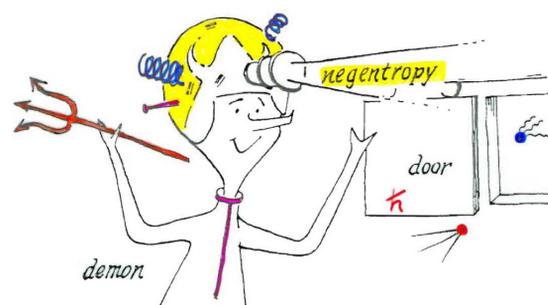
[1] S. Hilbert, P. Hänggi, and J. Dunkel, Thermodynamic Laws in Isolated Systems, *Phys. Rev. E* 90, 062116 (2014).

[2] P. Hänggi, S. Hilbert, and J. Dunkel, Meaning of temperature in different thermostistical ensembles, *Phil. Trans. Roy. Soc. A* 374, 20150039 (2016).

[3] P. Talkner and P. Hänggi, Open system trajectories specify fluctuating work but not heat, *Phys. Rev. E* 94, 022143 (2016).

Quantum Demon ?

A measurement \rightarrow Increase information \rightarrow Reduction of entropy



Source: H.S. Leff, *Maxwell's Demon* (Adam Hilger, Bristol, 1990)