MODERN SCIENCE AND TIME: AN EVALUATION

As Gadamer says[1], the problem of time is more inextricable and confusing than any other question. This is certainly one of the reasons why there is so much discussion going on about it. Is time real or is it a subjective form of our mind[2]? It has been argued by some that the traditional concept of time can no longer be upheld in the light of the discoveries of modern physics and should be placed in the museum. When one asks what is meant by «our traditional concept of time» the answer is that it considers time a sort of dimension, as space, independent of the bodies moving in time and, secondly, that it is the same for the entire universe and runs in one direction. This is the idea of absolute time. Influenced by the Cambridge Platonists Newton considered time an absolute reality in which things happen. His famous saying at the beginning of his *Philosophiae naturalis principia mathematica* runs[3]: «Absolute, true and mathematical time, of itself and from its own nature, flows equably without relation to anything external and by another name is called "duration". Relative, apparent and common time is some sensible and external measure of duration, by the means of motion which is commonly used instead of true time, such as an hour, a day, a month, a year». In this definition Newton reifies time and ascribes a kind of flowing to it which he sees as absolutely uniform and the same for all entities in the physical universe. Moreover, in Newton's view there seems to be something which controls the rate of flowing, so as to secure the same speed. Newton's time is independent of the sequence of events which it encompasses.

Newton's view of time was so much interwoven with daily experience that most physicists accepted it as self-evident until at the beginning of the twentieth century serious doubts arose about its correctness. After some initial hesitation scientists began to propose several new theories of time. They now held Newton's view to be no more than an approximation and thought that refined methods of observation oblige us to abandon it. I shall try to discuss some of the newer theories.

What led scientists to this new view was Einstein's attack on the theory of the world ether, functioning as a system in absolute rest serving as a basis of coordinates

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[1] In P. RICOEUR (Ed.), *Le temps et les philosophies*, Paris 1978, 39. Augustine makes a similar observation in his *Confessiones*.

[2] One of the 219 propositions condemned by Étienne Tempier, bishop of Paris, in 1277, asserts that time exists in human apprehension and not in reality (*in re*).

[3] Scholion to Definition VIII.

and, secondly, his Special Theory of relativity which stated that time is relative to the position of the observer. Two observers at different distances from an event will see it happen at a different moment, since each of them has his «own time» and so they will disagree about the precise time at which the event actually happened. Einstein went so far as to suggest that there never is pure and absolute simultaneity, because light signals need time to reach us. All our observations are retarded because light needs time to traverse a certain distance. At a certain moment of the observer's time the world cannot be observed as it is at that moment. However, as Maxwell had argued before, Einstein assumed that the speed at which the signal (magnetic and light waves or particles) is propagated is always the same. However, this assumption goes beyond what experiments have yielded. In the the vicinity of celestial bodies which exercise a certain attraction of gravity, the speed of propagation of light varies, or at least its curved trajectory means that it needs more time to reach us. Observed simultaneity is always dependent on distance, location and the speed of light. One can even construct a curious illustration of this view. Suppose you set out on a journey in space on Easter Day noon when the Pope is blessing the crowds on the square of St. Peter's. When leaving behind the earth at the speed of light, you would at any given moment during your journey see the Pope's blessing hands raised. But if you would travel increasingly faster than the speed of light, you would see the Pope appear on the balcony, then leaving the elevator, then leaving his apartments. So you could actually go back in time. The events would seem to be running backwards. Some have wondered whether we have to do with reversibility here. However, the example does not mean more than a movie being played backward from the end to the beginning. In the real world, on this particular day at the Vatican, the Pope does not walk backwards from the balcony to his apartments. Let me add that it is impossible ever to carry out this type of experiment: there is no speed greater than that of light. Therefore, on closer inspection, the example loses its meaning, in other words, it is non-sensical, like a square which is said to be a circle. Einstein's way of arguing rests on a preconceived reduction of time as duration to time as a measure, so that time is just a category of the human mind. Let me add that when there is no absolute simultaneity, there is no absolute succession in time either, in other words there is no real time at all. The experimental relativity of simultaneity has led to a rejection of time[4].

In his approach Einstein starts from the observation of time as depending on the photons which allow us to see the indication of time on any type of clock, whether mechanical, electric, electronical or based on nuclear processes. The time the photons need to reach us is their speed divided by their distance from us. When the photons are emitted by a source moving away from us, they need more time to reach us. In other words, compared to our time on earth, the photons seem to move slower. In a paper published in 1911 Einstein submits the following consideration[5]. If we put a living organism in a box and would let it travel in space at close to the speed of light and have it then come back to the earth it would be in practically the same state,

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[4] Cf. K. GÖDEL, *Relationship between Relativity Theory and Idealistic Philosophy.*

[5] In *Vierteljahresschrift der Naturforsch Gesellschaft in Zürich* 56 (1911).

while organisms of the same species on earth would have aged or have passed away. Astronauts going to distant stars at the speed of light would consider their journey as quite short. At their return their children would in the mean time have aged considerably. This idea is aiso expressed in the well known paradox of twins, one of whom makes a long trip in a space craft which moves away at a speed close to that of light. Upon his return to the earth he would have lived in a slower time and be younger than his twin brother who had aged much more while staying behind on the earth. In this view each body has its own time resulting from where it is and how fast it moves. In my opinion this theory only concerns a certain way of measuring time. Needless to say that this is quite clumsy, since it confuses time as duration and time as a measure. The fact that at the beginning of the century the dominant theory of time was Kant's concept of time as «eine reine Anschauungsform» undoubtedly helped Einstein to argue the way he did. Since an absolute measuring of time is impossible (all standards, all fixed points are continuously changing) he wanted to do away with the idea of time as such, that is with the distinction between the past, present and future. To him time is no more than a function accompanying bodies in movement[6]. In this way time is spatialized. In reality, however, time and space are two different modes of being in the material world. But they are related. As we shall see later, there is a fundamental process of movement in the universe on which other processes depend and to which they can be compared, at least mentally. In the example of the twins the human organism and its processes each with its own duration will apparently go on as usual, regardless of their position in space and the speed at which the body is moving. There is a close connection between time and space, but temporal succession is not a spatial relationship.

A more serious problem arising from Einstein's and Minkowski's presentation of things is whether real things exist in space and time or whether space and time are connected functions and aspects of the same reality. The theory of relativity does not distinguish between coordinates in space and the pinpointing in time of a local movement. Since the speed at which light is propagated is always the same, Einstein, speaking of light emitted by a source, could construct a cone of light representing the trajectory which it covers in space-time. However, this did not take into account the influence of gravitation. In his General Theory of Relativity Einstein proposed the view that the trajectories of light in space-time are curved instead of following straight lines because of the attraction exercised by bodies in the universe. Indeed, in a further development of his theory Einstein argued that the velocity of time is affected by mass, so that if the earth were larger, time on earth would be slower. The following is meant: the more energy a beam of light possesses, the higher the frequency (the number of light waves per second). In the vicinity of a massive body the energy of light decreases under the influence of gravity, so that its frequency also diminishes. In other words, time as expressed in such a frequency will flow slower. So, in a a sense, Einstein eliminated time. Einstein even went beyond this position and suggested that all distinction between the past, present and future is an illusion[7].

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[6] Cf. V. MEYER, «Die Zeit in die Relativitätstheorie», in R. W. MEYER (Hrsg.), *Das Zeitproblem im 20.Jahrhundert*, Bern-München 1964, 27-34.

[7] See the volume *Correspondence Albert Einstein-Michele Besso (1903-1955)*, Paris 1972.

This apparently means that there is no real simultaneity, because we cannot measure it. Indeed, some physicists claim the relativity of simultaneity because of the fact that one observer may assert that A and B are simultaneous, whereas to another person, observing from a different point, say at unequal distance from A and B, they are not. But this example fails to prove that there is no absolute simultaneity. Only an idealist philosopher or physicist would project the observer's incapacity to see real simultaneity into an objective impossibility of simultaneity in the physical world.

In the past some have conceived time as an ultimate reality which we experience separately from things and in succession. In reality there would not be any succession: all events would already be present (Dunne) so that forms of precognition become possible. To explain precognition other authors suggest that our subconscious extends further than the apparent succession of events and is sometimes able to know the future. Bertrand Russell[8] and Alfred Jules Ayer[9] also assumed that precognition of the future should be possible. Their assumption is obviously based on determinism rather than on the denial of succession. Precognition of contingent events, not yet contained in their causes, is difficult to explain, unless it is a sort of supposition or feeling about what is likely to happen, based on previous experience. If one would say that our spiritual mind lies outside the successive movements of the physical world, has a different duration and may so in excepcional cases detach itself from its ordinary way of thinking, one faces the difficulty of explaining how this knowledge of contingent future events which will occur outside ourselves, comes to us. One sees no other way than that of knowledge infused by God and one hesitates to recur to such an extraordinary divine intervention to explain the cases of precognition claimed in literature dealing with extra-sensorial perception.

There appears to be a close connection between succession in time and causality. David Hume reduced the latter to temporal succession, but some modern authors would rather reduce succession to causality[10]. Against both positions one may object that most causes are observad as being simultaneous with their effects. In so far as the perception of a duration of a certain length is based on our retaining the past and present of a movement or process, and such movements always require a cause, one may indeed defend the position that time presupposes causality. However, this is not the same as to reduce temporal succession to causality and to identify both. A cause is prior to its effects, at least ontologically, but not necessarily chronologically. Time as we know it in our material world is the continued duration of a successive movement such as locomotion or alteration. Our concept of time does not concern the question of how this movement initiated and of what causes it, but refers only to its going on in succession, so that it never exists altogether in its entirety but in a flow of successive instants or nows. It appears then that time is an irreducible category, even if it is not an entity existing by itself but the continued duration of successive movements.

It is a conviction, a certitude of common sense that time is irreversible. History does not move back from the present to the days of the Roman Empire or, as

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[8] Cf. *Mysticism and Logic*, London 1917, p. 202: our memory should be able to reveal the future.

[9] Cf. *The Problem of Knowledge*, [7]London 1956, p. 234.

[10] Cf. J. R. PLATT, in *The American Scientist* 44 (1956) 183.

Nicodemus observed during his nightly conversation with Jesus, an adult person does not reverse the development of his body, become smaller and reenter as a tiny baby his mother's womb. In a ball game the ball does not move away from the net and seek to rejoin a player's foot. The pieces of a vase which fell from a table do not by themselves reasemble on the floor, move upward and take place again on the table. A past event cannot be made undone, even if its effects can sometimes be effaced.

The irreversibility of time is called by some the time arrow. Hawking distinguishes three types of time arrows: a thermodynamic one (entropy); a psychological time arrow (our awareness of the one directional flow of time); and a cosmic time arrow, the expansion of the universe[11]. Some say that the irreversibility of time is based on the human consciousness (which in its turn may depend on biological processes) which knows only one direction in time. Others see a connection with entropy, the second law of thermodynamics. We observe that heat does not move from a body at a lower temperature to a body at a higher temperature, but that the opposite happens. This and similar facts gave rise to the formulation of the law of entropy by the Austrian scientist Bolzmann. Energy tends to distribute itself as equally as possible in closed systems as well as in the universe at large. Living beings appear to be able to increase the amount of energy they possess through certain chemical processes, but eventually these organisms will decay and the accumulated energy will be divided over their environment. In the perspective of the particles theory this means that when physical particles, at first enclosed and concentrated in a certain place, are given the opportunity to wander around they will tend to fill all available surrounding space. Physicists call this, somewhat surprisingly, passing from more order to greater disorder. For instance, a gas loses its coherence when its molecules are spreading out into all possible directions. The particles now have more room to move about and are more disordered. According to this description one should say that when the molecules of a body have a certain order, entropy is smaller, but when this order is lacking, entropy is larger. Now the spreading out or concentration of particles appears to be reversible. Those who see all cosmic process in the perspective of particies conclude that process, and therefore time, are basically reversible.

One of the imaginary descriptions advanced is that when the expansion of the universe ends and contraction starts, time will be reversed. People living during this period will live backwards, die before they are born and become younger while the contraction proceeds. In 1902 the British author F. H. Bradley[12] described a world in which death precedes birth, a wound is prior to the blow which causes it, and punishment precedes the crime. In this supposition, however, our mind would also be reversed so that what is now precognition would be memory. So everything would be the same. Of course, this sort of wild hypothesis is only conceivable when one views the entire universe, man included, as consisting of moving particles which reverse their dominant direction. In this extreme materialistic view the irreversibility of time

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[11] Cf. S. W. HAWKING, *A Brief History of Time: From the Big Bang to the Black Holes*, New York 1988.

[12] Cf. *Appearance and Reality*, ^{2}London 1902, p. 215.

would be based on our human consciousness, which knows only one directional process and imposes one-directional time on the world of particles. So some physicists argue that there is reversibility in the real world of microphysics, while gross macrophysical processes appear as irreversible and obey the law of entropy. The British physicist G. Lewis advocated severing any connection between time (a subjective category of the human mind) and physical or chemical process. The category of time, he writes, has no place in thermodynamics[13].

Quantum physics as developed by the Copenhagen School shows that the observer cannot help but interfere with the situation in which an experiment develops. One can measure the speed of a particle or its position, but never both at the same time. According to some this uncertainty of our knowledge about what really happens would mean that there is a real indeterminacy in nature itself. In a further development of this line of thinking Niels Bohr asserted that all microscopic interactions are reversible, while macrophysical ones are not. If one waits long enough, one would see a gas return to its initial state. However, the difficulties affecting this position are considerable: there is no process or system totally isolated from its surroundings so that in the course of time its energy will be communicated to what is around it and decrease so that entropy will prevail; secondly, a strict application of this idea would mean that process in nature serves no purpose and is going nowhere; a third difficulty is that when one measures what is going on in atomic processes, one interferes with the movement of the particles and brings about certain changes, but these chnges are irreversible since they «freeze» the system at a given moment which will never return. Determining or measuring the position of a particle in a wave, causes the wave to collapse in the point where measuring affects the particle. This collapse is irreversible. The emission of radiation by stars is irreversible as are radioactive decay processes. The universe itself has a direction into which it develops and has a history. Biological processes such as the division of cells are irreversible, yet appear to move toward greater order. Likewise the division of strings of the genetical code is irreversible, although it should be reversible in the Niels Bohr's quantum mechanics. A further fact which quantum mechanics does not explain is the astonishing stability of the DNA string during many generations of living beings. From a philosophical point of view one might oberve that things tend to greater perfection, as is clearly exemplified in living beings and in anagenesis. More complex forms of life develop which show a greater independence of their physical environment. Steps in biological evolution are never repeated.

It is not surprising that for these reasons Prigogine rejected the claim of basic reversibility in nature and suggested that the alleged microscopic reversibility is an approximation. All systems are subjected to thermodynamics and are «running down»[14]. Others point to the remoteness of quantum physics from cornmon ways of preception to argue that the theory is transitional. Prof. Rae considers even the wellknown story of one photon simultaneously passing through two slits in a screen

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[13] In *Science* 71 (1930) 369-377.

[14] A. RAE, *Quantum Physics: Illusion or Reality?*, Cambridge 1986, p. 106.

an illusion[15]. Particles are not the ultimate reallty. Fundamental reality is irreversible. Space and time are not equivalent.

Even Hawkins abandoned his original theory of time going backwards in a contracting universe, denying now the similarity between expansion and contraction and maintaining that the psychological one-directional time remains the same. He explains his new position as follows: to live man needs food which is changed in heat and energy, increasing to entropy. This activity is only possible during the expansion of the universe (which is a movement to greater entropy or disorder). Intelligent life during the contraction of the universe, a movement to less entropy, is not possible. Therefore, it is quite correct that thermonuclear time and man's psychological time are one-directional[16].

If, as is claimed by quantum physics, observation of particles by a human observer imposes a certain energy on them, it creates a new situation. Some physicists even speak of an on-going creation of different worlds, as long as an observation is continued, meaning that under the influence of energy imparted by the observer particles will branch out in different ways which are not predictible. The future is not deterrmined but depends on a great number of factors which cannot be foreseen (against Einstein's God is not playing dice?).

We must finally compare the different theories analysed above to the Aristotelian-Thomistic doctrine of time. In this doctrine time has to do with movement, but a simple straight forward identification of both does not seem possible, for time is more encompassing than just a movement. It is everywhere in this sense that with the same time we measure different movements. We attain to the concept of time when we notice a «before» and «after» in a movement. With his mind man can place himself above the stream of change[17]. Time is that aspect of a movement which is counted by man according to a «before» and «after». So time expresses a duration, the continued existence of a movement or a process. This concept of time is far removed from Kant's theory who believed that our idea of time does not apply to the world as such, but is an a priori structure of our perception. However, a successive movement exists in indivisible instants which cannot have a certain length of duration, for the past is no longer and the future is not yet. The instant has a dual function. It is the expression of the continuity of the being of the movement and it divides what is past from what is to come as a point on a line divides it into two sections. In this way the being of a successive movement «rolls» through time as a perfectly round ball rolls down a totally flat slope touching the surface in indivisible points. The being of the ball is always the same, as the substancial being of things remains the same[18]. The instant has no length, but this does not mean that we experience it as such. Our experiences retains also what is just past and what is on the point to become. St. Augustine refers to this when he writes that time is built out of small units, a sort of

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[15] *Ibid.*, p. 116.

[16] *Op. cit.*, «The Arrow of Time».

[17] Cf. ST. THOMAS AQUINAS, *S. Th.* I-II q. 53 a. 2 ad 3um: «Anima est supra tempus». *S.c.G.* III 84: «Ea quae sunt circa intellectum, sunt omnino extra motum per se loquendo».

[18] Cfr. ST. THOMAS AQUINAS, *S.c.G.* I 20, where he says of the *esse* that is *aliquid fixum et quietum in ente.*

time atoms[19]. Locke argued that sense data are extended in space and endure for a short period of time. The human mind can enlarge individual durations[20]. Husserl speaks of the *Erlebnisstrom,* which comprizes what is just past[21]. This is also the view of Henri Bergson, who says that we perceive only the past but not the present[22]. The indivisibe instant or «now» cannot be a constituent out of which a length of time is made, as indivisible points do not constitute a line. Surprisingly St. Paul lends support to the concepts of indivisble instants when he writes that the transformation of our bodies into a glorious state will take place in one indivisible instant, ἐν ἀτόμῳ[23].

Thus far we considered time as a duration, but we must now turn to time as a measure. We retain in our memory the duration of a successive movement we are acquainted with, and compare it with that of other movements. So we retain in our memory certain movements of the celestial bodies which are important for the human life. With reference to their duration (day, month, year) we measure other processes. These movements are of fundamental importance to human life: work and rest, coming into being and perishing, the tides, weather and fertility are all related to them. Other time units can also be used. It is said that in ancient India the time interval needed to cook rice was considered a sort of standard length. Evidently a day or a month never exist as a whole. We retain in memory what is passed and what is yet to come and obtain in this way a certain length of duration, like a sort of yardstick with which to measure the duration of other movements.

Is time everywhere the same? In so far as we mean the present instant in which things exist, the answer is affirmative since whatever exists now, is simultaneous. If with «time» we denote a fundamental cosmic process, the answer is also affirmative, but in so far as each movement has its own being and duration, it has its own time. Time does not flow faster at one moment while slowing down at the next. Movements can have different velocities, but time as the succession of instants is the same. A comparison may help to understand this: three horses differ from three sheep, but the abstract number three is the same.

Time exists as a succession of instants in a movement even if there is no human being to notice it. However, for an adequate concept of time one must consider the successive instants together[24]. On the other hand, if there is no movement, there is no time[25]. Time is the numbering of a movement, but it is not the counting of all the nows. It consists in our retaining in thought the already past starting-point of a continuous change, so that a duration of a certain length results.

According to the interpretation some physicists give of the second law of thermodynamics, sc. entropy, all process tend to greater disorder. We have seen that «greater disorder» is not a very fortunate term to express the term of process in the world. Moreover, the process of life in living beings is certainly not directed to

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[19] *Sermo* 362.

[20] Cf. *An Essay Concerning Human Understanding,* II 14,6, and II 16,2.

[21] Cf. *Ideen zu einer reine Phänomenologie,* I 3 ch. 2, pp. 81-82.

[22] Cf. *Matière et mémoire.*

[23] I Cor. 15:52.

[24] Cf. ST. THOMAS AQUINAS, *In IV Phys.,* lect. 23, n. 629.

[25] Cf. ST. THOMAS AQUINAS, *De potentia* q. 3 a. 1 ad 10um: «Ante principium mundi non fuit aliquod tempus reale sed imaginarium».

greater disorder. I would like to recall that according to Plato «to exist in time» implies that one is becoming older. Plotinus likewise considered time a diminution of being and a fall towards non-being[26]. Aristotle, however, holds that one gets older not because of the passing of time but because of an inner weakness. Time as such is not degenerative and destructive.

I have kept the most important question for the end. To what extent time is the same for all things. In a sense this problem concerns the question whether time is subjective or objective. If time results from observing a change in the world, then those who do not perceive it would not have any awareness of time. If time results from a change one observes in oneself, time would no longer be something in nature, but strictly personal and subjective. If the notion of time would be abstracted from any particular movement or change, there would be as many «times» as there are movements, but this is impossible because two «times» do not exist simultaneously. In answer to this difficulty he himself has raised Aquinas notes that all movements in the universe are based on one movement which is the origin and cause of all process and change. Therefore, one who observes a change in himself or in the things surrounding him, actually perceives this fundamental mutability and the cosmic process on which it depends. «It follows that anyone who observes some movement perceives time, even if it is true that time is a consequence of the first movement [in the universe] through which all other movements are caused and measured. Hence we are left with one time»[27]. This answer differs from that of Augustine who writes that time should not be reduced to the movement of the celestial bodies, for even if this would come to a stand still, other movements such as that of spinning wheel would still be possible. For Aquinas this first movement was the revolution of the first heaven, whereas we would rather speak of a fundamental cosmic process such as the the expansion of the universe. The answer of Aquinas is important because it shows the underlying unity and common origin of all cosmic process, but it does not promote time to an absolute and autonomous reality. Communication with a being whose time would run contrary to ours would not be possible. Even if the expansion of the universe would make place for a general contraction, the basic cosmic process would still be one. Therefore, the idea of one order of time comprising the entire universe is not artificial and, contrary to what some say, it does not go beyond the phenomena we observe. Aquinas' solution is very remarkable and leaves behind as pityful many a suggestion made by contemporary physicists. It holds the middle between the theory which eliminates time and the view which considers time an autonomous entity.

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[26] See J. MOREAU in *Revue Philosophique de Louvain* 46 (1948) 57-84 and 245-274. For Plotinus time is characteristic of the life of the soul, while according to Plato it belongs to the physical world as eternity does to the world of ideas.

[27] ST. THOMAS AQUINAS, *In IV Phys.*, lect. 17, nn. 573-574. See also *S. Th.* I q. 10 a. 6.