

## **Inert Matter and Living Matter: A Thermodynamic Interpretation of their Fundamental Difference**

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**Abstract:** This short paper deals with a possible link between a theory that I have previously suggested (an equation linking thermodynamics to relativity and gravitation) and experimental observations recently reported in the field of biology, showing that an isolated system can go increasing in mass if it is mainly occupied by living matter.

**Keywords:** Thermodynamics, relativity, gravitation, mass, entropy, energy, living matter, inert matter, Lavoisier's principle, Einstein's mass-energy relation, chemical reactions, Schrödinger, neguentropy, violation of the second law of thermodynamics.

### **1. Introduction**

In an article recently published in the *Journal of Theoretics*<sup>1</sup>, Amrit Sorli has presented an interesting information which can be summarized as follows:

Having introduced living matter (such as fungus or worms) inside a series of test-tubes containing non living matter (such as water and various solutes), he has noted that the mass of each test-tube evolves with time. It increases in a first step and remains stable in a second one, the transition between the two steps corresponding to the death of the living matter. The important point is that after the insertion of the living matter, the test-tubes were closed both to matter and energy, so that in the conventional language of thermodynamics, they can be looked as isolated systems. Under such conditions, the increase in mass which is observed during the first step of the experiment requires an explanation that cannot be given by the usual conception of thermodynamics. As pointed out by Amrit Sorli, "it seems that organisms, especially during their growing period, absorb some unknown energy that is able to permeate a physically closed system".

### **2. Hypothesis for a Possible Explanation**

#### **2.1. Brief recall of the theory previously suggested.**

In the usual conception of thermodynamics, it is admitted that the evolution of an isolated system (and equally of a closed system) obeys the Lavoisier principle, which implies that its mass remains constant with time. I have previously suggested<sup>2,3,4</sup> a revision of this conception, due to the detection of a slight inconsistency between the first and the second laws of thermodynamics. The detailed analysis is given in the quoted papers. It has led me to substitute the classical entropic equation

$$dS = dQ/T_e + dS_i \quad (1)$$

by the energetic equation

$$T_e dS = dQ + T_e dS_i \quad (2)$$

Referring to a thermodynamic system, equation 2 can be formulated in the form

$$dU^* = dU_e + dU_i \quad (3)$$

which means that, for a given process, the total variation of energy of the system ( $dU^*$ ) is the sum of the energy exchanged between the system and its surroundings ( $dU_e$ ) and the energy created inside the system ( $dU_i$ ). It is important to keep in mind that each term of equation 2 has the meaning and value of the corresponding term of equation 3 (the one on the same vertical).

Note that in the usual conception of thermodynamics, the existence of the energetic term  $dU_i$  is not recognized, so that equation 3 is not taken into account. As a consequence,  $dU^*$  is not distinguished from  $dU_e$  which, being the only energetic term considered, is simply noted  $dU$ .

By contrast, the conception presented in papers<sup>2,3,4</sup> and used here, recognizes the existence of the term  $dU_i$  and links it to the Einstein's mass-energy relation ( $E = mc^2$ ) by the equation

$$dU_i = -c^2 dm \quad (4)$$

It can be recalled that the sign minus, inserted in equation 4, corresponds to the fact that a decrease in mass ( $dm < 0$ ) leads to an increase in energy ( $dU_i > 0$ ) and conversely.

The second law of thermodynamics (which is a generalized transcription of experimental observations) consists in admitting, as a principle, that the term  $dS_i$  of equation 1 obeys the condition

$$dS_i > 0 \quad (5)$$

Transferring this principle in expression 2 and given that  $T_e$  is necessarily positive (being an absolute temperature), the second law of thermodynamics becomes

$$T_e dS_i > 0 \quad (6)$$

Now remembering that  $T_e dS_i = dU_i$  and transferring expressions 6 in expressions 3 and 4, we see that in this extended theory, the second law of thermodynamics can be expressed through the two equations

$$dU_i > 0 \quad (7)$$

and

$$dm < 0 \quad (8)$$

More than telling that the normal evolution of a system is characterized by an increase in its internal entropy (information which is classically given by expression 6), expressions 7, and 8 tell us that this evolution implies a decrease in mass and a correlative increase in energy, according to the Einstein mass-energy relation.

## 2.2. Transposition of the suggested theory to the context of living matter.

After the statistical aspect of thermodynamics has been introduced in physics, in particular by Boltzmann, the concept of entropy has been related to that of order and disorder. Since an increase in entropy has been recognized equivalent to an increase in disorder, the normal evolution of a system has been interpreted as an increase of its degree of disorder.

This idea can be easily seen true when the systems we are dealing with are made of inert matter. The image of a castle falling to ruin, under the effect of natural erosion, is a good example of the process, even if not the more pleasing to the eye. We must not forget, however, that the thermodynamic theory has been inspired by experimental observations concerning inert matter and that its extension to living matter raises some fundamental questions that, presently, remain unanswered.

A first important and well known point concerns the fact that when a living organism is growing, -especially when he is leaving the state of embryo- his internal structure seems to become more and more ordered, not the contrary. Expressed in thermodynamic language, such an observation leads to the idea that, in this context, remembering that an increase in internal entropy means an increase in disorder, a better transcription of expression 5 would probably be

$$dS_i < 0 \quad (9)$$

which is the opposite of what is admitted for inert matter.

Numerical calculations being not easy to insert into the thermodynamic study of living matter, the scientific publications concerning this topic are often restricted to qualitative analysis, more or less associated with the idea that expression 9, in such a context, would perhaps be more suitable than expression 5.

As already emphasized, conventional thermodynamics obeys the Lavoisier principle, and thus admits that the evolution of an isolated system is characterized both by an increase of its entropy and by the constancy of its mass. Most scientists who raise the question of a possible decrease in entropy for an isolated system made of living matter keep silent regarding the Lavoisier principle, so that they give the impression of admitting implicitly the constancy of the mass.

In the theory that I have suggested<sup>2,3,4</sup>, whose scientific transcription is mainly given by equations 2, 3 and 4, the idea has been pushed forward - and thus explicitly admitted - that, referring to an isolated system, an increase in entropy is necessarily linked to a decrease in mass and a decrease in mass to an increase in entropy. Correlatively, a decrease in entropy is necessarily linked to an increase in mass and an increase in mass to a decrease in entropy.

Confronted with this theory, the report by Amrit Sorli, that an increase in mass has been observed in the experimental context of an isolated system, leads to a preliminary interpretation which can be summarized through the following propositions.

- a) The observed increase in mass means that the system considered is effectively characterized by a global decrease in entropy.
- b) Given that this system is composed of both living matter and inert matter, and that the latter - according to the usual conception of thermodynamics - is itself characterized by an increase in entropy, the global decrease in entropy is necessarily due to the living matter.
- c) The experiment having shown that the increase in mass is stopped at the time when the living matter dies, we can conclude that the decrease in entropy stops correlatively.

Concerning this last conclusion, a more accurate proposition would consist in saying that after the living matter has died, the global entropy of the system not only ceases to decrease but increases since, in this second step, the system is exclusively composed of inert matter. Being the simple expression of the second law of thermodynamics applied to inert matter, this idea is certainly true, but contrary to what has been seen for the first step, its experimental proof is not given, since no decrease in mass has been really observed during this second step.

As underlined in the previous articles<sup>2,3,4</sup>, every physico-chemical process implies that the mass of the products is not equal to the mass of the reactants, but referring to a system exclusively composed of inert matter, the variation of mass is generally too small to be detected. Such a situation is the rule with ordinary (i.e non-nuclear) chemical reactions and it is obviously for this reason that the Lavoisier principle is implicitly and strongly present in conventional thermodynamics. As recalled above, the argument that has led me to suggest a revision of this conception comes from the detection of a slight theoretical inconsistency in the classical way of combining the first and second laws of thermodynamics. To solve the problem, I have substituted equation 1 by equation 2, whose energetic meaning is given by equation 3.

Now referring to equations 2, 3 and 4 and keeping in mind that, in the context of inert matter,  $dS_i$  is positive, we easily see that  $dU_i$  is positive too, so that  $dm$  is negative. In other words the thermodynamic evolution of an isolated system exclusively composed of inert matter is characterized by an increase in energy, itself related to a correlative decrease in mass. This proposition has been emphasized in the quoted papers<sup>2,3,4</sup>.

On the contrary, the experiment reported by Amrit Sorli clearly indicates an increase in mass which, referring to the same equations, implies a correlative decrease in energy. The hypothesis can thus be advanced that, in opposition to inert matter and referring to an isolated system, the thermodynamic evolution of living matter is characterized by an increase in mass and a correlative decrease in energy and entropy.

### 3. Conclusions

When analyzed in the frame of conventional thermodynamics, the experimental data reported by Amrit Sorli meet with a conceptual difficulty, due to the fact that, in the context of an isolated system, a change in mass cannot be explained.

When they are analyzed under the light of the extended thermodynamic theory considered here, the problem vanishes and an interesting information can be extracted. Contrary to inert matter, whose evolution in the context of an isolated system, is characterized by a decrease in mass and therefore by an increase in energy and entropy, living matter, in the same context, is characterized by an increase in mass and therefore by a decrease in energy and entropy.

This proposition can be translated quantitatively by the fact that, in equation 4, the term  $dm$  has a positive value, so that  $dU_i$  becomes negative in equation 3 and  $dS_i$  negative in equations 2 and 1. As easily understandable, the negative value of  $dS_i$  in equation 1 cannot be obtained when equations 4, 3 and 2 are ignored, i.e. when the extended thermodynamic theory recalled above is not taken into account.

Regarding the potential usefulness of the present proposition, some preliminary orientations can be expected. A first one is its probable relation with the concept of negentropy, that has been introduced by Erwin Schrödinger<sup>5</sup> and was already connected to his hope of extending the thermodynamic theory to living matter. Directly linked to this topic, a

second one deals with the theoretical possibility, for biologists, to deduce entropic data from laboratory measurements of changes in mass. A third one, more speculative, concerns the thermodynamic behaviour of cosmic bodies such as black holes which, astonishingly, seems to present a similarity with that recognized here for living matter.

The question of the general direction of entropy variation has made recently a conspicuous come back, through an article relating an example of violation of the second law of thermodynamics and its experimental proof<sup>6</sup>. Referring to the extended thermodynamic theory recalled above, it can be said of the data reported by Amrit Sorli that they equally give the proof of an example of violation of the second law. Although a lot of complementary experiments are undoubtedly needed to proceed along with this topic, the problem seems more easily workable when –as done with equations 2, 3 and 4– the thermodynamic theory is closely related to that of relativity and gravitation.

## References

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