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Decision – information – time/space

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Abstract

Purpose – The standard terms of time and space lead to logical contradictions near the borderline of physics. Therefore, we suggest a new term for time and space, which enlarges the understanding but takes the actual knowledge of quantum mechanics into account.

Design/methodology/approach – The procedure to define a broader and basic term of time and space is based on the relation between the information stored inside a system, the decision which is to be connected with it and the interaction with other systems.

Findings – Fundamental to this new understanding is a definition and an explanation of the terms system, decision and information. Based on these three terms we developed a new understanding of time and space. In which case, it involves a specifying and extension of the present understandings. A meaningful point is that these three terms determine each other as they are open terms. Thus, they must be used in the interactive description before and during their own definition.

Originality/value – Produces a new understanding and viewpoint which is enlarged by taking into account the knowledge of quantum mechanics.

Keywords Cybernetics, Information control, Decision making, Time study

Paper type Viewpoint

Introduction

The standard terms of time and space (Green, 2002) lead to logical contradictions near the borderline of physics. Therefore, we suggest a new term for time and space, which enlarges the understanding but takes the actual knowledge of quantum mechanics into account (Heisenberg, 1984; Prigogine, 1998). The procedure to define a broader and basic term of time and space is based on the relation between the information stored inside a system, the decision which is to be connected with it and the interaction with other systems.

Fundamental to this new understanding is a definition and an explanation of the terms system, decision and information. Based on these three terms we develop a new understanding of time and space. In which case, it involves a specifying and extension of the present understandings. A meaningful point is that these three terms determine each other as they are open terms. Thus, they must be used in the interactive description before and during their own definition.

All scientific theories shall be downwardly compatible, to be valid. This is a precondition for the following.

The term system

The term System is defined at the beginning, because it is fundamental for the subsequent work. A system encompasses all those things and relations with other systems which can be described as tools for observation. Systems can be characterised by the following assertions:

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(1) Systems do exist.
(2) Each system contains: mass, energy and information.
(3) There are exclusively similar, but no totally equal systems. Each system distinguishes itself from another system in mass, energy or information.
(4) Phase interfaces do exist: status junction of mass, energy or information is characterised by phase interfaces.
(5) Systems have phase interfaces related to their function, characterised by the interaction with other systems. Each system is open in relation to the function of its phase interfaces which are initially defined by the interaction with other systems.
(6) Each system contains at least one decision. This decision is the reference information for the subsequent decisions.
(7) The existence of the terms time and space requires for a system that at least one decision is necessary in order to create a system.
(8) Each system that is observable is an open system. Closed systems in nature are not observable. Models that work with closed systems are feasible approximations.
(9) Principle of ambivalence: in the interaction of two systems A and B the result changes complementary to the function depending on the observing position in A or B.
(10) Systems are distinguished from each other by existing and defined limits. In physical systems these are phase interfaces. These limits are relocatable into or over each other depending on the position of observation and resolution of the observing tool.
(11) Every system (every decision) changes its valency along with time. The further you go in time from the valency change the more energy is required to maintain this valency. Reference systems and their characteristics change with each transition of a decision. Two consequences are:
    - information itself cannot be conserved (maintained); and
    - functional information changes along with time.

The world consists of systems described by:

- inner characteristics (mass, energy, information); and
- limits which are systems too (e.g. surfaces of solid bodies)

A fundamental question for understanding the term system is: are systems open or closed? Completely closed according to all properties means no mass, energy or information flows neither into nor out a system. Thus, a completely closed system is not observable or experienced by other systems. Thus, closed systems are those, which are not accessible, i.e. they cannot be observed, otherwise there would be at least one interaction between the observer and the system, which would lead to a flow of mass, energy or information. Overall, it can be said that all systems that can be experienced are open. This also results in the assumption that the system of cosmos/universe cannot be comprehended as a closed system. On the contrary, it must be assumed that the universe is an open system.

Isolation with respect to one or more characteristics but not all characteristics can be adequately attained, but not complete isolation. Thus, the following is applicable to the world that can be experienced:

- all systems that can be observed are open; and
- and since limits are also systems they are also open.

System characteristics are stored in the information on the system (Figure 1), which is ultimately reduced to decisions in the historic course of the system.

Systems can be distinguished from each other by at least one decision in their history and are thus *per se* incoherent. According to a valid knowledge base, coherent systems are characterised by identical information content and thus represent only one system as per our interpretation. From the conventional point of view, a subsystem emerges only by interacting with other systems. Coherent light can be mentioned here as an example, whose description through photons is reasonable only if it is based on an interaction with other systems. This means, a particle of light is isolated and measured.

Limits are formed through the transitions in the function of these systems. Examples of phase interfaces are shown in Table I.

Rules and laws of the interplay of system components change at the phase interface:

- At least one rule of the interplay changes.
- Impression or occurrence of the phase limit depends upon the number of rules undergoing change.

A rule is defined by assigning a characteristic to individual systems.

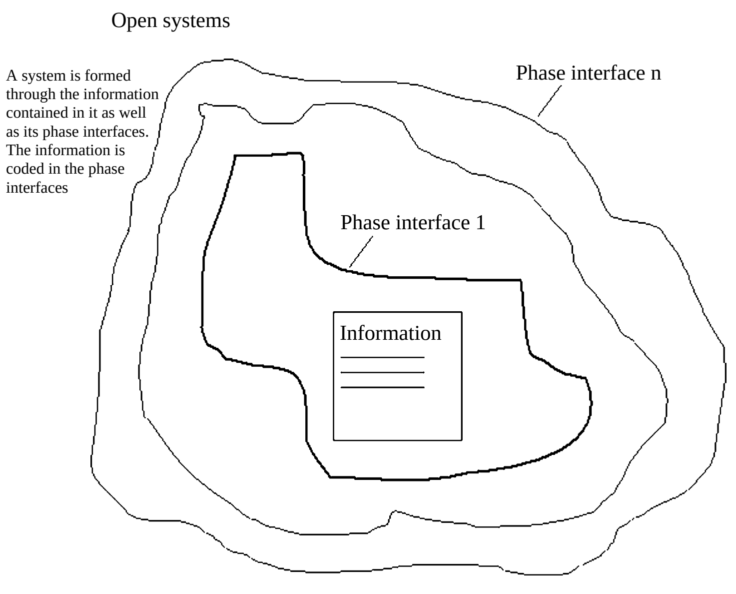


Figure 1.
Open system

Closed systems are present only in the form of information, cannot be observed and thus they represent a causal pole position. Examples are the absolute temperature zero point at 0 Kelvin, attaining the speed of light using matter, black holes without any interaction, etc.

The term of decision

The introduction of the concept of decision is directly derived from the existence of information itself and its variability. In addition to mass and energy, information is another principle quantity for describing systems that can be observed. At this point the concept of decision, which represents the basis of information, must first be clarified. The term decision defines and expands the term information. A decision is the ascertainment or determination of a binary transition. A decision is the last instance in the subdivision of nature (mass, energy, information). Generalisation to more complex decisions is derived from the interaction between individual systems. The idea that we are dealing with, e.g. turning down of a spin of an elementary particle or changing the storage location in the computer is very helpful for the following considerations. According to a prevailing time model, decisions can be differentiated in two categories:

(1) decisions that have already been made; and

(2) probable decisions.

The past is characterised by the first and the future is characterised by the second category. It is clear that the decisions made are bound by the temporal past. On the contrary, in case of probable decisions it is clear that the decisions that will only be taken in the future can still be seen in the present as probable decisions. This also includes probable decisions in the past. This case comes into being only if the information about a past decision is lost. Enough examples of this can be found in all the branches of science dealing with the history of systems.

A decision describes the selection of a particular path, if it is considered in the view of the classical idea of space. Every bifurcation in the path compels a decision made in the past and that which conditions the probable future. These are the paths in the field theories of quantum mechanics, which determine the trajectory of a particle. The decision is defined by the result, which conditions "continuation" or "non-continuation". Thus, a decision determines a transition of state from the logical or information theoretical point of view. This leads to the ascertainment that a decision is made only in conjunction with a reference or reference information. Accordingly, the essential condition for a decision is the presence of a reference. Since, reference is also a piece of information, this term should be explained in the section on information.

Phase interfaces	Functions
Surface	Roughness, structure, internal stresses, surface tension, temperature transition area, potential transition area
Communication interface	Information or data transmission
Currency	Adjustment of exchange rates of different countries

Table I.

It must be first ascertained that even the elementary decisions can emerge only as a result of the interaction between at least two systems. A decision can be inherent to a system or can be caused by interacting systems. If the decisions are inherent to a system, they must then contain subsystems, which can represent at least one reference. The decision should be described using parameter *D* (according to the word "*D*ecision"). It can assume the value, e.g. 0 or 1.

The decision is linked to systems and their function:

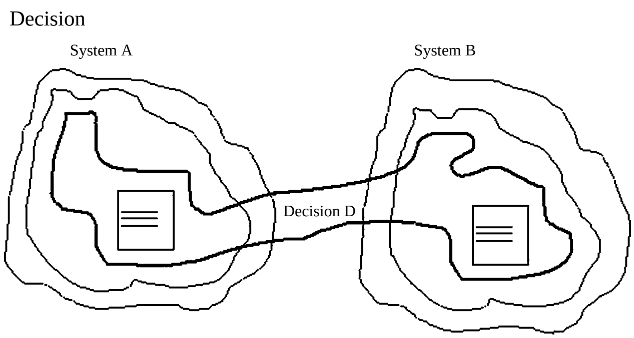
- it is necessary that every decision is linked to an interaction with a reference;
- it is necessary for every decision to lead to at least one subsequent decision; and
- every system distinguishes itself from others by at least one decision (Figure 2).

Overall, it can be said that: two systems interact with each other precisely when at least one decision is drawn emerging from the probable decisions. This can be described with the help of the simplest Feynman Graph (Feynman, 1989) (Figure 3).

What is the meaning of "to decide"? If one considers a system that can adopt two states, then "to decide" means a transition of the state within the system. Only a transition of the state of a system presupposes the concept of time. This leads to an idea that there exists a minimum decision-making time for a system. The term time makes no sense below this base quantity. Thus, for a system, time can be considered as a digital quantity. This idea has been further elaborated in the section on the definition of space and time.

System and decision

Every system is characterised by a number of decisions forming the reference information of the system. A system with a defined limit emerges only if at least one other decision is contained in that system. That is, every system, that can be experienced or observed, distinguishes itself from other systems by at least one decision.



System A exchanges information with system B. Information from A leads to a decision D as a result of the interfaction with the reference information. This decision causes the information in A and B to change.

A third system cannot observe A and B with respect to their phase limits in the decision transition. The phase limits of both systems form an independent system.

Figure 2.
Decision transition between systems

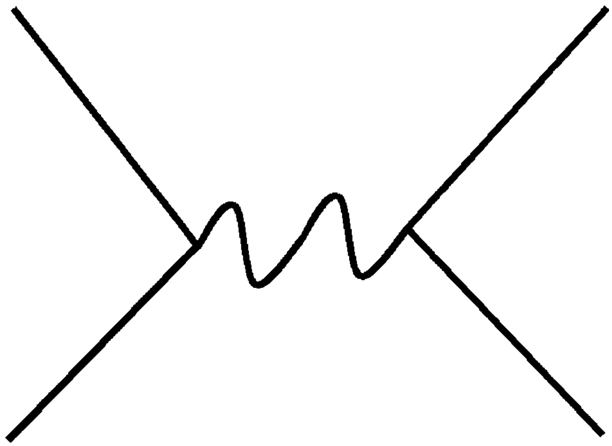


Figure 3.
Feynman graph

Decisions and quantum mechanics

It can thus be said that decisions are the most elementary system quantities. These decisions or those called by Weizsäcker Ure (Weizsäcker, 2002) ultimately have only two properties: they differentiate themselves on the basis of their position in space and their internal state (yes/no; ±; 0/1;...). Two decisions cannot be present at one point in space.

Latest developments in quantum mechanics led to the Quantum-Loop-Theory (Smolin and Markopoulou, 2004), in which also space-time has been quantified. These considerations result in the theory that there exist only sub-volumes of space with a limited quantity. Their quantity is determined using the Planck length: $V_{\min} = {l_p}^3$.

Both statements when combined state that decisions take up limited volumes of space, at least in the order of magnitude of the Planck length. Thus, this quantified space along with the decisions contained in it represents information storage.

The term information

The term information (Shannon, 1948) is basically characterised by the exchange of signals or messages (even more complex descriptions of states like, e.g. language), which is the basis for all types of communication. This term plays an important role even in thermodynamics for the energetic consideration of systems in the case of increasing disorder characterised by the term entropy. The information constitutes the set of decisions made. Accordingly, information is decisions taken in course of time and stored in the systems.

Quantum mechanics extends this term of information (Bruß 2003) to all probable decisions of a system.

This is mathematically evident by integration over an infinite number of states in the Hilbert space.

Abstention from the description of a system with trajectory curves (like, e.g. in classical mechanics) subsequently allows only probability statements about the future of a system. Although an individual system shall assume one of the probable states, it cannot be determined in advance as to which one it would be. Accordingly, in case of the gap diffraction experiment, the probability for the entire phenomenon – the diffraction pattern – can be given. However, it is not possible to define the path for every individual photon. This gives an altogether new dimension to the term of information. If the basic mathematics is taken into account, there exists unlimited potential information prior to the experiment, which is subsequently reduced to a decision at the end of the experiment.

In addition, thermodynamics (Sommerfeld, 1977) shows that information and energy are mutually conditional. The information is defined with the help of the entropy of a system. Energy is required to gather information. This energy becomes greater and greater in the classical time model in order to conserve a piece of information temporally. This further signifies that information cannot be conserved for an unlimited period of time. This is the outcome of the entropy principle by taking into account the limited volume of available energy.

Overall, information represents a superior and more abstract state, which determines the future development of the system while entropy is increasing.

The idea illustrated here lays down the following cascade: mass, energy, information. Thus, information is the superior descriptive term for systems and energy is a subordinate descriptive term comparable to the concepts between energy and mass.

Information is not static, but is a subject to change. This change is a result of decisions.

This must be clearly explained to support the term of reference defined in the previous section.

Basically, a reference is information. And exactly the information required to make a decision. It is stored in a system. If a decision is made based only on the information inside the system, then it is self-determining and termed as an intrinsic decision. If information to make a decision is required from another system, then such a decision is termed as an extrinsic decision. Let us consider a ball colliding against a wall: in order to determine the further path of the ball, information about the ball (path, speed) as well as about the wall (considerably greater mass) is required. Thus, the reference information of both systems is essential for the interaction.

There exists an information potential with respect to the quality of reference information. For example: what is logically wrong strengthens what is logically right (Contrast).

The reference information determines the phase interface of a system with respect to another system. The complete reference information about both systems to be considered must be present within this phase limit.

It can be summarised that the world is made of open systems. These can be single particles, living beings, crystals, planets or "universes". A large volume of information is stored as reference information in each of these systems: a point in space, time, size, charge, etc. This is valid as a reference while interacting with other systems. There is constant exchange of information as all systems interact with other systems. In elementary particles, this exchange takes place through the basic forces: gravity, electromagnetic, weak or strong interaction. In case of humans, this exchange takes place through visual or acoustic signals. This exchanged information assists on the one hand in the interaction between systems, i.e. particles with the same charge repel each other, planets are subjected to gravity or human beings converse with each other. On the other hand, it may so happen that references change due to this information. For example: a d Quark decays into a u Quark and a W^{-} Boson. A human being learns from mistakes. A biological system is subject to a hereditary modification. Decisions in the system play a decisive role in these transitions. These can be influenced externally, i.e. the system is stimulated to take a specific decision by an external system. Or even intrinsic, e.g. a radioactive particle decays; a human being decides to do something on his own. The element, which is the trigger factor for a particular decision, can count as the superior instance, which should not be investigated further at this point. Thus, decisions cause information to change.

Definition of space and time

Time exists as variable, whose direction is principally reversible in many descriptive models (Genz, 1999; Mainzer, 2002; Weyl, 1961) for physical relationships. The concept of time is based on the second main principle of thermodynamics, which describes the increasing disorder of systems. An irreversible direction of time as well as ideas about the past and the future can be derived from this.

We assume that the world consists of open systems, which interact with each other. Every system consists of reference information and information arriving from other systems. The system takes certain decisions based on the interaction between the incoming information and the reference information. Another system cannot observe the decision-making process of a system. An uncertainty emerges out of this decision transition. The observing system receives information only after the decision has been made and only then can it take its own decision based on the prior decision. For an individual system, local time emerges due to this decision transition created by the incoming information and the reference information. The local presence of a system originates as a result of the decision transition, this means time is system immanent and not an absolute quantity.

Thus, there exist local presents in every system. For a system, this signifies that the past can be put on the same level as the reference information of a system. Future is the quantity of all probable decisions based on the reference information and the information arriving from other systems. The time originates for an observer precisely when he exchanges information with another system and reduces the primary potential information. The chain of cause and effect of the observed decisions creates a feeling of time in the observer. This means a superior but locally restricted present for the systems exchanging information among each other. If a great number of systems exchanging information do exist, they synchronise themselves using defined information and a local and continually perceived course of time emerges from the same.

It can be concluded that space originates exactly at the point where information is being exchanged between the systems. Systems can be observed only through a decision, the observing system changes its phase interfaces and thus encompasses the system that is being observed. The phase interface changes if a decision is drawn. Thereby, space originates through the process of observation.

The time perceived as the decision-making time corresponds to the certainty of observation. This is conditioned through the Heisenberg principle of uncertainty. It can be theoretically minimally reduced to the duration of a decision (greater than or equal to Planck's time). The conclusion is: the past and the future are uncertain as far as the system is concerned. This is universally applicable to open systems.

A topology for the linked systems can be derived at this point (Figure 4). If one considers this world as a quantity of systems containing reference information, a

Network of decisions in space and time

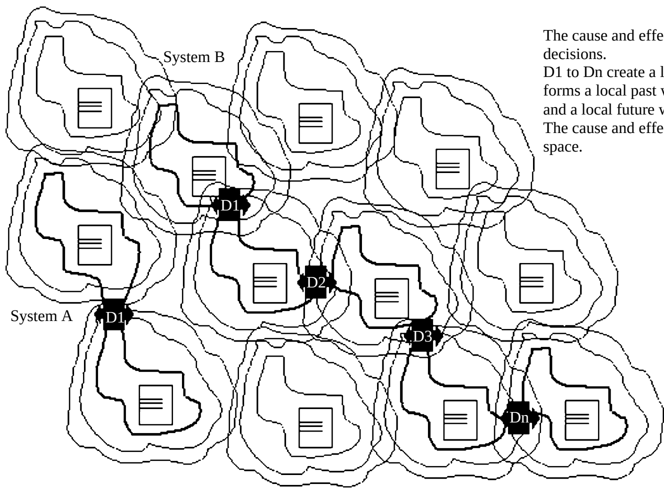


Figure 4.
Topology of the decision network

network of systems emerges. This network consists of the reference information as nodes and an exchange of information between systems, which forward the decisions that have already been taken and therefore the information in the form of links between the nodes. The space in which we perceive this scenario, to get at least some idea about this network, has primarily mathematical significance. Only the actually observed exchange of information stretches the physical space and time.

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