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Thermodynamic Energy-Laws Presuppose Time Orientation Subject to Principle of Least Action

Helmut Tributsch[1,2*]

[1]Institute for Physical and Theoretical Chemistry, Free University, Berlin, Germany
[2]Helmholtz Centre Berlin for Materials and Energy, Berlin, Germany
Email: helmut.tributsch@alice.it

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Abstract

It is shown that time asymmetry is essential for deriving thermodynamic law and arises from the turnover of energy while reducing its information content and driving entropy increase. A dynamically interpreted principle of least action enables time asymmetry and time flow as a generation of action and redefines useful energy as an information system which implements a form of acting information. This is demonstrated using a basic formula, originally applied for time symmetry/energy conservation considerations, relating time asymmetry (which is conventionally denied but here expressly allowed), to energy behaviour. The results derived then explained that a dynamic energy is driving time asymmetry. It is doing it by decreasing the information content of useful energy, thus generating action and entropy increase, explaining action-time as an information phenomenon. Thermodynamic laws follow directly. The formalism derived readily explains what energy is, why it is conserved (1st law of thermodynamics), why entropy increases (2nd law) and that maximum entropy production within the restraints of the system controls self-organized processes of non-linear irreversible thermodynamics. The general significance of the principle of least action arises from its role of controlling the action generating oriented time of nature. These results contrast with present understanding of time neutrality and clock-time, which are here considered a source of paradoxes, intellectual contradictions and dead-end roads in models explaining nature and the universe.

Keywords

Thermodynamic Laws, Newton's Time, Nature's Time, Entropy Increase, Irreversibility, Self-Organization, Least Action

*Retired.

1. Introduction

In a recent paper, time neutrality of physical laws was challenged [1]. Here the same formalism is used to mathematically derive, to discuss and to understand the hitherto empirical thermodynamic laws and their relation to the principle of least action. Because this is possible for the first time, it is argued that an action generating oriented time is a necessary condition to understand nature on a rational basis.

Due to the time, clock-time, adopted by Newton in his "*Philosophiae naturalis pricipia mathematica*" from 1687, which is placed outside the studied phenomena and works as a simple scale in both time directions, and due to the time neutral natural laws, which are assumed to act in time-neutral way, physics could up to now not derive thermodynamic laws and answer questions such as: What is energy? Why is it conserved? Why does entropy increase? What entropy law applies for irreversible, self-organized processes? Physics today explains the fact that entropy increases in nature with a purely mathematical-philosophical argument: a development (of clock-time) towards higher probability with a blocked way back. This is not acceptable for natural scientific systems which have to follow natural laws and it is additionally problematic, since Newton's time and the time of entropy increase in nature have different dimensions (time and turnover of action respectively). One cannot switch from one to the other just by invoking a development towards increasing probability, which explains the failure of mathematical derivation. In addition, time orientation and entropy generation are not limited to statistical ensembles. Efforts to derive time orientation from these (e.g. Boltzmann's H-Theorem [2]), to derive entropy increase via mathematical simplification or (Markovian [3]) memory loss strategies suffered from the problem, that they involve information loss. Since the work of Szilard [4] and Landauer [5], it is known that information turnover involves energy turnover. One Bit requires 17.5 meV and the energy involved turns into heat when erased (possible limitations of Landauer's principle are not addressed here). These mathematical procedures aimed at deriving experienced, oriented time consequently yielded an apparent time orientation through a nonintentional reduction of its energy content during simplification (elimination of information). A critical look at Boltzmann's famous formula $S = k \ln W$ (S = entropy, k = Boltzmann constant and W = probability), which is frequently used to justify a thermodynamic time arrow towards entropy increase, exposes additional problems (its incorrect interpretation probably goes back to Arthur Eddington and his book from 1928: "The Nature of the Physical World"). In Boltzmann's formula, there is no time orientation contained at all. Entropy is derived as a pure equilibrium quantity and probability is just a ratio of numbers. The impression of a time orientation arises only from human imagination and experience that systems will approach a state of maximum probability. The formula does not say that, and human beings, who suspect such a development, function with the action generating, entropy producing time of nature.

Additional facts may be added to characterize the problem faced: There is

sufficient evidence that statistical arguments cannot explain time orientation at all [6]. Other attempts to invoke symmetry breaking via arising chaotic processes [7] overlook, that feedback is needed to obtain self-organization including chaos and this always requires a situation of "before" and "after". Some "action" must occur before the consequence can be reintroduced into a starting new process. This is not possible with Newton's time scale used in physics, which is a time-neutral tool defined to exist outside of ongoing processes and does not generate action.

The problem to be addressed is the contradiction of time neutrality and thermodynamics. The solution proposed is action time, the understanding of time-oriented entropy turnover. Derivation of thermodynamic law is the consequence. To accomplish this the presented work concentrates on and evaluates a formula which, based on the Lagrange formalism and application of Noethers theorem, expresses and clearly explains the present handling of time and energy. Then it is analysed what happens when, in contrast to the present convention, actually existing time orientation, time asymmetry, is considered as an experimentally observed fact. The same Lagrange formalism is then further developed mathematically to derive action time and to explain thermodynamic laws.

2. Presently Used and Differently Understood Energy-Time Relation

What is the most basic formalism, which presently reflects the handling of energy and time in physics? This has been shown in [1] and will be used here again while concentrating on thermodynamic laws. By totally differentiating the Lagrange function L, which is expected to entirely describe a system, reorganizing the relation and considering the validity of the Euler-Lagrange-equation, one yields the well-known equation (q = degree of freedom, generalized coordinate; the point on it indicates time derivative) (e.g. [8]):

$$\frac{\mathrm{d}}{\mathrm{d}t}\left[\frac{\partial L}{\partial \dot{q}}\dot{q}-L\right]=-\frac{\partial L}{\partial t} \tag{1}$$

It equates the total time derivative of energy E

$$E=\frac{\partial L}{\partial \dot{q}}\dot{q}-L \tag{2}$$

with the negative partial time derivative of the Lagrange function (which describes the system via the principle of least action (more precise: stationary action, corresponding to a minimum or a saddle point) considering the Euler-Lagrange equations), and, rearranged, yields:

$$-\frac{\mathrm{d}E}{\mathrm{d}t}=\frac{\partial L}{\partial t} \tag{3}$$

This simple equation leads us to an understanding of present-time handling of energy and time. The partial time derivation of the Lagrange function is understood as time asymmetry, that is the change and deviation observed due to time displacement

and inversion:

$$\frac{\partial L}{\partial t} = \text{time asymmetry} \tag{4}$$

Due to Newton's time concept time asymmetry (4) is presently set zero, with the consequence that the total time derivative of energy in (3) is zero. According to Emmy Noether [9], conservation laws can be deduced from symmetry and invariance laws. This then follows from (3) because, as a consequence of zero time asymmetry (4) the total derivative of energy becomes zero. This is understood to mean that energy is conserved (compare [8]). It means confirmation of the first law of thermodynamics which has been fully confirmed experimentally.

This interpretation of energy-time relations is perfectly reflecting the present understanding of energy and time. Time, Newton's time concept, is a scale in the background, for dynamic systems homogeneously passable in both time directions. Consequently, according to (3) there is no time asymmetry. Energy is consequently conserved and is a scalar, non-oriented quantity, which can develop its ability to do work in both time directions. However, as well-known, it has, for this reason, only the potential, but no interest to do work and it has no relation to time.

2.1. New Interpretation of Energy-Time Relation

The energy-time relation (3) should now be interpreted differently. Since the here studied system (3) is not considered to be an equilibrium system, thermodynamic equilibrium quantities for energy do not apply. Energy here is the total inner energy available for energy conversion. Since it is not defined here as equilibrium value it is simply named E. In order to reach the aim of demonstrating that energy drives time and to understand the role of information the energy system and the Lagrange function are considered to be quite unspecific, with initial position and momentum of described objects assumed to be known. In addition, a distinction has to be made between useful energy $E`$ (e.g. liquid fuel), which contains active information I_{act}, and useless energy E (e.g. environmental heat) which has the same energy of information converted into environmental heat.

a) Time neutrality and symmetry challenged

To set time asymmetry (4) zero corresponds to present convention, but contradicts experience. We memorize only the past and processes move only in one direction, into the future. For spontaneous processes, entropy is also increasing only along the time direction we experience. The direction cannot be inversed. Palaeontology, the science of prior existing life, as well as history supports that. Consequently, time asymmetry (4) exists and cannot be set zero.

b) Time then arises from energy turnover

Formula (3) then shows that useful energy, here understood as behaving dynamically, actually drives time asymmetry and progressing time (4). Larger and smaller energy events around us and within us turn over information for generating time intervals between cause and effect. Such individual events are like tones that add up to a melody of progressing time in our brain. Time is consequently

part of our human experience and existence. All together nature should be logically understandable since the mechanisms linking cause and effect generally follow natural laws explaining understandable mechanisms.

c) Consequences for the time derivative of energy

For equation (3) this has two consequences: the decreasing total time derivative of energy is not zero and it has directional properties (since the experienced time asymmetry (4) in (3) is equally oriented). This definitively means that an energy property, the total time derivative of energy, is responsible for and driving time asymmetry (4). This way energy obtains a time oriented and time orienting property. But the total time derivative of energy offers additional insight.

d) Consequences for energy itself

There is no doubt that energy is conserved. Equation (3) in the form which accepts time asymmetry, does not contradict that, since it involves, what is important, a total derivative of energy. This implies that besides a time dependence with respect to energy states $E`$ themselves (which is identical to zero), additional time dependencies exist, which are present in the total derivative and have to be considered responsible for time asymmetry (4). Energy can be useful (containing much information, acting information I_{act}, as in the form of chemical fuels) or useless (in the form of entropy, with little or no information content, as in thermal heat vibrations). Energy is conserved, but I_{act} makes the difference between useful energy and useless energy, where I_{act} has been converted into heat. Redefining useful energy as "acting information" provides here a framework that aims at explaining thermodynamic laws and self-organization in non-linear systems.

The additional time dependency of energy, described in (3), is therefore one with respect to its information content (shown in (5)), and it is not equal to zero, thus generating a non-zero, finite value of time asymmetry (4) in (3).

Physics has not recognized this context between time asymmetry (4) and energy, which forced physics into a very special track of development: time became clock-time, functioning outside energy systems and through relativity and quantum theory this clock-time was recalculated as an object, explaining time as an illusion and involved in uncertainty respectively. Energy remained a pure number without any relation to time. Thermodynamic laws could not be derived. Photons spreading energy into the universe are, on the basis of quantum theory, presently not allowed to generate entropy.

2.2. What in Energy Makes Time Oriented?

For a derivation of this expected non-zero time-dependency of useful energy with its acting information I_{act}, energy is considered both to be dependent on its energy state $E`$ (useful or non-useful for considerations of energy conservation) and on contained information I_{act} in useful energy (for consideration of time orientation).

Equation (3) can then be rewritten by considering that energy E can depend on its state $E`$ (useful or useless) and on its usefulness (its content on I_{act}) to

$$-\frac{\mathrm{d}E}{\mathrm{d}t}=-\frac{\mathrm{d}E\left(E`,I_{act}\right)}{\mathrm{d}t}=-\left(\frac{\partial E}{\partial E`}\frac{\mathrm{d}E`}{\mathrm{d}t}+\frac{\partial E}{\partial I_{act}}\frac{\mathrm{d}I_{act}}{\mathrm{d}t}\right)$$
$$=-kT\ln 2\frac{\mathrm{d}I_{act}}{\mathrm{d}t}=\frac{\partial L}{\partial t} \quad (5)$$

with $\frac{\partial E}{\partial E`}\frac{\mathrm{d}E`}{\mathrm{d}t}$ being equal zero, respecting and satisfying the energy conservation law, and $\frac{\partial E}{\partial I_{act}}$ = energy needed for information.

This energy needed for generating information is the quantity of $kT\ln 2$, the energy (17.5 meV) needed to generate one Bit of information I_{act} [5], and it is converted into heat (entropy) with the equivalent energy content when this one Bit of information is erased (Landauer's principle) [6].

From (5), it then follows for the turnover of useful energy:

$$-\mathrm{d}E=-kT\ln 2\mathrm{d}I_{act}=T\mathrm{d}S \quad (6)$$

which shows that useful energy, when consumed (negative sign of dE), corresponds to entropic energy (TdS).

Derivable from (6), thermodynamic entropy is thus related to information entropy via

$$\mathrm{d}S=-k\ln 2\mathrm{d}I_{act} \quad (7)$$

Equation (5) now expresses, that time asymmetry (the partial time derivation of the Lagrange function (4)) is generated by a decreasing property (minus sign) of energy (which has to be assumed to react in a dynamic, oriented way), which corresponds to a decrease of acting information I_{act} contained in this useful energy (including its erasure). As a consequence, it is concluded that, due to its time orientation, useful energy (the time derivative (5) involved in information turnover) has the intrinsic property to decrease its information content, its presence per state. It thereby generates entropy and time asymmetry. As we will see, in this way it also follows the principle of least action and drives oriented, action generating time.

Relations (6) and (7) describe entropy increase as the consequence of breakdown of information. Integrating relation (7) yields a formula (7a), which has the shape of Boltzmann's formula $S=k\ln W$, but, in contrast, it actually expresses an oriented thermodynamic time-arrow, as it is experienced:

$$\int\mathrm{d}S=S=-\left(k\ln 2\right)\int\mathrm{d}I_{act} \quad (7a)$$

A comparison with the time-neutral formula of Boltzmann explains, that not probability W, the ratio of two numbers, (in $\ln W$), but breakdown of acting information ($-\ln 2\int\mathrm{d}I_{act}$) from useful energy accounts for entropy formation and the function and time orientation of the thermodynamic time arrow.

2.3. What Principle Is Involved in Energy Turnover and to What Consequence?

In order to find this out and to explore the consequences, Equation (3) is

rearranged (displacing the denominator to the respective other side) and subsequently integrated to get the time evolution of changes of the Lagrange function (right side of equation) which totally describes the system:

$$-\int \mathrm{d}E\partial t = \int \partial L\mathrm{d}t \tag{8}$$

The right side of Equation (8), the time integral over the Lagrange function is, by the way, the definition of action, the process of doing something. This action involves entropy turnover (6) and generates time experienced in nature. What can we learn about it? With (6) introduced into (8) it follows:

$$-\int \mathrm{d}E\partial t = -\int \left(kT\ln 2\right)\mathrm{d}I_{act}\partial t = \int \partial L\mathrm{d}t \tag{9}$$

The left side of Equations (8) and (9) is showing what causes these changes: It describes the negative (decreasing) time integral over a total differential energy quantity. It is the decreasing differential "action" (energy times time). Since the Euler-Lagrange equation was respected in deriving this equation, this is exactly what the principle of least action is expressing for an infinitesimal section of energy.

Equations (8) and (9) tell us, that the asymmetric development of the Lagrange function in time (right side), and thus of the physical system, is following and the consequence of the principle of least action (left side) through a consumption of information I_{act} (centre) corresponding to a generation of entropy. Time flow and changes caused in context with time flow are the consequence of energy turnover and of fulfilling the principle of least action. This principle is here derived and understood as a dynamically acting principle and governs time-oriented processes enabling the derivation of thermodynamic laws. It is presented here as essential for describing and understanding the oriented nature of time contrasting with the conventional view of time neutrality and clock-time.

This principle induces useful energy to decrease its information content (seen in Equation (9), middle), thereby generating changes and entropy, implementing thermodynamic laws and driving time. This is the progressing entropy generating time we are experiencing and, since it is turning over action and is subject to the principle of least action, it should be named "action time". Equation (9), action time, expresses the real entropy producing thermodynamic time arrow: The consumption of information (generation of entropy) is linked to active information abandoning useful, time orienting energy. This conflicts with present frameworks of physics, which link experienced time and entropy increase with increasing probability as (falsely) deduced from Boltzmann's formula, which includes no information on time orientation.

Action time (9) expresses turnover of action (energy x time) with the corresponding dimension, and is an information system which can be perceived from within and from outside. It has not the time dimension of Newtons clock-time. If no energy is turned over, action time does not proceed, but it goes on with the next energy event involving action and reaction. Typically, many energy events are proceeding simultaneously in the environment.

In order to elaborate the impression of time experienced with action time, action time has to be normalized by dividing it by the averaged energy flow from the sun, which is ultimately generating action time, though usually delayed. This normalized time of action time has now the dimension of time and can then be calibrated to geophysical cycles using clock-time. The result would be the time we actually perceive with our senses. It is the time experienced by humans before the encounter with technical clocks. With respect to changes in the environment it represents itself similar but it has essential properties clearly different from those of clock-time. It is progressing towards the future, is related to energy turnover, and allows experiencing a "now". This "now" can be understood, when considering that action time is simultaneously proceeding within living beings due to ongoing metabolic energy turnover (relation (9)). In the case of humans, they scan, while progressing in the frontline of action time, all ongoing processes of energy turnover in the environment with their senses within a time window of two to four seconds. It is the "now", which allows successful interaction with the environment and moves on with the action time of the observer and the environment into the future, essentially following the path of action and reaction and of energy supply from the sun. Such human experience from the frontline of active changes proceeding with a progressing time is confirmed by a proverb from Roman time: "time is ours". This frontline of time is based on information turnover and is a physical reality.

Important consequences for fundamental physics can immediately be recognized from (9), apart from the fact, that contemporary physics, including Einstein, denied time orientation and the existence of a "now" (which is true for clock-time):

a) Since generation of entropy for action time is a very fundamental phenomenon concerning all fields and mechanisms of physics, it can be concluded that action time, time in nature, is the reason for the relevance of the principle of least action. All mechanisms that generate entropy are subject to it, since they are subject to time. It is the ultimate expression of time orientation and irreversibility in nature. This explains for the first time a reason for the universal role and significance of the principle of least action. It characterizes it as an inseparable quality and a shaping phenomenon of nature's action-time, which is an information phenomenon, as seen from (5).

b) Wherever useful energy is not readily replaced, and where information is continuously converted into entropy, there will be a relative scarcity of acting information I_{act}. This will, in macroscopic systems, necessarily favour mechanisms and structures known to link the transition from order (much information) to chaos (little or no information), controlled by irrational numbers (e.g. golden ratio, Fibonacci numbers, structures frequently found in nature). In sub-microscopic environment, quantum states are expected to arise as products of least action activity of action time. They are systems, which are characterized by an extreme scarcity of information which necessarily will generate special energy states

and discrete energy quantities. Such a change in properties may be comparable to a decreasing flow of water from a water tap which will end up releasing water drops (see further discussion below).

2.4. Understanding the Derived Thermodynamic Laws

In the preceding section time neutrality was disputed and time asymmetry was shown to involve a dynamically understood principle of least action for implementation of thermodynamic laws.

2.4.1. What Is Energy?

In the famous Feynman Lectures on Physics one can read: "…in today's physics we have no knowledge what energy actually is.(..) It is an abstract thing, that does not tell us the mechanisms and reasons for the different formulas (it fulfils)". Equations (5) and (9) explain what energy actually is. The abstract thing Feynman mentions is acting information I_{act}. It is real and contains energy itself. [4] Energy is therefore an information phenomenon. Useful energy is useful because of its information content, for example, based on complex molecular structures of fuels or properties of magnetic, gravitational or electric fields. Not any more useful energy is deprived of information, but still present in form of low temperature heat as product of energy turnover. Energy has again and again been compared with money, since it equally can provide for benefits, materials and services. In fact, money is also an information system. Crypto currencies and credit cards prove it.

2.4.2. Why Is Energy Conserved?

Equations (5) and (6) explain that useful energy contains energy in form of acting information I_{act}, not anymore useful energy contains the same energy in form of generated heat (due to erasing of information) [5]. Energy is conserved, because energy phenomena are characterized by information turnover and information is either present in useful energy with its specific energy content [4] or erased with the equivalent amount of heat [5], liberated under circumstances of entropy formation. The time derivative with respect to its energy state E` (useful or non useful) is zero and, as we have learned, therefore does not contribute itself to time asymmetry (4) in (3) and (5). Energy conservation is respected.

2.4.3. Why Does Entropy Increase?

According to Equations (5) and (6) entropy increase (within a closed space) is caused by a time oriented natural energy law, aiming at a decrease and erasure of information contained in useful energy. This generates time orientation. The principle which is thereby followed is the principle of least action. The entropy increasing time arrow is not caused by a mathematical statistical trend towards increasing probability W, as up to now assumed in physics and inspired by Boltzmann's law (which however includes no statement on time). Rather, it is triggered by an information abandoning energy (5) and implemented by a dynamically functioning principle of least action (9) to express the time-oriented increase of entropy via a dynamic Boltzmann-type relation (7a).

2.4.4. What Is the New Understanding of Time, Nature's Action-Time?

Equation (9) explains, what progress of changes, progressing time, characterized by time asymmetry (4), means. It means erasure of information, which, during energy turnover, is liberated from ongoing energetic processes in the environment and in the human body. Energy is continuously turned over in nature and ultimately resupplied by the sun. Time flow is coupled to these ongoing energetic processes. It is information turned over, erased, and lost to the past, while energy itself is conserved. Our senses realize the frontline of information changes, which defines the "now", the progressing short time period, along cause and effect, when action is possible or necessary. Evolution has optimized senses for living and surviving with action time. Time is not an illusion, it is an information phenomenon, subject to the principle of least action and with the dimension of a flow of action (energy times time), since information is not only transmitted but also erased. This progressing time, here called "action time", remains relativistic invariant, in contrast to Newton's time in relativity theory. Newton's time just provides information, a time scale. This information is not erased. Newton's time is a constructed time imposed on nature from outside. Experienced time is in physics presently explained as clock-time, which is being rectified in direction of higher probability or of chaotic processes. But this concept could never be derived mathematically from time-neutral principles, since this would also have to involve a change of dimension. Action time (9) is the real entropy generating time implemented by nature. It is the time human beings have learned to live with. Since they are turning over energy, their being equally means action time.

2.4.5. What Is the Entropy Law for Non-Linear Irreversible Thermodynamics?

According to Equation (5) information loss, equivalent to entropy production, is the rate limiting process during time generating energy turnover. What happens, when feedback processes are inducing self-organized reactions? Feedback processes are generating an acceleration of the rate limiting process until it is restricted by the constraints of the system involved. The following entropy law is the necessary consequence: "maximum entropy turnover within the restraints of the system".

Life works as a self-organized system, however under the restrain of a controlling genetic code. In contrast to the prevailing opinion in biological science, which denies any aim [10], life should follow this internally present and acting aim, which also explains, why such self-organized systems fight for survival and follow a purpose. They do it like cybernetic systems, electronic control- and regulation-systems, do, which are coupled by regulating loops, which are equally subject to feedback-coupled mechanisms and have been recognized as teleological, purposeful, already more than eighty years ago [11]. It should be pointed out here that a law for non-linear thermodynamics has long been searched for in vain. The reason was, that, on the basis of clock-time and time-neutrality, it was not recognizable that generation of time (action-time) is controlling the rate of entropy production.

2.4.6. Understanding the Universal Role of the Principle of Least Action

From Equations (9), which describes the time development of a system via its Lagrange function (right side), it is seen that it is caused and guided by the principle of least action (left side). It is the fulfilment of this important principle, which causes useful energy to react dynamically and to generate time (5). Due to a hitherto assumed time neutrality and due to an energy, which has no interest to act, the principle of least action played only a purely mathematical role and is basically used as a neutral mathematical tool. Although its relevance for controlling natural laws has been known for 300 years, it was never understood, why nature is applying this principle and what it means, since, by minimizing action, it strangely seems to relate the actual path of a system to its future state. Is this actually the case?

Equation (9) expresses the nature of this widely experienced and observed law. The principle of least action guides action time and is of general importance, because it expresses the fundamental irreversibility of nature and controls the generation of entropy. It proceeds as an energy driven erasure of information to enable processes via entropy production, which concerns all macroscopic and microscopic processes which happen. The future provides the information in form of useful energy, the "now" turns it over, erases it, via the principle of least action, in the past, the information is gone, lost to heat. Here, via Equation (9) it is understood that the principle of least action is an information phenomenon, with information turnover as rate limiting process for generation of changes and of time. Since minimum (stationary) action is enforced, it appears to be that this rate limiting process of information turnover (entropy generation (7)) is responsible for this characteristic behaviour. Least action is achieved, because only a rate limiting least rate of information turnover is admitted within the limitations of the entropy generating system involved. This guides the way mechanisms proceed. It is also the reason, why feedback processes during self-organization aim at maximum entropy turnover within the restraints of the system involved (as explained in 2.4.5.)

2.4.7. What Can Be Said about the Third Law of Thermodynamics?

It is tempting here to also explore whether the derived formalism, based on an asymmetric time can equally explain the 3rd law of thermodynamics, which claims that no energetic process can ever reach the absolute zero temperature. Due to the absolute temperature T in the energy of information kTln2 (of one Bit) in Equations (5) and (9), which then becomes zero, it is learned, that dynamic energy cannot any more function via information turnover (5) and no contribution to time flow is anymore possible, since no information remains to be erased (9). The absolute zero temperature can therefore not be reached.

2.5. Discussion

2.5.1. Consistency and Reliability of Derivation of Thermodynamic Laws

The presented work started from the most fundamental statement of present physics on time behaviour of the Lagrange function, which, when known, is

expected to totally describe a physical system. It relates time asymmetry with a decrease of the total time derivative of energy (3). Present physics follows Newton's convention on time neutrality and symmetry as well as Noether's conservation law basing on it. Equation (3) appeared in this interpretation to support the traditional understanding of nature: the asymmetry of time is zero and energy consequently conserved.

The only change introduced here into Equation (3) is abandoning the convention of (an experimentally not observed) time symmetry in favour of actually observed time orientation, time asymmetry. The immediate consequence is, that the decreasing total time derivative of energy cannot be set zero and that energy obtains a time driving property. This is possible and does not contradict energy conservation, because the total derivative of energy in (3) includes, besides of the derivative expressing a change of energy state E', which is equal zero, another characteristic component which turns out to be the property of decreasing contained information (order) I_{act} parallel to entropy increase. The mathematical derivation of action time (9) includes no additional assumption and it is claimed to reflect experimentally observed reality. It is the real thermodynamic time arrow. But it obviously does not integrate with established time-neutral frameworks such as relativity theory and quantum theory. The reason is that these theories use an artificially constructed time scale, clock-time, defined outside of studied processes, and explore new properties of this originally differently defined time.

Since the consequences of action-time are significant and require a departure from the presently followed paradigm of time neutrality, a falsification criterion is presented: "the here provided derivation of thermodynamic laws is falsified if the oriented, progressing time, its asymmetry, which is invoked, can be disproven". Since action-time is an information system and quantum and elementary processes, which are traditionally cited as arguments for time reversibility, are associated with a low information content, they should not be included in falsification tests.

Relativity theory can attempt challenging this falsification, since it claims that time, the distinction between present, past and future is just an illusion. But the rebuttal would be that relativity theory is using and talking about a constructed time, a passive time, Newton's time, defined outside energetic processes, making it in addition to an object for new calculations, which is a mathematically questionable procedure. The real time, action time (9), which is subject to the principle of least action and thus follows fundamental natural law, is relativistic invariant. It is not subject to relativistic paradoxes. It is an information phenomenon which allows the distinction between presence, past and future on the basis of a turnover of information. Newton's time is not the really experienced time working in nature, as already recognized long time ago by philosopher Gottfried Wilhelm Leibniz, physicist-philosopher Ernst Mach or later by philosopher Henri Bergson. This explains why passive clock-time did not allow derivation of the technologically so important thermodynamic laws until now, which requires a progressing time

related to energy turnover.

2.5.2. The Nature of Thermodynamic Laws

As shown in subsection 2.4., just with the concession of a really observed time orientation, the thermodynamic laws could readily be derived and explained starting from the basic relation (3). These thermodynamic laws are both practically and scientifically very relevant, which in turn supports the conclusion, that the nature of time is indeed oriented, asymmetrical and originating from an energy driven information turnover. For the first time, it is understood what thermodynamic laws mean and what quantities are relevant. They all express consequences of changes and this has a reason. They are the outcome of a dynamically acting energy following the principle of least action, dealing with and erasing information. They are a necessary attribute of progressing action-time and this explains their relevance in nature. Apart from that, the behavior of energetic mechanisms can be viewed as an experimental verification of this theory, which predicts these mechanisms.

2.5.3. Consequence of Understanding Time and Energy Dynamically

Since the thermodynamic laws could not be derived during the past scientifically very active century their first-time derivation and explanation should be thought-provoking. This suggests that something new can be learned, since the difference as compared to former attempts to derive them just consisted in accepting that time is not neutral but asymmetrically progressing. This is, of course, an essential support for a progressing time, action-time. Another one is, that thermodynamic laws themselves, conservation of energy, generation of entropy, production of local order, presuppose active changes. A progressing time must provide the opportunity to allow them to do this.

It will also be necessary to have a new look at established theories, that use Newtons passive time scale. Quantum theory and relativity theory as well as theories, that try to unify them, do that. However, Newtons time, clock-time was defined to exist outside proceeding phenomena as a scale only for registering changes. It was not intended to become an object of study itself. This however happened in these important theories. They manipulated mathematically Newton's time and gave this time, clock-time, new properties. In relativity theory, every object gets in this way its own time. In quantum theory, clock-time enters in new shape and with new properties the uncertainty relation and in statistical results. The disturbing number of paradoxes in major physical theories, adopted during the past century, may be related to a misinterpreted time, which is not the action generating time of nature [12].

2.5.4. Quantization Can Be Explained as a Dynamic Phenomenon

Quantum theory was not derived from basic principles but essentially and with great success adjusted to explain experimental results, using Newton's time, clock-time, to describe its time dependent behaviour. Quantum theory cannot explain why quantization occurs. It can be mathematically considered as a consequence

of an assumed boundary condition due to the wave character of electrons but it cannot be explained why nature is implementing such a condition, since no boundary exists, which may be enforcing such a condition. With Equation (9), this can be understood. Useful energy aims at decreasing its information content per state following the principle of least action and pushing time. Reasonably isolated systems will progressively lose information. Quantum states are states left with minimal information, they are ultimate products of the principle of least action. They are structured in such a way as to contain and turnover minimum information.

What does this quantization mean? All electron orbits around a nucleus, which require too much information or are chaotically changing will be suppressed. Only those which fit the electron wave length into stationary orbits, thus getting by with a minimum of information, can survive. This explains also why electrons do not collide with the positively charged nucleus. However, time-neutral quantum theory does not expect that. A dynamically understood quantum theory is needed, which has been sketched [13]. It describes quantum processes by considering particle and wave as action and effect including entropy formation, but allows compensation of entropy through information, which is provided for this purpose. There is reason to expect that quantum processes are logically understandable and paradoxes will disappear under such dynamic conditions.

The uncertainty relation has changed the way of understanding the development of our world. One version of it relates the product of energy- and time-uncertainty to the Planck constant (time in this relation is not considered as an observable quantity, but a parameter). Can one, nevertheless, draw philosophical and time-related conclusions from a clock-time, which is not nature's time, and from an energy, which is considered to just be a number, a scalar quantity, not related to change? A dynamic quantum theory may give a different answer.

2.5.5. Relativity Theory Is a Theory of Clocks, Not of Nature

As Einstein himself confirms saying that time is what the clock shows, he used Newton's time to design the fourth dimension of space-time. Such a construction would not have been possible using action-time (9) with its different dimension and dependence on energy laws. Action-time, which is controlling processes in nature, and being subject to the principle of least action, cannot become relative. It applies everywhere in the universe, relying on energy locally available. Einstein used Newton's time scale of clocks, which was defined to function outside ongoing processes, to calculate and get new information on this clock-time. Apart from this being a mathematically questionable procedure, relativity theory is definitively a theory of clocks, which only register, counting periodic events, and do not generate action. This has already been recognized by the French philosopher Henri Bergson during a controversy with Einstein in Paris in 1922. The concept of action time as a redefinition of time in nature and as link between energy, information and time asymmetry requires, of course, profound natural scientific and empirical evidence as well as support from traditional experience with time

and from different disciplines of science. Such information is extensive and provided in two recently published books [12] [14].

2.5.6. At the Beginning of the Universe Was Information

From Equation (9) it is learned that time, action-time, the time of nature, is an information system. Useful energy as well acts via information, as seen from (5). Gravitation, within a dynamic quantum physics, is equally understood as information [13]. Already from these contexts, it can be concluded that at the beginning of the universe there was no chaotic explosion, but information. Otherwise time and energy were not possible. Since dynamic energy has the property of decreasing its information content while spreading into space, the redshift of galactic objects, increasing with distance, is caused by information loss, that is entropy generation, and not by a dramatically expanding space.

Considerations on the basis of action-time suggest that information to compensate entropy formation is, on a large scale, already present in a self-sufficient, differently understood universe [14]. There is no need for energy from outside the universe to explain its mechanisms (e.g. as required for explaining the Big Bang event, which claims, that all energy of the universe is originating from a tiny seed. When the seed started to be there, the universe did not yet exist. Therefore, its energy came from outside and in a scientifically incomprehensible form).

2.5.7. Relevance for Self-Organized Processes and Biological Materials

In a more recent publication, the author has compared 50 years of research and technology of water splitting with the strategy and accomplishments of nature in photosynthesis [15]. The insight was that nature has solved problems more elegantly and efficiently: rectified electron transfer instead of charge separation via inbuilt thermodynamic potentials, self-organized catalysis instead of noble metal catalysis, low temperature substances instead of high-temperature materials. Physics is presently hampered by the fact that it builds its quantum theory around Newton's concept of a passive time in the background and time neutrality. The here presented ideas have shown, that by abandoning this time neutral concept, the technologically very important thermodynamic laws as well as the origin of action generating time in nature can readily be derived and understood. Natural law, that decreases information per state also includes states with least information, quantum states. This supports the conclusion, that this path is relevant and should give access to quantum processes allowing time intervals and feedback, as observed in nature. Involving action-time one would be able to explore nanoscale science and technology closer to the strategies nature herself has used which would also prepare the way for developing and optimising solid state materials, catalysts and functional systems as applied in biological nature [16]. Their synthesis and function are controlled by self-organization, which presupposes a progressing time, action-time.

Dealing with a dynamic energy, generating oriented time, will open new opportunities and definitively facilitate research in direction of irreversible and self-

organized systems [1] [12]. A confrontation of Newton's clock-time with the discussed action-time of nature, as well as the consequences for a different idea of nature and the universe have also been presented in a popular scientific book [14].

2.5.8. The Significance of Time for Epistemology, the Theory of Knowledge

Established physics treats time as a parameter, as clock-time, devoid of intrinsic orientation and placed outside energetic activity. Long ago different ideas prevailed. Francis Bacon (1561-1626) was convinced that "truth is the daughter of time" and he suggested "to look for principles that support thinking in context between cause and effect in nature". Newton, his compatriot, a century later, did not follow that advice and defined time, clock-time, to function in time-neutral manner as a scale outside the chains of action and effect. Later, quantum and relativity theory used that artificial time, made it even an object of calculation and derived new properties of time, adding to the time mystery.

Interestingly, advanced science philosophy and theory of knowledge did apparently never question the use of Newtons clock-time for finding the truth in mayor theories of physics.

When, for example, looking up Karl Poppers extensive master work: "The Two Fundamental Problems of the Theory of Knowledge" (Routledge, 2011) one does not even find the word "time" in the voluminous index of expressions used. Time is obviously not considered to be a relevant phenomenon and its correct interpretation prerequisite for acquiring reliable knowledge and understanding nature.

The here presented considerations contradict. They tie in with Francis Bacons assessment of time and challenge in essential points, the image which physics is presently drawing as world view. Apart from that, a main target is elimination of the increasing number of paradoxes claimed by physical theories, which have been declared to be unavoidable properties of the universe. These theories have been adjusted to make reliable prediction (which was a big accomplishment), but did it at the expense of counterintuitive mechanisms, which appear to reflect the misunderstood characteristics of clock-time.

3. Conclusions

Within the fundamental features, into which thermodynamic laws are fitting, nature works irreversibly and useful energy is a dynamic information system which aims at decreasing its information content. Nature's time, action-time arises as an information phenomenon from energy driven processes and is guided by the principle of least action subject to thermodynamic laws. On earth, nature's action time is ultimately powered by the sun, causing time intervals between cause and effect and proceeding as an ongoing erasure of information. From some ancient civilisations (e.g. the Indian-Vedic, the Egyptian, the Japanese), it is known that they have considered the sun (energy) as the source of ongoing action and of (action) time. Humans were understood to be part of it. Simultaneously they measured and subdivided time using the periodically migrating shadow as a scale. When

Newton introduced time into physics, he did not understand how time works in nature and selected shadow time, clock-time to describe the always changing nature. This has led physics on a peculiar journey through time, which made time more and more a mystery. The great theories of physics used clock-time to calculate new properties of time, but could nevertheless be fairly well fitted to explain experimental facts. However, in compensation for the wrong time, they mathematically invoked a number of bizarre paradoxes, suggesting a partially illogical universe. This is here understood to be the consequence of not understanding and considering nature's action-time, the real time-orienting thermodynamic time arrow.

A transition from the passive time Newton's to the progressing action-time reflecting nature's own energetic dynamics appears to open the door to a more logically understandable universe. Since thermodynamic law could never before be derived from time-neutral initial conditions, it is concluded that the physical world is subject to an energy-driven time, guided by a dynamically understood principle of least action. This concept should help better understand and imitate the creativity, nature is showing in its self-organized mechanisms and materials, as well as reproducing nature's energy technology in support of a sustainable environment.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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