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Looking at the Dimension of Time among Science, Psychology and Everyday Reality

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ABSTRACT

In this paper it is given an interesting overview about the concept of time. Starting by the three historically identified arrows of time, we consider the perception of time in relation to philosophy and psychology, then focusing about charming results of modern high energy physics and thermodynamics, which make the study of time and space one of the most fascinating challenges of contemporary knowledge.

***Keywords*:** Time; Philosophy of Science; Modern Physics; Cosmology; Thermodynamics; Irreversibility; Reality

1. INTRODUCTION

If we consider the "real" time, there is a great difference between the forward and backward directions, as everyone well knows. Physics recognizes in the universe an asymmetry between past and future, which is determined by the second law of thermodynamics. However, examining the matter at atomic level, the origin of the temporal asymmetry appears to be a mystery; in fact, the process of collision of any two molecules is completely reversible and does not show preferential orientations towards the future or the past. This problem, known as the "arrow of time", interested physicists, scientists, philosophers, writers. The Austrian physicist and mathematician Ludwig Boltzmann tried to define the delicate question in a clear manner, but it remains still open.

Even if we have the impression of the flow "always ahead" of time, in the electromagnetic and mechanical laws of motion, for example, nothing differentiates the time advancing from that flowing backward.

The second law of thermodynamics describes a quantity called "entropy", which always increases or remains constant and is related to the degree of disorder of a system. At global level, whenever there is a reaction, the entropy always increases so as the time.

Not only in the field of thermodynamics, but also at cosmological level, we can denote the arrow of time in the expansion of the universe; as time increases, so the mutual distances between galaxies are increasing too.

It has been historically identified at least three arrows of time:

1) the *psychological arrow*, related to the direction in which we "feel" to pass time;
2) the *cosmological arrow*, that is the direction in which the universe is expanding and not contracting;

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3) the *thermodynamic arrow*, which affects the direction of time in which disorder increases.

The psychological and thermodynamic arrows would point in the same direction, the cosmological and thermodynamic arrows could not point in the same direction for the entire history of the universe, according to some current cosmological theories and in relation to the boundary conditions of the universe and the "anthropic principle".

Even literature and art are full of images of time: the "river of time", the "pressure of time", the "wagon of time". According with some line of thought, the "now" moves continuously through the time from the past to the future; according to other ones, the "now" appears motionless in the "flowing incessantly river of time" [1,2].

In the following of paper interesting informations and reflections are considered, in particular considering modern developments of knowledge and science.

2. THE PERCEPTION OF TIME BETWEEN PHILOSOPHY AND PSYCHOLOGY

Our experience of reality is so bound to the time, that the attempts to dispute this concept have always encountered considerable resistance. Our sense of personal identity is inseparably linked to the memory and to the continuation of the experience. The sense of time is one of the most elementary sensations of our experience; we feel the flow of time in a well evident manner. Different senses are predisposed to the perception of space: touch, sight, hearing. There is not a special sense for the perception of time, although we can talk about a "sense of time".

The relativity of time involves the irreducible plurality of times in relation to the dimensions of human experience, matter not only of scientific research, but also of philosophy (Bergson, Wittgenstein) [3,4] and literature (Proust, Musil) [5,6]. Some authors, including Bradley, have studied the so-called "parallel times", everyone independent by each other. Psychology has spoken of a "pseudo-present" (W. James) or "psychic present" (W. Stern), which is not the "now", but involves some number of seconds [7].

James considered a model that divides the universe into many sub-universes of reality, each governed by its own criteria of meaning; so we have the "world of everyday life", the "world of dreams", the "world of myth", the "world of madness", the "world of scientific knowledge", etc. People live into multiple different time regimes, with local times. We assist to the fall of the barrier of the "present as a point". The point becomes viable in both directions; the three dimensions of time result combined.

In everyday life we have the impression of time flowing, in the sense that the present is continuously updated. We have a deep insight of the fact that the future is open until it becomes present and that the past is fixed. Passing time, this structure of fixed past, immediate present and open future is transported in time and from it depends the way of our lives. This thinking modality is natural, but it doesn't have scientific basis. The Einstein's theory of relativity suggests that there isn't a single special present and all moments are equally real.

The difference between the scientific idea and our everyday idea of time has grown enthusiasm among thinkers; physicists deprived the time of most of the properties, that we normally ascribe to it. According to many theoreticians, the time could even not exist. At a fundamental level, the time may not exist, but it appear at higher levels, such as a table looks solid, although it is a set of particles composed mostly by empty space.

The solidity is a "collective", or "emergent" property of the particles. Even the time could be an emergent property of the basic ingredients of the universe. Some philosophers considered distorted this vision of the universe, because it does not include the idea of an arrow of time, which is on the contrary the basis existential dimension of human beings.

It is not exactly known how the human brain works, but we know a lot about the work of computer memories. Therefore, examining the psychological arrow of time for computers, scientists are getting interesting informations in relation to the human brain. A classical computer memory is basically a device containing elements, that may exist in one of two different states. A simple example is the abacus.

Before an information is recorded in a computer memory, it is in a disordered state, with equal probabilities for each of the two possible states; after interaction with the system that needs to be remembered, the memory will be found in one state. Each ball of the abacus will be or in the right, or in the left side of each rod; the memory passes from a disordered to an ordered state. But for doing that, some amount of energy is needed, so as to move the balls of the abacus and to supply power to a computer.

This energy is dissipated as heat and contributes to increase the amount of disorder in the universe. It can be shown that such increase in disorder is always greater than the increase of order in the memory. Thus, the heat expelled by the fan of the computer means that, when a computer keeps track of information in his memory, the total amount of disorder in the universe increases again. The direction of time in which a computer remembers the past is the same in which disorder increases. Our subjective sense of the direction of time, the "psychological arrow of time", is therefore determined in our brains from the thermodynamic arrow of time. Just like a computer, we remember things in the order in which entropy increases.

3. TIME AND MODERN HIGH ENERGY PHYSICS

The Isaac Newton's laws of motion require that the time has specific characteristics. Regardless of when and where an event occurs, classical physics assumes that it is possible to say objectively whether it happened before, after or simultaneously with any other event in the universe; time orders the events of the world.

Furthermore, in order to define speed and acceleration, time must be continuous. According to Newton, the world has a universal clock and time flows by providing an arrow through which we know the direction of the future. The characteristics of the Newton's time are "order", "continuity", "duration", "simultaneity", "flow" and "arrow". Between the late nineteenth and early twentieth century, two new ideas revolutionized the classical Newtonian physics:

a) Ludwig Boltzmann pointed out how Newton's laws work both forward and backward in time, so time does not have a pre-defined arrow. He proposed that the distinction between past and future was not intrinsic to time, but it was born by asymmetries in the organization of matter in the universe;

b) Albert Einstein eliminated the idea of absolute simultaneity. According to special relativity, the simultaneity of two events depends on the speed at which we move.

With the Einstein's theory of general relativity, which extended the special relativity, gravity warps time, then a second in two different places cannot have the same meaning. In general it is not more possible to think the reality as if it evolved a moment after another, following a single time parameter. In general relativity, however, the time has a distinct and important function: it locally distinguish between "time-like" and "space-like" directions. The events with a "time-like" relation may have a causal link among them. These are events for which a signal can pass from an object to another, influencing what happens. The events with a "space-like" relation are not linked in a causal way.

One of the most important objectives of physics is the union between general relativity and quantum mechanics, for having a single theory that deals with both macroscopic gravitational and microscopic quantum aspects of matter. Quantum mechanics says that objects have a richer behaviour than that described by classical physics. The complete description of an object is given by a mathematical function, the "quantum state", which evolves in time. This quantum state can give us only the probabilities of the various outcomes; the outcome of the experiments has therefore a probabilistic nature.

Several research areas tried to reconcile general relativity with quantum mechanics: the superstring theory, the quantum gravity, the theory of causal triangulation, the non-commutative geometry. In particular, with the "loop quantum gravity" (LQG) (Carlo Rovelli, Lee Smolin), derived from the canonical quantum gravity, Einstein's gravity equations have been rewritten, thinking to the same ideas utilized to develop the quantum theory of electromagnetism [8,9]. A very strange result appeared: in the equation, called "Wheeler-DeWitt equation", the time variable is not present.

Carlo Rovelli and Julian Barbour are among the most prominent supporters of this idea. They tried to rewrite quantum mechanics without the time. As example, instead of saying that a ball accelerates to ten meters per second at square, we can describe it in terms of the change of an object or in terms of the variation of temperature or pressure. Time becomes redundant and a change can be described without it directly, but with other correlations. This huge network of correlations is organized in an orderly manner, therefore we can "invent" something called "time" and relate everything to it, without keeping track of all direct relations.

Also the money helps life, if compared to the ancient modality of the "exchange", but it is an invented label, that we attach to things to which we attribute a value, it is not something that has a value in itself. The universe may be free of time, but if we divide it into several parts, some can become the "watch" for others; so the time "emerges from the absence of time". We perceive the time because our nature is to be one of those parts, and the time of our everyday experience exists; it is the time as a fundamental variable that cannot exist. Quantum gravity describes what happens on a very small scale. The time of our experience, in this context, is something emerging from phenomena, such as colours emerge from our perception of light.

The notion of time arises from the fact that at macroscopic scale we have an approximate description of the world; time is a result of our ignorance. In fact, while we can write the equations of mechanics without time, we cannot do it with those of thermodynamics. The idea of reversibility and irreversibility requires an arrow of time. But this happens because we choose a few variables (pressure, volume, temperature) for describing the system, and these are mediated variables, by the evolution of which time emerges in a natural way.

The laws of science do not distinguish between past and future. The so-called "CPT symmetry" is a fundamental symmetry of physical laws under transformations that involve the simultaneous inversions of charge (C), parity (P) and time reversal (T). The CPT symmetry implies that a mirror image of our universe, with all objects having moments and positions as reflected by an imaginary mirror (corresponding to the inversion of the right with the left), with all matter replaced by antimatter (corresponding to the inversion of the charge, i.e. the exchange between particles and antiparticles), and with time running backwards, will evolve just like our universe.

At each instant the two universes would be identical; the CPT transformation can transform one into the other. The laws of science governing the behaviour of matter remain (in normal situations) unchanged under the combination of the two operations C and P; being unchanged also under the combination C, P and T, they must remain unchanged even under the single operation T [10].

Nevertheless there is a big difference between the forward and backward operations in real time in the common life. The second law of thermodynamics results from the fact that states are always more disordered than ordered; an intact glass on a table is in a state of high order, while broken on the floor is in a state of disorder. The increase of disorder with time (or the increase of entropy) is an example of the arrow of time, something that distinguishes the past from the future, while providing a precise direction [11-13].

4. REVERSIBILITY, IRREVERSIBILITY OF NATURE AND THERMODYNAMIC SYSTEMS

We observe the irreversibility at each level of observation. There are simple irreversible physical-chemical processes, such as the heat conduction, the viscosity, chemical reactions. But the introduction of the irreversibility in the fundamental laws of physics is a different problem. The two most important theories of this century, quantum mechanics and relativity, deny that time has a direction (in our common sense). A tendency is to say that we introduce the direction of time through approximations inside the physics laws, which are reversible with respect to time.

These approximations are generally associated with studies of entire systems from a more macroscopic viewpoint than the examination of the individual composing particles. Another approach is to emphasize the so-called “decoherence”; it would originate from the influence of the outside world on the studied system.

The deterministic point of view implies the possibility to keep everything under control just by changing the initial conditions, so that science produces certainty; on the contrary, introducing the irreversibility of time, also the probability is introduced. The end of certainty implies the possibility of novelty and evolution.

Systems near the equilibrium, and those who are far, react substantially different to perturbations. When a system near equilibrium is perturbed, it returns to equilibrium like a small perturbation of a pendulum. The mathematical reason is that there are extremal principles in thermodynamics, as the fact that entropy is maximum at equilibrium, and if the equilibrium is perturbed, entropy get low and the system responds by returning to maximum entropy.

Far from equilibrium, stability with respect to perturbations is in general lost; we have “bifurcation points”, originating from the non-linear character of the equations of evolution. There is a large number of new phenomena associating to irreversibility and this happens only in systems far from equilibrium. In front of a bifurcation, different possibilities are eligible, different paths to follow. The system “chooses” a way; repeating the experiment, the system can choose a different way. The choice is associated to probability, the future is not fixed [14,15].

Jean-Louis Deneubourg made important experiments with ants. Thinking to an anthill, a source of food and two bridges, in some time all ants are on a bridge; repeating the experiment, ants can be on the other bridge. The mechanism appears “auto-catalytic”: each ant encourages the others to pass on the same bridge. This is a simple example of bifurcation in biology; also the human history is full of bifurcations.

When we passed from Paleolithic to Neolithic era, humans began to take advantage of the resources of agriculture and metallurgy; we can consider this as a bifurcation, with several ways, since (for example) the Neolithic period in China was different from that of the Middle East or Latin America. As a new material resource was discovered (such as coal or electricity), the world has been reorganized; these are bifurcations. Currently the world is changing for the information technology, growing at an unexpected speed.

Deneubourg assessed the existence of 12000 species of ants, some living in small anthills of a few hundred units, others as members of huge anthills with millions of units. In small anthills every ant acts independently from the others; in larger anthills there are “collective motions”. We found a similar behaviour in the traffic flow: when it is diluted, everyone follows his own inclination, there is the tendency to follow a personal program; when a critical concentration is reached, we have a bifurcation and people goes together to a new path. It is a collective motion [16].

The historical perspectives correspond to a sequence of bifurcations. Two very close initial conditions may give rise to very different evolutionary trajectories. For every deterministic chaotic system it exists another representation in which the crucial quantity is the probability.

Bernard Koopman and John von Neumann introduced a description of classical mechanics in terms of the Hilbert space, the so called “Koopman-von Neumann mechanics”. They demonstrated that it is possible to define an Hilbert space of complex, square integrable wave-functions in which the classical mechanics can be formulated as an operatorial theory, similar to quantum mechanics. This is true only in the context of the Hilbert space. The extension of the evolution operator outside the Hilbert space gives rise to different formulations of the physics laws, which include the “time symmetry breaking” and in which the basic quantity is the probability. At mathematical level the origin of irreversibility is as follows: the “evolution operator L”, the “Liouville-von Neumann” operator for particles, has real eigenvalues within the Hilbert space, while in general presents complex eigenstates out of the Hilbert space. Out of this space, a probability distribution is obtained, which cannot be expressed in terms of trajectories; in this process of transition to thermodynamic limit there is the breaking of time symmetry [17].

This is a well-known situation in sociology: the behaviour of a population cannot be attributed to the behaviour of individuals. The same appears to be true for a lot of important classes of systems such as the thermodynamic systems and the interacting fields [18-20].

5. ARROW OF TIME AND MODER COSMOLOGY

The entropy of the present universe is low because it was much lower a billion years ago. This line of reasoning leads back to the “big bang”, when the entropy was extremely low. There are strong reasons to believe that, in the early universe, the matter was uniformly distributed and in thermal equilibrium at a uniform temperature. For a system submitted only to short-range forces, matter would be homogeneously distributed and at uniform temperature in a state of maximum entropy; but the situation changes dramatically when a long-range force, such as gravity, is present.

There are two basic ways for the possible explanation of the “so special” initial state of the very early universe:

a) the initial state of the universe was “completely random”; dynamical evolutionary behaviour was responsible for making the universe to be “so special”;

b) the universe simply came into existence in a very special state.

The first viewpoint appears to be presently favoured by the majority of cosmologists. The best developed idea for producing a such universe from random initial conditions is the so-called “chaotic inflation” [20]. The fact that inflation can provide a satisfactory explanation for the origin of the thermodynamic arrow of time is however still controversial. In order to dynamically evolve from an assumed "random" initial state to the kind of very "special" observed state, it is necessary to invoke rare and highly unlikely events.

6. CONCLUSION

It is possible to assume that everything in our universe is evolving in the same direction of time: rocks, stars, galaxies, clusters and superclusters of galaxies, everything is evolving in the same direction; we get old together too. We can conclude that our universe appears to be the result of a process of broken temporal symmetry. It is a still open question in which the direction of time plays in every case a central role.

It is not yet clear whether space and time are concepts entering into the definition of the universe, or useful knowledge for its description; a precise answer is currently not present. In any case, the richness of the involved concepts and their deep bond with aspects of contemporary mathematics, physics and philosophy makes the study of time and space one of the most fascinating challenges of contemporary knowledge.

Biography

Paolo Di Sia is currently professor of "Foundations of Mathematics and Didactics" by the Free University of Bolzano-Bozen (Italy). He obtained a Bachelor in Metaphysics, a Laurea in Theoretical Physics and a PhD in Mathematical Modelling applied to Nano-Bio-Technologies. He interested in Classical-Quantum-Relativistic Nanophysics, Theoretical Physics, Planck Scale Physics, Mind-Brain Philosophy, Philosophy of Science, of Physics and of Cosmology, Econophysics. He is author of more than 130 works at today (articles on national and international journals, scientific international book chapters, books, internal academic notes, scientific web-pages, in press), reviewer of two mathematics academic books and is preparing a chapter for a scientific international encyclopedia. He is reviewer of some international journals and invited to review and as editor. He obtained 4 international awards, was included in Who's Who in the World 2015 (32nd Edition), is member of 5 scientific societies and of 13 International Advisory/Editorial Boards.

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