A Thermodynamic Negentropy Mirror Image Second Law

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Abstract

In this article, we provide a comment on how negative entropy can be viewed as an essential part of thermodynamics and our everyday life. We do this with a simple Negentropy Mirror Image Second Law proof. Although simple, the results may help clear up such confusion as the Schrödinger Paradox. This is because the proof shows that Negentropy Second Law is essentially a mirror image of the Second Law and already an inherent part of thermodynamics. Although there are many interpretations of the Second Law of thermodynamics, we often think of it as a statement of matter having a spontaneous tendency to become disordered. However, we cannot have disorder with first having order. Most of the literature focuses on negative entropy almost as a separate science related to living systems and in many cases as a paradox to the Second Law. To merge order and disorder in thermodynamics, we illustrate a simple view to illustrate a Negentropy Mirror Image Second Law simply by thinking of disorder as the removal of order. We then extend it to living systems.

Key Words: Thermodynamics**,** Negative Entropy, Second Law, Schrödinger Paradox, Living Systems, Negentropy Second Law, Mirror Image Second Law

1. Introduction

Negative entropy was first introduced by Erwin Schrödinger in 1944 [1] in a non-technical field in the popular science book, *What is Life*. Schrödinger uses it to identify the propensity of the living system to want to organize, which is seemingly contrary to the Second Law (on disorder) and is sometimes referred to as Schrödinger's paradox. That is, for most of us, we like to build houses, build cities, and organize our way of life. This is also observed in lower life forms. Thus, the Second Law, when it comes to the spontaneous tendency for order that occurs in growth and repair as somewhat controversial. Schrödinger resolved the apparent contradiction by noting that living systems are necessarily open. That is, the Second Law applies to closed systems (matter cannot be exchanged with the environment) that are isolated. Nevertheless, the concept of spontaneous negative entropy remains a subject of confusion. Furthermore, the concept of closed systems can be very broad when it comes to its deduced application statement that the entropy of the universe is increasing where living systems tend to organize which can add an element of even more misunderstanding. However, if we derive a simple proof that negative entropy is already a part of traditional thermodynamics Second Law, a type of mirror image of it, it should help diminish the confusion posed by the Schrödinger Paradox. In this article, we will start with the transformation of order into disorder, then discuss living systems and the creation of order. While there is a vast amount of work in the area of negative entropy for living systems, it is not within the scope of this brief article on our everyday experience to review it.

2. Method

It is a convenience in thermodynamics to have a science with its Second Law having an emphasis on disorder. However, without order, we cannot have disorder. Thus, without order, the science of thermodynamics related to its Second Law could not exist and our universe would be too chaotic. This is the basis for our proof. Any change in entropy causing disorder must correspond to a change of negative entropy (order) that already occurred at one time. We first start with a unique approach with the removal of negative entropy rather than its creation. In this way, entropy can be thought of as a reverse mirror image or the opposite of order

3. Results

A closed system (no exchange of matter) that undergoes an internal entropy change (increase in disorder) obeys the Second Law

$$\Delta S_{i\_System} \geq 0 \tag{1}$$

where the term ΔS_{i_System} represents a quantity internal irreversibility (permanent disorder) change that occurs in the system. However, this means that order in the system is diminished, thus the negative entropy change that had to

have taken place at one time to allow this disorder to occur, must mirror and be equal to the system's entropy change, so that

$$\Delta S_{i\_System} = \Delta S_{i\_NSystem} \tag{2}$$

where the term $\Delta S_{i\_NSystem}$ represents the quantity of internal change of order that occurred to the system at one time. The equal sign indicates a perfect mirror exchange between order and disorder. We denote the mirror image Second Law on negative entropy to Eq. 1 as

$$-\Delta S_{i\_NSystem} \leq 0 \tag{3}$$

When we include entropy flow to the environment (typically entropy flow occurs in the form of heat from the system to the environment of visa versa) the Second Law can also be written as

$$\Delta S_{Environment} + \Delta S_{System} = \Delta S_{Environment} + \Delta S_{i\_System} + \Delta S_{flow} \geq 0 \tag{4}$$

where $\Delta S_{Environment}$ is the entropy exchange with the neighboring environment, and the entropy flow such as heat, can be positive or negative from the system which is denoted as ΔS_{flow}. Then it is also true from Eq. 2 and 4 that the mirror image occurs

$$\Delta S_{Environment} + \Delta S_{NSystem} = \Delta S_{Environment} + \Delta S_{i\_NSystem} + \Delta S_{flow} \geq 0 \tag{5}$$

Equations 1 and 4 comprise the Second law, while Equations 3 and 5 comprise a Negentropy Mirror Image Second Law. A simple statement that without order, we cannot have disorder. Therefore, we can address order in thermodynamics through its mirror image Second Law as it is part of our everyday life experience.

3.1 Development of Order

In the development of order, living systems create internal order by taking from their surroundings free energy, in the form of nutrients, and returning to their environment an amount of energy as heat and waste entropy (see for example Lehninger's, [2]). Order in living systems takes the form of growth and/or repair. Since the process is inefficient, the order created in the living system is less than the disorder generated in the environment which we can note in Eq. 5 when we write it as

$$\Delta S_{Environment} \geq -\Delta S_{NSystem} \tag{6}$$

It is our everyday experience that living systems evolve in different stages over time. For example, as we grow older, the amount of growth and repair capability changes. For example, Ahn [3] found that bone healing in young versus old mice was faster and had a higher quality of repair. As well, Gerstein et al. [4] noted similar results of wound healing in humans. Therefore, it is best to recognize this by adding an element of time which may be helpful since living systems' ability to generate negative entropy varies over time. Then the mirror image second law can be written

$$-\Delta S_{i\_NSystem}(t) \leq 0 \tag{7}$$

This allows us to write Eq. 5 in a time-dependent way that may be useful in describing the Negative Entropy Second Law for open systems (exchange of matter such as nutrition) more generally, writing the equation as

$$\Delta S_{Environment} + \Delta S_{i\_NSystem}(t) + \Delta S_{flow} \geq 0 \tag{8}$$

4. Discussion

Equations 5 or 8 apply well to the Negative Entropy Mirror Image Second Law with Eq. 7 the most general form for open living systems, a concern of the Schrödinger Paradox. Any internal order created by a living system occurs by taking from their surroundings free energy, in the form of nutrients, and returning to their surroundings excess entropy. The equal sign suggests this process is 100% efficient, all the free energy taken from the surroundings is

used to create order, while the inequality suggests that the process is less than 100% efficient in creating order returning the inefficient entropy portion to the environment in the form of heat and waste.

In recent years, a notion has evolved that living systems may maximize entropy production when creating order in growth and/or repair (Martyushev et al. [5]. Kleidon [6]). This concept is similar to that originally developed by Odum working with Pinkerton also in 1955 [7] that claimed that maximum power in living systems occurred when the efficiency of energy production was about half of what was theoretically possible. Recently, Feinberg [8], developed an efficiency model that somewhat supported this view in living systems with nervous systems that have a sense of feedback so that repair occurs. Many living systems, such as plants and trees, mainly grow with little or no repair. We note that these concepts and Eq. 5 and 8 are important in the development of such theories.

5. Conclusion

In this short article, we have provided a Negentropy Mirror Image Second Law proof to help explain the concept of order in thermodynamics and this helped in reducing the confusion surrounding the Schrödinger Paradox. The results is a comment on how the Mirror Image Law is part of our everyday experience since, without order, we cannot have disorder.

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Ethical Responsibilities: The author verifies that this article meets all ethical responsibilities listed by the journal.
Consent to publish: The author assures he has the right to publish.
Conflicts of Interest: The author declares that there are no conflicts of interest Funding: This study was unfunded.
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