Chapter 9
Second Law Viewed as Ban over Perpetuum Mobile

ABSTRACT

It is proven that under boundedness, the efficiency of a non-mechanical engine never exceeds the efficiency of the corresponding Carnot engine where the engine is free from necessity of a physical coupling to two heat reservoirs. The proof is free from the condition for entropy maximization viewed as condition for reaching equilibrium. Thus the proof substantiates the most ubiquitous formulation of the Second Law to be ban over perpetuum mobile. Further, the ban over the information perpetuum mobile appears a consequence of the most general formulation of the Second Law which asserts that it is impossible to build a non-mechanical “engine,” which works steadily in a cyclic regime without exerting any functional changes of its homeostasis during the working cycle.

INTRODUCTION

Nowadays the Second Law of the thermodynamics is considered as one of the fundamental laws of Nature since it is supposed to govern the arrow of time. It is assumed to reveal one of the principal early mysteries of thermodynamics, namely the origin of irreversibility: while microscopic equations of motion describe behaviors that are the same in both time directions, why do large-scale systems exhibit temporal asymmetries? Many thermodynamic processes go in one direction: closed systems devolve from order to disorder, heat flows from high temperature to low temperature, and shattered glass does not reassemble itself spontaneously. These are described as transient relaxation processes in which a system moves from one macroscopic state to another with high
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probability since there is an overwhelming number of microscopic configurations that realize the eventual state. The Second Law asserts that the natural processes spontaneously evolve in the direction of increasing entropy so that eventually to reach equilibrium, the state of maximum entropy, where a system stays arbitrarily long time.

The success of the Second law is due to a great extent to its relation with the other key concepts of thermodynamics, the most important of which is the concept of thermodynamical potential. To remind, the notion of thermodynamical potential, considered along with the idea of thermodynamical equilibrium, gives rise to the ubiquitous Boltzmann-Gibbs measure whose role then stands as the probability for deviation from the equilibrium. Yet, the major advantage of the above setting is its enormous ubiquity: it allows each object in Nature to acquire thermodynamical properties such as heat capacity, susceptibility, etc. It is worth noting that these values are assigned to each object regardless to its internal structure and functionality. Thus, from the viewpoint of the traditional understanding of the Second Law, the structure and the functionality of an object are ignorant for its thermodynamical properties. As we already know, the complex systems exhibit long-range correlations encapsulated in the so-called power laws which in turn also are subject to create an arrow of time. Then, is it to be expected that the structure and the functionality are always ignorant for the thermodynamical behavior?! A question arises: are indeed thermodynamical properties such as heat capacity and susceptibility insensitive to the structure and functionality of the objects?

The most fundamental flaw of the Second Law is its controversy with the principle of relativity. By assuming that it sets the arrow of time, we actually select a point on the time scale where a process is initiated. Thus, every repetition of a process is also marked by enumerating its initiation point. This, however, violates the principle of relativity, which says that neither a process nor any one of its repetition selects a special time point. This controversy has a practical implication: if the natural processes and their repetitions select time points, it would be impossible to define a power spectrum because, by definition, it selects correlations among distant responses but so that these correlations to be insensitive to the length and the position on the time arrow of the window at which the signal is recorded. Not only the sophisticated scientific tool such as the power spectrum, but our daily experience also suggests that finding solution of the controversy between these two fundamental laws of Nature: the Second law viewed as an implement for setting the arrow of time and the principle of relativity viewed as a ban over selecting of a special time points related to initiating or terminating a process, requires novel understanding of the thermodynamics and in particular requires novel understanding of the role of structure and functionality of the natural objects. The essence that could be taken out from these theoretical premises is to view the role of structure and functioning of the natural objects in a framework where both seemingly controversial facts peacefully coexist.

The goal of the present Chapter is to demonstrate that the above problem can successfully be resolved by the theory of boundedness. Not only it opens the door to re-formulation of the Second Law so that to eliminate it conflict with the principle of relativity, but it defines a specific measure for creating semantic units: the work done by the non-mechanical "engine" that constitutes the meaning of each semantic unit. Moreover, the operation of the corresponding non-mechanical "engine" is explicitly grounded on the functional properties of the corresponding system. At the same time, the developed approach "incorporates" the structure and functionality of a system in the traditional thermodynamical properties such as heat capacity and susceptibility.

The relation between the semantics and the arrow of time is grounded on the understanding of the sensitivity to permutations of the seman-