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INTRODUCTION

The articles included in this second volume of Studies in Science and Theology (SSTh) were presented and discussed in different workshops during the Fourth European Conference on Science and Theology (ECST IV). This conference was organized by the European Society for the Study of Science and Theology in cooperation with the Vatican Observatory, Vatican City State, and was held in Mondo Migliore near Rome from March 23 to 29, 1992. In choosing a title for the present 1994 volume we proceeded in the same manner as for the first volume of SSTh: we took the general theme of ECST IV, which was 'Origins, Time and Complexity'. The titles of the seven sections that follow this introduction are the same as the names of the workshops in the 1992 conference.

Whereas the first volume of SSTh mainly included the plenary lectures and only a small selection of papers presented in the workshops, this second volume of SSTh - with its 46 articles - contains a much more representative selection of the written contributions discussed during the conference. The authors of these articles work in various disciplines. These are distributed among the contributors in the following way: theology 17, physics 11, biology 7, astronomy 3, 2 each in religious studies, chemistry and mathematics, as well as 1 each in the history of science, medicine, geology and engineering. The countries represented by these authors are the following: Belgium 1, Canada 2, Finland 1, France 4, Germany 6, Hungary 2, Italy 4, the Netherlands 8, Norway 1, Poland 3, Russia 3, Spain 1, Sweden 1, Switzerland 4, United Kingdom 1, USA 3. A final characteristic is the interconfessional and ecumenical spirit in which these papers were presented and discussed.

The main part of the editorial work for this volume was effected by George V. Coyne, S.J., director of the Vatican Observatory, and by Karl Schmitz-Moormann, the president of ESSSAT. Final changes to the papers were done by myself during the typesetting process, which included

Section 1

Origins of Time and the Universe

ON THE POSSIBILITY OF A UNIFIED COSMOLOGY

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For many centuries religion dictated the terms of cosmology. Cosmological tenets, supposedly derived from religious doctrines or serving as their presuppositions, determined the limits for the permissible in these matters. The case of Galileo Galilei and Giordano Bruno are too well known to need reiteration.

The last two or three centuries, however, have more or less brought about an opposite picture. Although science has not enforced its views with the help of political or other outward means - apart from some atheistic states - science has so totally dominated the field of cosmology that religious or even philosophical viewpoints have been virtually excluded. Scientists could entertain what religious beliefs they liked - as well as various preferences i.e. in the field of arts - but those had no relevance whatsoever to science. This policy of separate, water-tight compartments for religion and science may be found in the minds of some scientists - and some theologians - even today.

The dissatisfaction with this state of affairs has been, however, strongly felt by some sensitive spirits, who felt urged to search for an understanding or a vision which might - to some extent at least - combine science and religion in a "unified cosmology".

In his little book, "Einführung in die Schöpfungslehre"[1], the Roman-Catholic theologian, Professor Leo Scheffczyk, points to this trend and briefly mentions some well-known scholars who have attempted this kind of combination.

Among them are Pascual Jordan and Pierre Teilhard de Chardin, but in particular Werner Heisenberg, who closely relates science and religion when posing the question: "Ist es völlig sinnlos, sich hinter den ordnenden Strukturen der Welt im Grossen ein Bewussstsein zu denken, dessen Absicht sie sind?"[2]

This close relationship should not mean, however, to gloss over the limits between science and theology. Science should deal with its observations and problems on its own terms, but with openness for questions and interpretations beyond its limits. Correspondingly, theology should stay within its limits and accept scientific cognition without making itself into a philosophy of nature. This relative separateness and yet connection between science and theology may, Dr. Scheffczyk indicates, be taken care of by a way of thinking which understands each of these ways of perception as different aspects or dimensions of one and the same reality:

> Damit wird deutlich, dass beide Erkenntnisbemühungen das Seiende unter einem verschiedenen Aspekt und in einer verschiedenen Dimension betrachten, so dass eigentlich keine Widersprüche zwischen ihnen auftreten brauchen, wenn nur auf jeder Seite Grenzüberschreitungen vermieden werden.[3]

Although not using the same terminology, a parallel way of thinking may be found in the book by Professor at Cambridge University, Stephen W. Hawking, "A Brief History of Time. From the Big Bang to Black Holes". A physicist and professor of mathematics, Dr. Hawking attempts to find and formulate - on scientific grounds - a general theory of the universe. One conclusion of his is that science may indicate the universe is unlimited in space and time, having no beginning and no end - a conclusion with "serious consequences for God's role in the universe":

> So long as the universe had a beginning, we could suppose it had a creator. But if the universe is really completely self-contained, having no boundary or edge, it would have neither beginning nor end: it would simply be. What place, then, for a creator?[4]

This is taken as the main conclusion by Dr. Carl Sagan in his preface to the book.[5] There may be scholarly objections to this conclusion: Dr. Hawking operates with a particle/antiparticle dichotomy which makes the universe self-creative and seems to ignore the problems of ontology. However that might be - in principle Dr. Hawking's conclusion must be deemed valid: There is no place for a creator - on scientific terms, *within* the aspect or dimension of science, which deals only with scientific observations and data. God is no scientifically observable fact, nor a factor to be registered in the chain of cause and event.

At the same time, however, Dr. Hawking in his book frequently speaks about God, God's acts, God's design and intention. He points out, towards the end, that scientists have been so preoccupied with describing *what* the universe is, that they have not posed the question of *why*. Why does the universe exist at all? And the final conclusion by Dr. Hawking is that, presumably on the basis of a general theory of the universe, all of us will be able to discuss why the universe and we ourselves exist. "If we find the answer to that, it would be the ultimate triumph of human reason - for then we would know the mind of God."[6] These are the last words of the book. Despite some seeming inconsistencies and a different terminology, it may be permissible to interpret Dr. Hawking's statement as related to two different dimensions or aspects of the perception of the universe: the scientific aspect/dimension, which does not and cannot know anything about God and within which there is no place for a creator - and the religious aspect/dimension which acknowledges God as the source and ground of being.

The intention of this theory of reality's two dimensions or aspects is to attain to a unified cosmology which does not fall apart in different compartments. This may have been achieved with regard to ontology: it is possible to argue convincingly for the idea that there is *one* and only *one* reality, which exists in two (or more) ontological dimensions which are mirrored by different perceptions. Reality exists in two or more dimensions, an analogy being the cube which exists in three dimensions of space. Thus reality is one and unified - but the very perceptions of reality are disconnected and disunited, so that reality *to the human perspective* appears to fall into two (or more) separate sections. This disconnection in the perceptions of reality is particularly evident in the contrast between natural causation, which is observed by science as the basic tenet within the scientific perception of reality - and purposeful acts of the Creator God, which are basic to the religious perception of reality. The natural causation perceived by science understands reality as held together and developed by an interplay of energy and masses in accordance with strict and immutable natural laws, thus determining the movements within reality, so to speak, "from behind". In contrast, the purposeful acts of God, by which the universe according to the religious perception is upheld and moves, determine the universe from goals set by a divine and almighty consciousness. Is it possible to attain a cosmology which unites these two different or even contradictory perceptions of reality?

The task may seem difficult, but we may come some steps closer with the help of some very simple day-to-day oberservations. The parallel appearance of natural causation and purposeful acts is not limited to the

vast perspectives of cosmology, but takes place in our every-day life, proving the two perceptions to be compatible. In front of me, on my desk, lies a book I have just read. I may stretch out my hand, take the book, lift it up and place it on the shelf. Or I may refrain from doing so. The act of shelving the book may surely - if one cares to do so - be described in detail from an empirical scientific point of view: the stretching and retraction of my muscles, the nerve impulses which made my muscles stretch and retract, the blood stream necessary to give sufficient strength to life and to shelve the book, etc. But at the same time the decisive point bringing the act into being is my intention to take and to shelve the book - for some purpose, i.e. to create a better order on my desk (if possible). And the act may thus be described quite differently - on ethical terms taking into account my purpose, my motives for that purpose, the way I carried out the act, its possible consequences measured by a value system, etc. The point is that one and the same movement may be described in empirical scientific terms as an event determined "from behind" - but also in ethical terms as the implementation of a conscious purpose, without conflict or mutual exclusion between the descriptions - or rather: perceptions - and without rendering the act/event impossible or illusory. The movement, understood as a conscious act according to a purpose, does not by its implementation break or eliminate the natural laws, but rather utilizes them. On the other hand, the movement understood as an event determined "from behind", does not eliminate or contradict the ethical purpose, because it is simply beyond its horizon of perception.

The idea of bringing in this example of the book to be shelved and the concomitance of empirical and ethical perception is, of course, to offer an analogy to the problem of understanding the universe as simultaneously determined by natural laws and maintained by the acts of God. The ethical freedom and possibilities of man without conflicting with the scientific understanding of reality cannot be less for God - if God is God, by any meaningful terminology. And as there is no incompatibility between the ethical and the scientific perception and description of the shelving of the book, there should be no incompatibility between the scientific perception and description of the universe as existing and moving in accordance with natural laws and causes, and the ethico-religious perception and description of the universe as maintained and directed by the purposeful acts of God.

We may still lack a language which is able to express the compatibility of these two perceptions in terms of one unified cosmology. But maybe we for the time being may acquiesce with a slightly more precise wording of a day-to-day saying like "I will lift up the book". When

THE INDUCTIVE CHEMIST LOOKING AT LOCAL MINKOWSKI TIME, COMPATIBILITY OF GRAVITY AND QUANTA, AND FORMATION OF MATTER HAVING REST-MASS

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Our discussions at this conference are anchored to an awesome idea: the beginning of time [I almost feel the anxiety of Columbus' seamen that they may fall over the rim of the ocean]. Though I shall try my best to express myself slightly later as (a fairly typical) chemist, I cannot hide that our rate of consumption of paradigms is exponentially increasing (as are many raw materials). Thomas Kuhn [1] is right that General Relativity theory has some pre-Newtonian restauration built into it, pretending to explain attractions, and not only describe their dynamics. Our pragmatic coordinate systems are not absolute time and space in D dimensions. There has been some worry[2] as to whether the Universe (by definition) contains everything. Not only may the local time not be meaningful before the Big Bang, but there may be a multitude[3,4] of universes having formed separately in a foambath (say, in a reservoir with D = 5, 10, 26.. as first suggested by Kaluza and Klein), and no longer able to communicate with our light-cone [my only liturgical joke is that the Torah epithet "King of the Universe" has become "King of all Universes" in a recent French anaphore, as a salutary correction of De Gaulle using the word for this planet].

Our local time is a reasonably [because of quite low mass density] well-behaved [5] imaginary Minkowski coordinate(–*ict*) perpendicular on the Cartesian (x, y, z) but its direction has only parochial sense in a foam-bath [like North and East on the Earth's surface; in the Solar system

conceivably dictates the relative concentrations of elements in the Earth's crust, representing the "ashes" of very exothermic reactions. The relative abundances in the solar atmosphere and in other stars were (in part) qualitatively known since Bunsen and Kirchhoff (1860) rationalized the absorption lines studied (1815) by Fraunhofer. However, estimates (better than a factor 2) became available[9] since 1920. The Sun is fairly typical, 1 ton (10^6 g) contains 740 kg hydrogen 240 kg helium, less than 0.001 g lithium, beryllium and boron (very apt to thermonuclear reactions), 13 kg carbon, nitrogen and oxygen, 4 kg elements from neon to nickel (Z= 10 to 28), the two most abundant being silicon and iron. For all Z above 36, only 0.4 g occur. One ton of the outer crust of the Earth contains 466 kg oxygen, 277 kg silicon, 81 kg Al, 50 kg Fe, 36 kg Ca, 28 kg Na, 26 kg K, 21 kg Mg, 4 kg Ti; and 1.3 kg with Z above 36.

Curiously, the suggestions by Crookes have largely been confirmed by modern astrophysics[9, 10]. The temperature T after the Big Bang is roughly 10^{10} K (10 gigakelvin) divided by the square-root of the running time t in seconds. It seems fairly well established that the soup of uncombined quarks had coagulated to baryons (protons, neutrons, ..) around t = 20 microseconds, maintaining 2 terakelvin. The subsequent evolution the next 200 seconds (3 minutes[11]) provided 78 percent of the baryon mass as hydrogen, 22 as helium, and only 10^{-7} percent as lithium. Then, at first protogalaxies, and later many stars, formed within 10^9 years (present t marginally above 10^{10} years) but the heavier elements (named "metals" by astrophysicists) came very slowly. There are several alternative syntheses of carbon (e.g. resonant collision of three ^{4}He well above 10^7 K; "Dark Matter" candidates; or unknown "elementary" particles) but nearly all the "biological" elements C, N, O seem to be formed by supernova explosions, when for few seconds T exceeds 1 gigakelvin. If we disregard some "Dark Matter" type mechanisms (such as uds "strange" matter)[12-15] the only known way of producing Z above 30 is an enormous concentration of free neutrons adding to iron, cobalt and nickel isotopes (thermodynamically stable below a few gigakelvin) although the origin of Z above 83 remains somewhat enigmatic [10]. Normal stars (like our Sun, or 2 to 3 times heavier) produce helium from hydrogen (the solar energy production indicates 1 percent of the total mass transmuted per 10^9 years). Heavier (and far more luminous) stars may only exist for 10^8 or, in extreme cases, only a few million years.

In many ways, formal logic [16] and mathematics have their autonomous subsistence, like literature, theater and painting. Natural sciences are very different, they depend on comparison with observations as the final criterion. Nevertheless, physicists have a strong propensity to *deductive* thought, and chemists to *induction* although they study, to a large

extent, the same matter. Classical physicists like Newton, Maxwell, and even Planck and Einstein, learned from the derivation of theorems from axioms, as done by Euclid, and much later, by Frege, Peano and Bertrand Russell. Chemists are far more inductive than Platonic. They have learned the hard way that [A implies B] does not imply that [B implies A]; almost perfect agreement with measurements (which normally have an uncertainty, be it in the second or the eleventh decimal) does not *prove* the theory; that several quite different alternative rationalizations may be as good, be found tomorrow, be more apt for generalization; and our earlier theory may break its neck any time on a new crucial observation.

Scientists (and philosophers), who are not professional chemists, may conserve quite archaic ideas about chemistry. For instance, a monatomic entity has one nucleus (Z) and K electrons. The atom can be neutral (Z=K), be a positive ion with charge (Z–K), or, in the case of most elements, be a gaseous anion with K=Z+1. Then, Dalton (1805) said that compounds consist of molecules; and molecules of atoms, justifying the composition showing multiple proportions. For us, molecules are two or more nuclei characterized by Z_1, Z_2, Z_3 and a number K^* of electrons forming an extended charge distribution, not necessarily localized to definite atoms. This entity is a polyatomic cation if the sum of Z values is larger than K^*, a neutral molecule if the Z sum equals K^*, and an anion if K^* is larger. This statement is valid for gaseous inorganic compounds [although the species in vapours can be unexpected] and in most organic solids and liquids [polymers like cellulose or nylon are at the limit] as well as all organic vapours. However, the majority of inorganic *solids does not* consist of individual molecules[17]. In cristalline LiH, LiF, NaF, NaCl, KBr, RbI ... , MgO, MgS, CaO, BaS ... each M is surrounded by a regular octahedron of six X, and each X by octahedral M_6. Crystalline BeO, AlN, SiC, CuCl, CuBr, CuI, ZnO, ZnS, GaAs, AgI, CdS, InSb ... have each M surrounded by four X (frequently as a regular tetrahedron) and each X by four M. It should be noted that this "salt-like" polymerization is no proof of exclusive electrovalent bonding; many of the examples look quite covalent, and diamond, silicon, germanium and gray tin are elements having the same crystal structure as CuBr if the two Z values were not distinguished. The last large-scale paradigm of chemical bonding (not based on the quantum chemistry which has developed since 1927) was constructed by Lewis (1916) that a chemical bond is established by two electrons, a "double" bond by 4 electrons, a "triple" bond by 6, and that a well-behaved element (with its inner electron shells) is surrounded by 8 outer electrons (except hydrogen 2). If some outer electrons are not involved in bonds, they subsist as "lone-pairs". Again, most organic compounds, and hence a large part of all compounds, can be

described (more or less easily) by Lewis electron-pairs. However, since 1984, it has been abundantly illustrated [17] that the Lewis paradigm is the exception rather than the rule for compounds containing elements with Z above 20. Most minerals and solids are readily non-stoichiometric.

In the perspective of the natural sciences discussed in this note, there is little doubt that atomic spectra and Quantum Chemistry (Q.C.) are the most profund revolution (around 1926) that has ever occurred. For instance, identical small systems (and "elementary" particles) are *identical* to an extent logicians had never imagined [16, 18]. On the other hand, time has a very distinct arrow (much less evident in Newtonian theory) since we do (at the best) know the outcome of an experiment (to be performed soon) as a statistical table of probabilities of results; but once performed, we know (in principle) the definite result forever. Many physicists said around 1930: the chemists must be delighted that chemistry now can be *deduced* from Q.C. Indeed, it works to 6 or 8 decimals for (very carefully) selected problems, but the conceptual jump from Z and K values being integers did not allow the expected "solution". With huge supercomputers today, a few nuclei, and up to 20 or 30 electrons, succeed fairly well. However, as is also true for atomic spectra, Q.C. is severely limited to one-digit Z values. Closer analysis [18] shows that correlation effects (mixing of electron configurations by non-diagonal elements of inter-electronic repulsion in the Schrödinger equation) are dramatic, and of the same order of magnitude as the (very weak) chemical bonding (compared to total binding energy of all electrons) in presence of two-digit Z.

The quest of "reducing" chemistry to physics has a quite fashionable analogy: can biology be deduced from chemistry? Unfortunately, life is far too complicated for me, but my feeling is that the weak deductive link is already between Q.C. and chemistry. When we are now accustomed to receive four new paradigms with each new telephone book, I would like to add a few sentences about the second subject of this conference, i.e. theology (subjectively, I find it less alien than biology). I hope most sincerely that it is no blasphemy to conclude from the patently non-linear and haphazard growth of scientific history that His thoughts are not like ours. When the Christians had come out of the underground, they drafted (1610 years ago) their Nicean-Constantinopolitan Creed that the two closest Persons in His family (I cannot find a better word) were born before *all* time. He apparently has another relation to time than we, He is co-simultaneous with the half of our colleagues that have left to keep Him company. He loves us all, all of us, but what can be the relation of the finite (we and the others) with the Transfinite, Who is?

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to practitioners of quantum gravity, primarily because lower dimensions offer significant mathematical simplification. For the purposes of theology, such lower-dimensional theories offer the hope of clarifying scientific concepts which must be incorporated in any attempt to deepen theological insight into creation.

To this end the present paper describes a recently-proposed relativistic theory of gravity in two spacetime dimensions (2D) which bears a remarkable similarity to GR[6]. An outline of its basic features is given, followed by a brief discussion as to how it could be used in focussing issues associated with the significance of time, the beginning of the universe and the incorporation of quantum mechanics.

2. GRAVITY IN TWO SPACETIME DIMENSIONS

The GR field equations are a set of 4x4 equations

$$G_{ab}[g] = 8\pi G\, T_{ab} \qquad (1)$$

which express the "curvature = matter" concept referred to above. G_{ab} is a measure of the curvature of spacetime, and is a complicated tensorial combination of derivatives of the metric g_{ab}, which measures the spacetime interval ds:

$$(ds)^2 = g_{ab}(dx^a)(dx^b) \qquad (2)$$

$dx^a = (dt,dx,dy,dz)$ being the (small) change in time and distance from one place and time (event) to another, repeated indices being summed over $(a,b = 0,1,2,3)$. T_{ab} is the stress-energy, whose conservation is guaranteed by a mathematical identity on G_{ab}. Since the coordinates $x^a = (t,x,y,z)$ may be freely chosen there are only 6 unknown elements in the 4x4 matrix g_{ab}; the aforementioned identity reduces (1) to a system of 6 equations in these 6 unknowns. In this way, eqs. (1) determine the curvature of spacetime in terms of the distribution of mass/energy, G being Newton's gravitational constant.

In 2D the GR equations (1) are useless: $G_{ab} = 0$ for *any* metric[6]. Here the only measure of curvature is given by the Ricci scalar R (again, a non-linear combination of derivatives of the metric g_{ab}), and so one might consider[6]

$$R = 8\pi G\, T \qquad (3)$$

as a candidate theory of gravity in 2D. $T = T^a{}_a$ is the trace of the 2D stress-energy tensor (which is 2x2). As there are only two coordinates $x^a = (t,x)$ representing time and distance, the metric now has only one

line of collapsing dust, $\alpha = 2M|x|-1$; for small M this reduces to Newtonian gravity in one spatial dimension[6]. Once the dust collapses below a length 1/2M a black hole of mass M forms[7,8]. As in GR, this situation occurs if the gravitational forces in the matter overpower all other non-gravitational forces, causing the matter to collapse to a region of zero size and infinite density[8].

Here time stops in a manner meriting further exploration. Scientifically this suggests a fundamental incompleteness to the theory (3), reflecting the situation in GR[4]. Theologically, this provides a simple illustration of the Augustianian conception of time: not in itself transcendent, but part of the 2D 'creation', both influencing and being influenced by the presence of matter.

This is congruent with the theological notion that God's role as Creator is much more that of an Abiding Sustainer forming the ground of existence as opposed to Temporal Originator. The origins of the 2D universe have already been explored to a certain degree[9]. The simplest model with T_{ab} containing matter and radiation has the metric

$$(ds)^2 = -(dT)^2 + (1-2\pi G\sigma T^2)^2\,(dX)^2 \qquad (6)$$

where σ is the matter density. The universe goes from a big bang at $T = T_- = -1/(2\pi G\sigma)$ to a big crunch at $T = T_+ = 1/(2\pi G\sigma)$, similar to the GR expansion predicted by (1). Here in stark simplicity one is again faced with the problems associated with initial conditions and the origin of time. At T_- the universe is of zero size and infinite density, its history prior to this point outside the realm of predictability of the system (3). The creation of the universe depends quite specifically on the details of the matter distribution T_{ab} employed. A theological explanation of this creation will therefore depend upon the explanation for the origin and realization of the (not yet complete) set of laws governing both the matter and gravity of the 2D world.

Investigation of the quantization of the theory associated with (3) is just now beginning. Here is truly uncharted territory, both scientifically and theologically. This is a natural place for a scientist to look for means to address the incompleteness problems mentioned above. Indeed, the close resemblance of the 2D theory (3) to GR suggests that it should be quite useful in testing the ideas and assumptions that many theorists hope will resolve the analogous 4D problems[4]. Preliminary work has indicated that tunnelling between universes of different configurations can occur in a manner similar to that seen in other, more complicated contexts. How such quantum effects will eventually modify present day scientific and theological notions of time, space and matter remains to be seen, but

the simplicity of the 2D theory (3) offers much hope for new insights in both areas.

4. SUMMARY

Although quite a number of other 2D theories of gravity have been explored in recent years, the present theory has a distinct advantage in that it has a well defined nonrelativistic limit[6] and (non-quantum-mechanically) mimics quite closely the essential features of GR. It is this property which gives one confidence that a deeper exploration of quantum effects, origins and the role of time played in the theory will be instructive in clarifying the associated issues which arise in our own world. While a more complete exposition of this topic is beyond the scope of this paper, it is hoped that the simplicity of the examples presented here will provide a useful counterweight in righting the one-sidedness of the science/theology dialogue.

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ON A POSSIBLE VIRTUAL NATURE OF SPACETIME.

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After general relativity one speaks not so much about the problem of time as about the representation of spacetime in the form of a continuum of events with pseudoriemannian metrics. The quantum theory considers the world of reality as a projection of possible worlds [11]. The world law was a number for Pythagoras; it is a function (law of number transformation) for Newton and Einstein, whereas it became an operator (law of function transformation) for Heisenberg. The complete spectrum of possible realizations corresponds to each operator.

The description of atomic processes is introduced by quantum theory, as an inevitable element of world cognition, a transition from possible to real being performed in measuring. Thereby, as the creators of quantum mechanics repeatedly emphasized [1], the world of real phenomena proved to be too narrow for the formulation of laws of nature. Such a formulation has been reached only in wider frames of possibile worlds. Quantum-field theory equations should describe latter worlds, corresponding to a deeper level of reality. The complete set of local Heisenberg field operators at a given space-time point generally describes everything that may happen at this point (and so it may exhaust the notion of a point, see below). The field operators come out here as universal world characteristics. The ontological status of real existence may be ascribed to them in Plato's spirit, as a distinction from creating and annihilating quanta particles.

The unification of general relativity and quantum theory inevitably leads to involving space-time structure in such a description, which is known to pose many difficulties. Keeping the *a priori* mathematical role of an element of a variety for a point of space-time on supersmall scales appears to be an obstacle even in a soft version of quantum gravity. It is just that conclusion which is obtained as a result of considerations in [2,3] on inevitability of a virtual gravitational collapse on supersmall scales (the Wheeler-Hawking space-time foam).

In [4,5] these considerations are interpreted as representing a lack of any primary classical geometrical structure for states of the world. And let us note that the distances, being less than Planckian ones, are unphysical. This may challenge the adequacy of the space-time description on all scales using continuous images. Hence the model [4,5] constructed at the level of virtual events on primary space-time as a discrete set of local elements of the world, not being connected classically, has been adopted. In this set only a causal ordering is conserved [6], hence the set is split into an assemblage of many branching and intersecting series of elements (l), (2), ... , (t), (t+l), ...

The identification of a local space-time element (t) with a set of operators (A(t)) describing *in situ* all virtual events is a keystone of the construction. The concept of a point frees itself from any *a priori* non-physical contents. The concept of distance is not primarily defined in the scheme. Instead we make an attempt to tip the sets of operators closest to each other with respect to the causal ordering ((A(t) < A(t+l)) with a closed algebra describing field evolution and containing a fun assumption. This defines a limiting time-like proximity in the model, instead of the definition of the time-like interval in the Lorentz classical variety.

It is assumed that combinations of the causal ordering and of the elementary length introduced may likewise prove to be sufficient for the appearance of classical distances at the level of asymptotical states of the field theory in this scheme. Gravity does not enter into the model as an independent field, but is considered to be an effect of the deformability of the assumed space-time structure. In the complete spacetime there exist pairs of points which are not in a causal, but in a space-like relation among themselves. The corresponding sets of operators commute in this case. Their presence is assumed to be a result of the existence of a branching of operator solutions for the causal algebra. In its extreme case this assumption is in agreement with cosmology [7] in that the "operator" world is created by multiple successive branchings of causal chains originating from one point. Therewith in accordance with well-known cosmological scenarios [8] an existence of the "change of a mode" may be assumed for the corresponding solutions of the equations, when compe-

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physics is operating, it must have an essentially time-asymmetrical ingredient."[4] In the following pages of the book, he brings to us the well described physical exception from this general rule of time-reversibility, namely the second law of themodynamics. Increasing entropy in the current universe calls for an explanation of the origins of the low state of entropy in the early universe. With the problem we approach the limits of our understanding of physics, and finally, the answer to the question where the second law came from has to wait for the quantum theory of space and time, referred to as quantum gravity.

But even while we are waiting we are not idle. Penrose writes here about his own investigation of quantum gravity. This theory appears to have some astonishing features. One of them is a non-local description of space-time geometry, and another one is time-asymmetry.

How does all this fit in with our consciousness, "the one phenomenon that we know of, according to which time needs to 'flow' at all?"[5] "My guess is that there is something illusory here too, and the time of our perceptions does not 'really' flow quite the linear forward-moving way that we perceive it to flow. The temporal ordering that we 'appear' to perceive is, I am claiming, something that we impose upon our perceptions in order to make sense of them in relation to the uniform forward time-progression of an external physical reality."[6] So "consciousness, in essence, is the 'seeing' of a necessary truth; and ... it may represent some kind of actual contact with Plato's world of ideal mathematical concepts. [...] Plato's world is itself timeless."[7] This capacity of the mind is represented by the non-algorithmic i.e. non-predictable nature of human thought.

The objection I have to the view presented above is that it is based on a Platonic understanding of time in which the world is clearly divided into time and timelessness. This philosophical view of time might fit well with mathematics or music, in which we can, in principle, grasp a whole proof or melody in one instant, but it seems to be a rather poor model for biological or psychological concepts of time.

Where human consciousness is concerned it might be interesting to take the Aristotelian concept of time. According to Aristotle, time is closely associated with the human mind. Without the soul there would be no time.

In that way we could say, that in this problem at least three great scientific approaches to time meet together. First, we have the Archimedean tradition, where time could be totally neglected. Then we have the empricist's approach of Aristotle, for whom time is different but closely connected with motion and soul. Finally, we have Plato's view where time is only a *moving image of eternity.*

NOTES

1. R. Penrose, *The Emperor's New Mind: Concerning Computers, Minds, and the Laws of Physics,* Oxford 1989.
2. R.Penrose, "Singularity and Time-Asymmetry", in: S.W. Hawking (ed.), *General Relativity*, Cambridge 1979, 581 sqq..
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4. R. Penrose, *The Emperor's ...* , 394
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ORIGINS, TIME AND COMPLEXITY: A COMMENT ON THE RELATION BETWEEN A CHRISTIAN THEOLOGY OF CREATION AND CONTEMPORARY COSMOLOGY

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1. INTRODUCTION

Within the broad subject of the science-theology dialogue I will focus on such interactions between physical cosmology and Christian teaching on creation as are possible when we tackle ultimate questions about origins, time and the cause of complexity. It seems to me that the theology of creation may be called into debate by cosmology when the following issues are raised:

a) Cosmological models which try to explain the origin of the universe: approaching the classical singularities in FLRW models[1]; removing Big Bang type singularities and describing the birth of the universe by quantum fluctuations of the ground-state of a cosmological function without boundary conditions[2]; employing a superstring theory, developed in a Grand Unification scenario, meant as an all-encompassing, selfconsistent "theory of everything"[3].

b) Inquiry on the origin and the ultimate nature of time[4]; this issue is obviously related to the previous one and often included in it.

c) Theories which explain the emergence of highly ordered, complex structures, on the basis of amplification of random fluctuations occurring in less ordered systems, when far-from-equilibrium conditions are explored[5].

Christian teaching on creation, on one hand, maintains that the origin of the world, the multiplicity and historical diversification of whatever exists, all depend on the will of a personal Creator, primary and final cause of the whole universe. The ultimate reason for the nature of each thing is nothing but a grounding relation with God, which is called creation.

According to some authors, theology is called into debate because the inquiry of cosmology about origins would remove the role of a Creator[6], while the interpretation of complex structures in terms of chance products could make the role of a creative design completely irrelevant[7]. The aim of the present paper is to recall some points in order to warrant the two following statements:

i) cosmological inquiry on ultimate questions about origins and complexity does not clash with, nor remove, the ultimate answers given by theology;

ii) the philosophical content of the theological concept of creation is consistent with an ontological background, implicitly assumed by science, which makes the work of science possible and ensures the intelligibility of its analysis.

2. THEOLOGY OF CREATION: A BRIEF SURVEY

Contrary to natural religions, the Judaeo-Christian revelation does not originate as a search to a solution for a cosmological problem[8]. Nevertheless, Christian teaching on creation contains specific answers for a philosophical, not for a physical formulation of that problem. The reason is that the physical world stands only as background for the spiritual message of this religion. The pages of the Bible shape the universe much more in its theological and philosophical characters than in its physical ones.

Using the perspective of Thomas Aquinas as reference frame, the main properties of creation can be summarized as follows. Creation is fundamentally a relation: it indicates the constant metaphysical dependence of what is contingent, or transient, i.e. created, on what is necessary in itself, i.e. a Creator[9]. Such relation is precisely what constitutes a creature, since each creature participates in being through it. On the side of the creature, this relation is real and gives origin to an act of being coupled with a specific metaphysical essence. In this way things are and are something. Because of its essence, each entity has a specific nature, that

Creation answers to God's purposeful plan. Multiplicity and complexity arise not by chance, but because of God's foresight, who wills each creature as it is. Since the universe has been worked out by an intelligent and personal being, it must appear to us rational and intelligible. Creation is a word pronounced by God[16], so it must contain a certain dialogic power, to be decoded by those to whom this word is directed. Creating the cosmos, God makes a choice (Einstein's question). The bulk of this choice does not regard a special set of constants and boundary conditions (Penrose's question). It mainly regards the very existence of natural laws, of specific steady natures. Here is where the project, that is the information, lies. So, when theology asserts that complexity, in shaping the world as we know it, works out a world project, it simply asserts that steady, conservative and coordinate laws exist, which receive their specific natures from a primary cause. The concept of nature, in displaying the bent of each entity toward its own effect, embodies the presence of finality and shows the way in which each thing shares in that project[17].

3. CREATION AND SCIENTIFIC INQUIRY ON ULTIMATE QUESTIONS

The notion of creation sheds light on the comparison between the perspective of theology and the analysis of science, thus making two points clear. Firstly, that the concepts of act of being and that of nature (which are exactly what the relation of creation gives rise to in creatures) do not interfere with the description of the physical universe in its being and becoming. They are metaphysical concepts which anticipate and give foundation to any experimental description or observation whatsoever. This ontological perspective holds no matter how deep or varied be the analysis of science, because of its distinct formal object. Secondly, scientific inquiry is unable to affirm, or to deny, the presence of a purposive plan intrinsic to the world. Since a primary and transcendent causality pursues its own intention through the secondary causality of created natures, even a view that explains complexity in terms of random processes and/or non-predictable fluctuations can be reconciled with a philosophy admitting finality. Any process or fluctuation, insofar as it is natural, does not escape the status of being created[18].

a) Creation and origins. No direct comparison is viable between the first physical event (if any) and the act of creation. This holds not only because the Big Bang is screened by theoretical and observational thresholds (last photon scattering surface, horizons of classical singularities,

lution. The basis for explaining why this relation is not conflictual can be found in early teachings of Christian theology; the compatibility of both notions has been affirmed by recent Church magisterium and also stressed by a number of contemporary authors[24].

From a theoretical point of view, this compatibility lies in two facts. Firstly, the notion of finality appeals to the metaphysical notion of nature, understood in the sense of formal properties not further groundable. The very existence of these properties and laws transcends the analysis of science, as does finality. Secondly, any material nature can give rise to a material nature of higher order, as its potencies (dispositions to higher acts) can be put in act when interacting with other natures. In this way, the nature of a tree can be put in act by the nature of a growing seed. Following Thomas Aquinas, we could say that the new *causa formalis* is drawn out from the potentiality of matter[25]. Secondary causes can allow a constant and increasing enrichment, according to God's world project, because they are ontologically supported by his primary causality[26].

Summarizing, evolution and complexity presuppose creation not only because creation would contain the beginning in time of all reality, but also because creation holds the world in being and contains in itself the entire evolutionary project of the universe. Theologians would substantially agree with biologist Dobzhanski's insight, according to whom evolution is the method by which God creates: cosmical, biological and cultural evolution are nothing but parts of a unique creative process[27].

4. CREATION AND THE INTELLIGIBILITY OF THE WORLD

Theology's affirmation that the ultimate cause of reality is a Person is expected to have strong implications for the intelligibility of the created world. Since it has been worked out by an intelligent being, the universe must disclose itself as rational and intelligible. Since it is the result of a unique plan and the effect of a unique cause, it must show a strong gnoseological unity, i.e. a unity of properties and characters, recognizable over all its ranges.

From a philosophical point of view, creation involves intelligibility at different levels. First of all, the act of being is the primary object of intelligibility; it is the deepest and the most fundamental act on which all the predicables and properties of an entity rest. Second, the notion of a primary cause ensures the intelligibility of any rational procedure based on a cause-effect analysis; in fact, reducing the causes of an entity to more and more fundamental causes and processes does not explain that entity unless we admit that the chain is capable of resting upon a cause

whose existence is necessary in itself. Third, the notion of nature is precisely what makes science possible, since science grows through the discovery of laws and steady properties. Finally, the notion of an absolute beginning of time and that of a world project favor the intelligibility of evolution itself, disclosing it as a global development and not as a mere local change.

In performing their research work, physicists are inclined to find the comprehensibility of the world a non-trivial property[28]. Moreover, when the ultimate question about origins is tackled, cosmology seems to realize that the existence of the universe, its formal specificity and intelligibility are three aspects to be treated together, though within a broader philosophical context[29]. It is worth mentioning that theology, on its part, teaches that these three aspects are necessarily interrelated. They are mysteriously centered around the Person of the Christian Logos, who seems to possess a very special role with respect to creation[30].

The Triune God has in His Logos the reason for the existence of the universe[31], the exemplar cause of its rationality and the apex of its intelligibility, since the Word made flesh reveals by His own words the meaning of all that exists. The entrance of the Logos into human history shows not only that such rationality is necessarily dialogic, but also that it is a facet of the immanence of God's wisdom in the world.

The correspondence between the rationality of creation and human rationality (Einstein's question[32]) is ensured by the existence of God's image in the human being, which is, again, another aspect of the central role of the Logos over the whole of creation[33]. Within a Christian perspective, the universe is intelligible because it is between two intellects: "res naturalis inter duos intellectos constituta"[34] - namely the divine and the human.

NOTES

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7. Cf. J. Monod, *Chance and Necessity*, (Vintage Books) New York 1972; I. Prigogine and I. Stengers, *Order out of Chaos*, op. cit.
8. See on this point G. Tanzella-Nitti, *Questions in Science and Religious Belief,* (Pachart) Tucson 1992.
9. According to Thomas Aquinas, creation is understood as a *relatio*, not a *mutatio* (change):
   "Creation is not a change, but is the mere dependence of created being on the principle (*ipsa dependentia ad principium*) by which it is set up, and so comes under the category of relation" (*Summa Contra Gentiles*, II, n.18).
   "Creation is not a change, except merely according to our way of understanding. For change means that a constant is now otherwise than what it was before: sometimes this is the same actual being which varies by changes of quantity or quality or place; sometimes it is the same potential being, as in the case of substantial change where matter is the subject. But creation, whereby the entire substance of things is produced, does not allow of some common subject now different from what it was before, except according to our way of understanding, which conceives an object as first not existing at all and afterwards as existing" (*Summa Theologiae*, I, q.45, a.2, ad 2).
   "Creation puts a reality into a created thing (*ponit aliquid in creato*) only as a relation. For to be created is not to be produced through a motion or mutation which works on something that already exists, as is the case with the limited causality that produces some sorts of being. Not, however, with the production of the entire existence by the universal cause of all beings, which is God. Hence in creating he produces a thing without motion in the making. Take away motion from the acting-on acted-upon situation and only relation remains" (*ibid.*, a.3, resp.).
10. See on this point G. Tanzella-Nitti, *Questions in Science and Religious Belief*, op. cit. and W.R. Stoeger, *The Origin of the Universe in Science and Religion,* (preprint, 1992).

11. "God does not maintain things in existence by any new action, but by the continuation of the act whereby he bestows being (*esse*); an act subject neither to change nor time" (*Summa Theologiae*, I, q.104, a.1, ad 4).
"God exists in everything; not indeed as part of their substance or as an accident, but as an agent is present to that in which its action is taking place (...). Now since it is God's nature to exist, he it must be who properly causes existence in creatures; just as it is fire itself that sets other things on fire. And God is causing this effect in things not just when they begin to exist, but all the time they are maintained in existence, just as the sun is lighting up the atmosphere all the time the atmosphere remains lit. During the whole period of a thing's existence, therefore, God must be present to it, and present in a way in keeping with the way in which the thing possesses its existence" (*ibid.*, q.8, a.1, resp.).
12. Cf. Thomas Aquinas *De aeternitate mundi*; see also *Summa Theologiae*, I, q.46, a.2.
13. Cf. Genesis 1:1; Psalms 102:26-27.
14. "The phrase about things being created in the beginning of time means that the heavens and earth were created together with time; it does not suggest that the beginning of time was the measure of creation" (*Summa Theologiae*, I, q.46, a.3, ad 1)
"The world considered in itself offers no grounds for demonstration that it was once all new (*novitas mundi non potest demonstrationem recipere ex parte ipsius mundi*)" (*ibid.*, a.2, resp).
15. Cf. 2. Maccabees 7:28; cf. Lateran Council IV, Vatican Council I.
16. Cf. Genesis 1:3.6; Psalms 33:6.
17. On this point consider the following texts by Thomas Aquinas:
"The nature of a thing whatsoever is a sort of tendency that the prime mover has inscribed in it (*quaedam inclinatio indita ei a primo movente*), so aiming it toward a proper purpose. For it is clear that natural things act for a purpose - although they are not aware of this purpose - since they have received their tendency toward such purpose from the primary intelligent cause" (*In XII Metaphys.*, lect. 12).
"For it is clear that nature is nothing but the rule of an art (*ratio cuiusdam artis*), namely a godly art, a rule inner to each thing and by which all things are moved and so aimed to a specific purpose. It is just as if a shipbuilder were to give the various elements of wood, of which the ship is to be made, the capability to assemble themselves in order to build up the structure of the ship. In summary, nature is therefore a cause, one which acts because of a purpose" (*In II Phys.*, lect. 14)
18. "*Quidquid a Deo fit, est naturale quodammodo*" (*Summa Theologiae*, I-II, q.94, a.5, ad 2)
19. Cf. C. Misner, "Absolute Zero of Time", *Phys. Rev.* Sec. Ser. *186* (1969) 1328-1333.
20. See E.A. Milne, *Kinematics Relativity*, London 1947; M. Heller, "Big Bang on Ultimate Questions", in: *Origin and Early History of Universe, Proceed. of the 26th Liège Int. Astrophys. Colloquium*, Liège 1987. Cf. also E. McMullin, "How Should Cosmology Relate to Theology?" in: A. Peacocke (ed.), *The Sciences and Theology in the Twentieth Century*, (Univ. of Notre Dame Press) Notre Dame 1981.

applies it so successfully to the universe. The very common answer to this question is the following. It is within the human mind where mathematics is being conceived or constructed and then projected into the world. The universe is mathematical because it has been created such by the human mind. However, this fashionable doctrine explains very little. Even if the human mind indeed projects its own structures onto the world (and it certainly does to a certain extent), the universe must have a property allowing it to be projected" (M. Heller, *Big Bang on Ultimate Questions*, op. cit.).

29. Cf. G. Ellis, "Major Themes in the Relation between Philosophy and Cosmology. Venice Conference on Cosmology and Philosophy", *Memorie della S.A.It. 62* (1991) 553-605. On the nature of the physical laws see also the stimulating book by J. Barrow, *The World whithin the World*, (Oxford Univ. Press) Oxford 1988.
30. Cf. John 1:1-3; 1 Corinthians 8:6; Hebrews 1:2-3.
"Whoever makes something by intelligence, works according to a plan that he has before him of the things made; a house, which exists in matter is made by a builder according to the plan of a house that he has in his mind (*per rationem domus quae habet in mente*). But we have shown earlier that God brought things into being, not by physical necessity, but as one acting by intelligence and will. Hence God made all things by his Word, which is the plan of the things made by him (*ratio rerum factarum ab ipso*). (...) 'He spoke and they were made' (cf. John 1:3; Genesis 1:3.6; Psalms 148:5) For to speak is to produce a word. That God 'spoke and they were made' is therefore to be understood that he produced a Word, by which he brought things into being, as by a perfect plan of them (*per earum rationem perfecta*). But because the causes of the conservation of the things is the same as the cause of the production of them, just as all things were made by the Word, so too all things are conserved in being by the Word of God" (*Summa Contra Gentiles*, IV, c. XIII).
31. Cf. Colossians 1:15-16.
32. "You find it surprising that I think of the comprehensibility of the world (insofar as we are entitled to speak of such a world) as a miracle or an eternal mystery. But surely, *a priori*, one should expect the world to be chaotic, not to be grasped by thought in any way. One might (indeed one should) expect that the world evidenced itself as lawful only so far as we grasp it in an orderly fashion. This would be a sort of order like the alphabetical order of words. On the other hand, the kind of order created, for example, by Newton's gravitational theory is of a very different character. Even if the axioms of the theory are posited by man, the success of such a procedure supposes in the objective world a high degree of order, which we are in no way entitled to expect *a priori*. Therein lies the miracle which becomes more and more evident as our knowledge develops" (A. Einstein, *Letter to M. Solovine*, 30.3.1952).
33. Cf. Ephesians 1:4-6.
34. Cf. Thomas Aquinas, *De Veritate*, q.1, a.2

INDIVIDUAL PSYCHOSOCIAL STRUCTURES IN HIGHER MAMMALS: POSSIBLE REQUIREMENTS FOR THE REALIZATION OF HUMAN MIND AND MORALITY

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From my experience with psychosocial structures and processes in higher mammals[1], I have recently described the acquired, non-accidental individual psychosocial structure developed by higher mammals during ontogeny[2]. This "eidetic" individual structure is of fundamental importance for the cognitive and intentional performances of the animal. I will not repeat the more detailed descriptions here, but after a short characterization proceed to a tentative evaluation of the possible relevance of this mammalian quality for the evolutionary development of human mind, culture, and morality. For this purpose two distinct questions will be addressed. The first is still confined to the domain of my scientific experience and will be considered in more detail: the phylogenetic development of cognition, orientation, and tradition or "culture" in non-human mammals. The second question relates to a domain outside my scientific experience and is treated briefly and speculatively: the transition from non-human to human mental qualities in cognition and orientation.

1. INDIVIDUAL PSYCHOSOCIAL STRUCTURES IN MAMMALS

Concerning individual qualities developed in areas not genetically determined, the following distinction is important: are they accidental,

acquired by the organism during ontogeny without essentially contributing to species-specific functions, or do these individual qualities of an organism contribute to the perfection of the animal, the terminal state of its ontogenetical development? This is a difficult, but also an important question discussed by philosophers for some thousand years. It is essential for understanding organismic dynamics. The answer obviously depends on the type of quality and the type of organism considered. In organisms whose development is largely determined genetically, the individual qualities not resulting from genetic dispositions are predominantly accidental, while in organisms whose psychosocial individuality is developed and structured in an area left open by genetic programs, these individual qualities are not merely accidental, but of fundamental importance for the functional performance of these organisms. This is especially the case in humans, but the boundary between accidental and structural acquired individuality is not one between animal and man. In both, animal and man, inherited and acquired, and accidental and structural acquired individual qualities are found in various combinations.[3]

The mammalian psychosocial individuality is constructed in an area left open by genetic dispositions. It is not focussed here on individually developed traits, preferences, and aversions of the mammal, but on the connecting composition of these acquired traits in one relatively stable structure. Specific qualities, preferences and aversions, attachments and relations, developed by the animal interacting with its specific social environment, and essential for the control of its motivational and arousal states, become connected in a specific way, providing the animal with an individual structure which is of paramount importance for the integration of its functional subsystems as well as for its environmental orientations. In accordance with the philosophical tradition such a structure can be called an "eidetic" structure.[4] Various developments end as they settle in a specific relation of their qualities, an imprinting-type of settling in a specific state of connectedness.[5]

2. INTENTIONALITY AND AWARENESS IN MAMMALS

Social actions of mammals, although they often look very similar to the observer even among different species, can to various degrees be intentional[6] and non-intentional, and to various degrees be accompanied by different states of awareness. These differences can change the quality of the control of the behavioral patterns involved and of their functional significance. Examples of such actions are a lowranking individual seeking the proximity and protection of a dominant individual, thereby es-

caping the threat or aggression of a less dominant animal than the one approached, or the intervention of a dominant individual ending a quarrel or fight between two subdominant ones. Such behavior can "just happen", without any intention and without any awareness on the part of the animals involved, or it can be learned and intentionally employed by one or both of the interacting animals. It can even be recognized and "understood" by other individuals "observing" the event. This sometimes can be read from the consequent actions of these animals, including their intentional movements, which can enable the observer to follow the processes of orientation and decision in the observed individuals.[7]

The attention of a mammal is only very rarely restricted to one specific object or to one functional or motivational context. Its attention generally, in various stages of intensity, covers several areas simultaneously. It is thus able to choose several impulses out of many, and to respond to the combination of these selected impulses in a way fitting its program. It can, in such a case, sometimes choose its action, while possibly not the form in which it is carried out. A mammal even can "load" specific structures and events in its environment with specific significance and meaning, attributing to them specific qualities that make them a source of security or fear, of excitement and tension. In attributing such qualities to specific parts of its environment the mammal can show some kind of what, in humans, is called imagination, invention, and creativity.

In the steering of an organism various domains or areas of different dimensions have to be combined and integrated: physiological, emotional, cognitive, and social processes. These operate with different mechanisms in different environments; they are differently organized and controlled. A fright reaction can change an animal at all the levels influencing its control: physiologically, motivationally, mentally, and socially. It therefore is misleading to conceive of a mammal as mainly controlled by its cortex. The older brain structures play an important role, and the rest of the nervous system including its autonomous parts are also involved. Physiological, emotional, motivational, cognitive, and psychosocial conflicts and tensions have to be solved by the acting animal. Decisions concerning possible and optimal regulations have to be taken and, in the process of acting, maintained with some independence from the further development of the original situation with its specific constellation of incentives. The resulting behavior and the process leading to its realization both can be inherited or acquired. In many cases the behavior shown is inherited, while the program for its implementation is not.[8] The maintenance of such a process can be achieved by tenaciously adhering to the decisions taken entering the process, such as an attack or a chase, warding

off all further influences, or by an intentional maintenance in a specific orientation balancing influences from various domains.

3. ORIENTATION AND COGNITION IN MAMMALS

Mammals orientate themselves in physical, social, and "cultural" environments and regulate their activities, combining motivational and environmental conditions, constraints and possibilities. Concerning the processes of perception and cognition involved in these performances, several levels can be distinguished: a) Processes of perceptual categorization and diagnosis that are, without referring to any mental "images", formed like reflexes. Such processes of detecting and using cues and structural configurations in the environment can be based on "hard-wired" inherited closed programs or on open inherited programs that became more or less closed responding to specific experiences during ontogenetic development. b) Processes using procedural "knowledge" in spatial and social orientation - "path maps", "perceptive images"; such performances can possibly still be achieved by programs without using mental "images", but may also include reference to such representations. c) Processes of spatial and social orientation using conceptual knowledge - "survey maps", "memory images" of environmental qualities; such performances operate with mental representations of environmental aspects, while awareness of this by the acting individuals is not required. d) Processes of cognition, that in addition to mental images of environmental aspects, use fictive conceptualizations in orientation, planning, and evaluation of actions; such performances are accompanied by, and partly dependent on, states of awareness, they do not yet require verbal language.

A multilayer organization has to be assumed for the cognitive system of mammals. In evolution additional levels developed and were integrated with older ones. With the integration of these higher levels the cognitive system changed, developing specific, and generating new qualities.[9] Its functional organization includes hard-wired closed programs, open ones being closed during ontogeny, and programs that remain open. In the spaces remaining open, decisions have to be generated using mental representations of various kinds.

One correlate of this development is the horizon of orientation, the distance in space and time of situations and events included in the process of decision. In groups of mammals, the attention of the younger and of the less dominant individuals is generally directed more toward actual events in close proximity and toward the actions of the conspecifics in

their group. The horizon of their orientation does usually not encompass events in greater spatial, social, or temporal distance. The orientation of the older and of the more dominant individuals, in contrast, does include more distant environments. Their attention is not restricted to close events but directed also toward conspecifics beyond their own group and toward the movements of prey and predators. They do not only react to such animals when these are in sight, but also to optic, acoustic, or olfactorial cues of their earlier or actual, but distant presence, and they relate these to earlier experiences and to specific places and situations connected in their memory with specific events. In species with higher cognitive capacities such performances can be carried out with or without the use of mental representations.[10] The attention of the young of all mammalian species at first is absorbed by events occuring in close proximity. In species in which the adult animals live without permanent attachment to conspecifics the horizon of orientation roughly speaking grows with age. In species which form permanent groups of adult animals the horizon of the individuals' orientation does not necessarily grow with age: that of subdominant individuals stays restricted as characterized above. Only the dominant individuals realize the full horizon of orientation possible in that species.

In very highly organized groups with highly differentiated means of communication old subdominant animals can also gain wide horizons of orientation. In some species subdominant old individuals can develop orientations different from that of the dominant one, but of comparable complexity and differentiation. For organisms with such highly differentiated contacts to various levels of their environments with continuously changing situations for possible actions, it is important to be able to evaluate and select situations offered by the environment in relation to their own potential actions. With increasing complexity[11] this evaluation becomes increasingly difficult to achieve using programs connecting learned cues to fixed reactions. The evaluation using conceptual mental representations, though difficult to develop and time consuming in practise, is more efficient.

4. EIDETIC INDIVIDUAL STRUCTURE AND THE DEVELOPMENT OF HUMAN MIND AND MORALITY

Concerning the transition from non-human to human mental qualities, two important aspects have to be kept in mind: a new level of organization has been reached and new ways of communication have been developed.[12] In these developments older structures became integrated

9. G. Ryle (*The Concept of Mind*, [Barnes and Nobl] New York 1949) distinguished two important types of knowledge in human cognition: "knowledge how" and "knowledge that". B. M. Velichkovsky (*Wissen und Handeln*, [Verlag Chemie] Weinheim 1988) with regard to the functional organization of human cognition, including protoperceptive regulations and coordinations, distinguishes six levels. The development of new organizational levels in the domain of biology can lead to changes in units of evolution and especially of selection, cf. L. W. Buss, *The Evolution of Individuality*, (Princeton University Press) Princeton 1987.
10. For a survey of our knowledge of the cognitive capacities of non-human primates cf. D. L. Cheney and R. M. Seyfarth, *How Monkeys See the World. Inside the Mind of Another Species*, (University of Chicago Press) Chicago-London 1990.
11. The horizon of orientation and attention changes the animals' possibilities to be stressed. With increasing differentiation of attention, perception, and cognition the stressing potential of the environmental processes differentiates. A dominant animal can be terrified by an event to which the subdominant animals of the group scarcely react. An agonistic interaction between a dominant and a subdominant individual can stress the two in very different ways. Some ways affect the dominant, others the subdominant animals. At the same time, the differentiating cognitive system provides the animal with new means to cope with stressful events and situations. Accordingly the contact between organism and environment becomes increasingly dense. The effort to manage this dense contact gains in relative importance, in cost and benefit.
12. M. Donald (*Origins of the Modern Mind. Three Stages in the Evolution of Culture and Cognition*, [Harvard University Press] Cambridge/Mass.-London 1991) proposes to distinguish four stages in the development of culture, depending on the cognitive quality of communication and of image construction, four types of contacting the environment and of representing the world in the cognitive "machinery" of brain and mind: a) episodic culture with perceptual categorizations; b) mimetic culture: body and facial expressions of emotions and intentions, nonverbal communication, iconic representation; c) mythic culture: verbal communication, narrative development, and tradition of worldviews, iconic and symbolic representations; d) theoretic culture: based on verbal communication and dominated by symbolic representation.

FROM A MYTHICAL TO A HERMENEUTICAL CONSCIOUSNESS OF ORIGINS: A 3-STEP COMPLEXIFICATION PROCESS

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The aim of this contribution is to study the relationship that traditional myths and scientific rationality have with respect to the order and origins of the world. Its content may be summarized in the following three points: 1) Mythical accounts of the origins describe the emergence of order. They imply that order and disorder make a system. 2) The rationalization of mythical thought seeks the logical in the mythical. It implies that *mythos* and *logos* make a system. 3) The duplication of hermeneutics reveals the permanence of the mythical. It implies that knowledge and belief make a system.

1. MYTHICAL ACCOUNTS OF THE ORIGINS OF THE WORLD

In traditional societies - those whose legitimacy results from creation myths originating with gods or heroes - the creation narrative reveals how the world was formed and this "how" gives the reason why the world is as it is. The myths recount the primordial order which may surge from various processes.[1]

a) A Creative Will. A first type of narrative understands the origins of the world as the result of a divine will able to bring into existence what had been only appearance and potentiality (Colombia, Winnebago Indians) or a divine will able to create by a word (Israel, Poly-

nesia). The creative will can also take the form of an artisan god, who fashions the world (China, India, Egypt). The act of creation is not easy and does not always succeed at the first attempt (African cycle of Dogon, China). Finally, we must mention the theme of the cosmogenic dive, known by the prehistoric population of Central Asia: God himself dives or commands an amphibious animal to dive to the depths of the water to bring back a handful of mud from which he forms the earth. Organised life may also emerge from the depths of the earth, as recounted by the Hopi Indians who first lived below ground. Be it dive or ascent, stress is placed on the visible world coming from the depths.

b) Procreation or Differentiation. Another type of narrative supposes a primordial couple at the origin of the world (South-East Asia, Oceania, Middle-East, Greece [Hesiod], Mayan mythology). The notion of the original couple is bound to that of the primordial egg (China, India, Japan, Polynesia, Africa) which contains the germ of the universe. Finally, the world may emerge from chaos: waters, darkness, original vacuum, oblivion. Very interestingly, certain myths describe the creation of the world as the emergence of the self-consciousness of the first being (Alaskan Eskimo myth of the father-crow, the Gnostic myth of the androgynous father who "contained the whole cosmos and rested in his being, bereft of consciousness").

c) A Sacrificial Act. In Mesopotamia the god Marduk kills the monster mother-goddess, Tiamat, and makes heaven and earth from her body. In the Rig-Veda the sacrifice of Purusha (= man) is accomplished by the gods: his head becomes the sun, his feet the earth; the moon is born from his consciousness. In Scandinavian mythology, the dismembering of the giant Ymir produces the different species.

Different though creation myths may be, they all assume a living first cause - God, couple, egg, monster - or an homogeneous, undifferentiated chaos. Starting from a simple primordial reality the cosmogenic myth explains how the world became complex. The myth speaks of the primordial order but the real order is necessarily different, and the world is constantly threatened by a return to chaos.[2] It is then a matter of averting disorder and change but, as time passes, this becomes more difficult. In fact a 4-phase cycle is produced (see Figure 1, lower level). At a given moment a new theme appears and becomes the core of a narrative which is put forward as a new explanation of the world: this is the genesis of the myth. When the narrative is widely accepted as a satisfactory expla-

nation, the myth enters a phase of stability. It then gives rise to variations: the drift-phase. Finally, the myth loses its appeal and is brought into question by new experiences or new knowledge. This is the phase of wasting; the myth provides materials for secondary elaboration (folktale or legend). Competing explanations come to the fore; the myth undergoes metaphorphosis and the cycle can restart.

With the emergence of experimental science in the 17th century, the order of the world found a new intelligibility: from falling bodies on the earth to the revolving planets, the movements of matter form a chain of causes and effects without leaving room for metaphysics. Indeed, the first cause - the absolute beginning - is still provisionally entrusted to a God who is engineer, architect or watchmaker. However, the rift between the animism of traditional societies and the physical causality of modern societies leads to a bifurcation: on the one hand, the natural order follows its own laws and it is the task of science to shed light on these; scientific theories replace myths. On the other hand, discursive reason takes up the myth as an object for reflection. This leads to a second level of complexity.

2. THE RATIONALIZATION OF MYTHIC THOUGHT

Certain accounts of the creation of the world became obsolete long before the coming of modernity: from antiquity, the presocratic philosophers distanced themselves from Hesiod's mythology. *Mythos* is distinguished from *logos*. Plato purged the myths of all that seemed unworthy of the gods. Euhemerus, a contemporary of Alexander the Great, suggested an historical interpretation of myths: they take their origins from historical events and the gods are no more than heroic personalities later deified. Euhemerism prevailed throughout the Middle Ages and claimed the superiority of Christianity over pagan myths. At the time of the Renaissance, the West rediscovered the texts of Antiquity and, at first, accorded them total credit in matters of knowledge. And then, in the 18th century, the improbability of mythical accounts nourished the Quarrel of the Ancients and Moderns. The spirit of the Enlightenment discredited antique beliefs: myths were thus considered as moral tales. During the romantic period, myths became symbolic accounts of the divine message inscribed in nature (Schelling). Since the 19th century the comparative study of myths has given rise to various schools of interpretation: evolutionism (Comte, Spencer, Frazer), diffusionism (Frobenius, Eliot-Smith), socio-functionalism (Durkheim, Malinowski, Lévy-Brühl, Mauss), the French school of anthropology (Griaule, Dumézil), the Cam-

bridge "Myth and Rite" school (Harrison, Murray), the psychoanalytical approach (Freud, Bettelheim, Jung, Kerény, von Franz), the phenomenology of religion (Eliade, Girard), and structural anthropology (Lévi-Strauss and disciples). Myth is successively understood as prelogical thought, a social charter, a powerful world-view, a thinking tool, the theory of ritual, the screen-memory of peoples, an archetype of existence, a sacred history forming the existential experience of human beings, a universally shared vision of the world, a metalanguage.[3] So, what is a myth? A definition comes to the fore (initial phase), is dominant for some time (stability), changes (drift), and then the paradigm wastes (see Fig. 1, intermediate level). The definition and the function of myths fluctuate, modifying the objects considered as myths. From the second half of the 19th century approximately, the study of mythic thought in so-called primitive societies had a feedback effect on modern societies. Indeed, the study of myths is not an entertainment devoid of consequences and the student of myths seldom emerges unscathed. One realizes that the characterisation of myth depends on the point of view of the mythanalyst: *mythos* and *logos* determine each other, myths and their logic make a system. By degrees modern scholars came to understand this fact even though they had considered themselves free from any mythic thought.

If the myths of primitive societies are concepts of the world formerly held to be true and now considered out of date, what has taken their place in modern societies? On one hand, experimental science has laid a new foundation for the natural order. On the other, the Enlightenment nourished the revolutionary spirit which has substituted social consensus for divine transcendence. It became necessary to discriminate between the natural oder and the social order. This was no light matter: the process took more than two centuries, during which time science, philosophies of history and social utopias divided the spoils of the heritage of western Christianity and ancient mythologies. For modernity, the Golden Age - the perfect order - lies not behind but ahead: mankind progresses, largely thanks to science, towards a future which will be better than the past.

Today, for various reasons, modernity is doubtful about its foundations. Science no longer claims to describe the whole of reality and it no longer even maintains that it describes reality as it is - reality is veiled.[4] In fact, it is impossible for us to speak of any reality other than in the form of the content of our mind. Physical laws are less those of nature than those of our mind; the postulate according to which reality is rational is undecidable. To reduce reality to rationality, such was the myth *par excellence* of western epistemology.

On the other side of modernity, that of the human sciences, the history of the 20th century has discredited one by one the ideals which had

A SCIENTIFIC BIPOLAR ANTHROPOLOGY COMPLETED BY A TRIPOLAR THEOLOGICAL ANTHROPOLOGY

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While reading the Proceedings of the Second European Conference on Science and Religion held at Enschede in 1988, one can only be struck by the large agreement among the lectures. A prevailing idea was that the process of evolution, in its major axis, led to ever higher forms ending inclusively with the reflexive conscience of man. The scientific vision of evolution is undoubtedly of a continuity in which the potentialities of nature are gradually worked out. The Christian will add that these potentialities were bestowed on nature by God, but then he no longer speaks as a scientist.

There was, however, a lecture which raised an interesting question. I refer to the contribution of Dr. J. Durant (Imperial College, London) stressing that there are two questions for which science provides no answer for the very reason that they lie outside its province. One is quite classical: "Why is there anything rather than nothing ?"; this problem of existence belongs obviously to metaphysics. But the other question is surely more controversial. The author calls it the problem of experience. "Why is there subjective experience?" a question which may be put in a slightly different way. "How is there personality in the universe?" Such a question cannot be answered by science for, necessarily and by its very method, as it is said, "science deals exclusively in objective knowledge", meaning that "while people may be known scientifically as objects, they can never be known scientifically as subjects. Even the secular sciences which deal with subjective experience - some branches of psychology

for example - deal with it only as objective fact; always, in a scientific analysis, the strictly subjective point of view is written out". This exclusion of subjectivity from the domain belonging to scientific investigation will surely be diversely appreciated. Nevertheless, even if Dr. Durant's positions may be deemed by many as too radical, they are a token of a much larger refusal of a reductionist monism.

However, to reject monism does not at all mean to adopt dualism. There are many facts and experiments against dualism which give a clear indication of the interactions between body and mind; we all know that organic injuries disturb our psyche. They reveal the deep unity of our being, but it is a unity comprising two distinctive aspects. The scientific vision leads us to a bipolar anthropology.

Different authors have extended this bipolarity at all levels of the creation. Among them, Teilhard de Chardin is one of the best known. For him, reality is "biface" (two-sided); he distinguishes in any being an "outside" and an "inside".

In this matter, the vocabulary may vary. Let me say that, for many years, I preferred the term complementarity for characterizing the unity of a being comprising two aspects for which the most general suitable terms are an aspect of "substratum" and another of "information", corresponding respectively to the outside and the inside. Naturally, these general terms take various forms appropriate to each level.

The very word complementarity has, of course, its origin in the well known principle of Bohr showing that, at the basic level of physical elementary entities, reality reveals itself under two antagonistic aspects according to the experiment being performed: either a localized one (the so-called corpuscular aspect) or a non-localized one (the so-called undulatory aspect, the "wave"). Now, in spite of being opposites, these two aspects are necessarily present in a unified entity: they constitute a complementarity.

But let us not remain at the basic level. We may recognize a similar structure, that is to say a complementarity of two aspects, at ascending levels of reality:

- at the level of atoms and molecules, the elementary entities constitute the substratum which takes forms thanks to the interactions;
- at the beginning of the biological level, in the cell, macromolecules provide the substratum which becomes living by the interplay of an informative organization;
- at the level of developed living beings, we have a multicellular "substratum" and an informative psychism:

- finally, at the level of man, a body quite similar to that of superior animals constitutes the substratum which is associated with an informative aspect having reached the stage of reflexive conscience.

From this sequence, a structural similarity appears at all levels, either physical or biological. The unity of the being requires joining two aspects without really understanding how they work together. Let us consider only the two extreme cases. We have already recognized in elementary physical entities a logical contradiction since their behaviour is sometimes localized and sometimes non-localized in space. And at the other extreme, it will be sufficient to put the question: "how can a network of neurones become the seat of the mind?" This body-mind problem, as Dr. Durant said, "has remained totally untouched by any and all advances in scientific understanding". It remains a colossal mystery! We may still remark that, in this generalized complementarity, at each level the substratum takes over the whole of the previous level while the emergence of a new quality takes always place on the side of the information. The structural isomorphism disclosed at all levels of reality would favour a vision of continuity. But if the attention is focused on the emergence of new qualities, which precisely allows us to distinguish various levels, one puts forward arguments promoting a vision of discontinuities. The scientific endeavour, however, is to account for emergences on the sole basis of the potentialities of nature, thus obviously favoring a vision of continuity. This was, altogether, the predominant position at Enschede, extended also to man with the emergence of his reflexive conscience. Nevertheless, huge difficulties remain and one hesitates.

In particular, when considering the case of man, one cannot but be struck by the contrast between the degrees of somatic and psychic differences between him and the primates which are undoubtedly the most evolved animals. One hears that men and chimpanzees have in common around 99% of their chromosomes. It seems unconceivable that such a relatively small genetic difference may be sufficient to account for the extraordinary new capacities on the spiritual level. And even if one refers to the cognitive and affective capacities of the primates, specialists underline irreducible differences with respect to human behaviour. Let us but quote in this respect professor Mark Callens, of the Flemish University of Louvain, who says: "The huge problem of the emergence of the specifically human behaviour finds but thoroughly unsatisfactory solutions at the neurophysiological level".

Are we not then legitimately led to search for some light in another direction? Even more for a spiritualist who considers that the problem of the status of man goes beyond the field of science. Let us thus look

at the theological Christian vision or, better, at a theological vision, for, in this domain also, one finds various interpretations and we have to make a choice.

We refer to the study of the late Cardinal Father Henri de Lubac entitled "*Anthropologie tripartite*" (Tripolar anthropology). He starts from a scriptural reference, a verse from the conclusion of the first epistle to the Thessalonians: "may the God of peace sanctify you wholly and that your entire being, spirit, soul and body be kept beyond reproach up to the coming of our Lord Jesus-Christ" (1Thess 5:23).

Thus, the whole being of man comprises the spirit, the soul and the body. To the dichotomy soul-body usually attributed to all living beings, the spirit is added for man in a distinctive manner. And in the first epistle to the Corinthians (1Cor 2:14) St. Paul says that the couple soul-body alone would only lead to a "psychic man", unable to receive the Spirit of God and that, for this reason, he proposes the "spiritual man".

Surely this passage from dichotomy to trichotomy has been a controversial subject. We can but refer to the work of de Lubac for a historical survey on this matter. But if 85 pages have been devoted to this question, it is well, as underlined by the author, because "the tripolar anthropology, in the tradition of the Church, has continuously provided a basis for doctrine and spiritual life". We then find ourselves authorized to take into consideration this tripolar perspective, even more as it throws a quite interesting light on the fundamental problem of man's specificity.

Let us immediately enter into the heart of the question. Whatever differences may be pointed out between the handling of a tool or the recognition of a signal by a man or by a primate, the specificity of man is decisively better established by the emergence of responsibility, which is a fruit of liberty. Nobody would have the idea to attribute responsibility to another being than man. This intrusion of ethics is something radically new on our earth, completely foreign to a nature remaining fundamentally deterministic in spite of a certain amount of unforeseeability (Prigogine has shown that systems far from equilibrium may evolve in a way altogether deterministic but unforeseeable). Man being responsible means that he is a person, capable of establishing relations with others, free and creative. Any Christian will recognize in such attributes the main characteristics of man created as an Image of God.

Finally, the best definition of man is a theological one: the being that biological evolution has brought to such a level that he becomes able to respond to the call of God and to receive therefore the gift of the spirit. Obviously, we then enter in a sphere beyond the mere natural one, for the response to such a call requires a gift, that of the spirit. We would like to add that such a vision may also throw light on a classical theo-

logical assertion, namely the direct creation of the human "soul" by God. May we not suggest that the usage of the word "soul" instead of "spirit" derives from the historical medieval context under the influence of an Aristotelian vocabulary? In the tripolar vision, "soul" is natural and it is the "spirit" which is a direct gift.

We successively presented two visions of man, one scientific and bipolar, the other theological and tripolar. The latter is not a substitute for the first. It completes it. It takes over wholly the complementarity of soul and body but adds the gift of the spirit. For us, this character of fulfilment and not of opposition is very important. Man is not set apart from nature, he is not an a-cosmic being, but the gift of the spirit underlines his quite exceptional position among all creatures (at least on our earth!). If generalized complementarity allows us, through the structural isomorphisms consisting in the conjunction of apparent antinomies, to see in all Creation a reflection of the Creator (we developed this point at Enschede) - man only has been created as "Image and Likeness of God" - then man becomes a person, free, creative and capable of establishing relations with others. He is a responsible being who has to act in order to find accomplishment in divine adoption. The Christian retains all that science may learn but science cannot reach the sphere of this Image! Should he then not propose a complete vision of man which requires this supplement that theology only can provide? Should he not proclaim with the late Father Urs von Balthasar that it is "to the God of life that we owe our self"?

Proximity to non-existence is a characteristic not only of space but of time as well. Imagine a dark street along which we go with a lantern. The houses behind (the past) and ahead (the future) exist as well as the houses we illuminate (the present). In Einstein's spacetime the past and future are given at once as well. But quantum mechanics due to Heisenberg's uncertainty principle makes either time (Dirac-Wheeler-DeWitt 1+3 splitting) or one dimension of space (my dyadic formalism of 2+2 splitting of space-time, 1971) ephemeral. Evidently, there exists only a singular boundary between the past and the future - the present. In this case the past is a spatial record (text, traces, memory) of the temporal evolution existing up to now. Bones of the past live now. History is a translation of the modus of time into that of space. And the future is created every instant ambiguously, so that nature itself does not know its tomorrow completely. The mystery of the past (not everything remains) and the mystery of the future (not everything is predictable) meet in the mystery of the present (it exists as much as it does not exist, it is here and directed out of itself, it is open and not completely open).

The present not only contains the past but also the future. I think that history is not a river, but an ocean with travelling waves, which do not transfer the historical substratum, i.e. all phases of history and of the evolution of the cosmos, in a sense, are contained in the present that is divided every time a new text is written with old worlds. The waves of history diverge (the concept of progress is local), but the semantic centre of being remains *in situ*.

Hence there recurs a longing for the truth and the absolute. Since they have not been reached, they are reference points, but not a state. Man sees and conceives the changeable world in terms of invariants, but the ontological status of these invariants is essentially different from the status of being available. The paradox of man is that the completeness of his existence is confined to his finite available being in the present, but he finds his sense only in eternity, God (the Absolute). In this respect man is a marginal, singular creature. And the physical premise of man and intellect is a focussing of natural forces, which arise inevitably, on individual instants in individual corners of the cosmos.

NOTE

1. See the article by Serge S. Khorugi, "Isihasm and History", in the Journal *Chelovek*, Moscow, 1991, N 45.

THEODICY AND SOCIOBIOLOGY

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There are two types of evil. When humans do wrong, they sin. This is moral evil. The other sort is natural evil, when suffering and destruction happen through natural agencies and humans are not responsible. All people experience both types of evil. We all feel pain, injustice, suffering, a sense of helplessness, and each of us intentionally and unintentionally does wrong.

Suffering and evil raise a problem for theology: why the almighty God allows them to happen. John Hick states the theodicy question well: "If God is perfectly loving, God must wish to abolish all evil; and if God is allpowerful, God must be able to abolish all evil. But evil exists; therefore God cannot be both omnipotent and perfectly loving" (Hick 1983, 40-41).

Theodicy is more than academic. Humans hate suffering. So we think it cannot be part of God and the good life on the other side of the grave. We think God has to hate it too. God must have our sense of right and wrong. We think God has this even if it is within a divine scheme or plan beyond our understanding.

This paper will explore these issues using human sociobiology as a source of ideas. Sociobiology is a new field that takes evolutionary theory beyond the biological into the social. Theologians have paid little attention to the light it might shed on their problems (see also Sharpe 1991; and In Press).

Built into the human mind are various patterns or rules by which it works. The sociobiologists E.O. Wilson and Charles Lumsden assume their existence and call them epigenetic rules. They process information which comes into the mind from the outside as well as from internal

emotions. There are two types of these patterns. Primary epigenetic rules process raw emotional and sense data. Secondary epigenetic rules assemble inner mental processes. These include conscious and deliberate decision making and the placing of values. Epigenetic rules guide people into thoughts and actions that insure human survival. Genes encode them because they have proved so worthwhile in the struggles of our human and prehuman ancestors (Lumsden and Wilson 1983; and Ruse 1989).

A second aspect of sociobiology has to do with reproductive success. From an evolutionary point of view, people are successful when they pass their genes to the next generation. One way to achieve this is through cooperative behavior called biological "altruism". "Altruistic" behavior enhances genetic success at risk or cost to oneself. For example, parents can promote their children's success by providing an expensive education rather than having a large family and more money for themselves. They are behaving "altruistically". People also practice "reciprocal altruism". This happens when they do something for others. Their reward is that someone sometime may help them more.

Further, humans have altruistic feelings that pressure them to behave "altruistically". These feelings come through epigenetic rules and oppose selfish inclinations which also exist for biological reasons. The rules give morality the feeling of objective truth and guide moral reasoning.

Sociobiology, while making biology the key player in explaining human moral behavior, does not dismiss the role culture has to play. A society's moral system is a cultural construct, based on biological requirements. The culture determines good and bad by comparing various epigenetic rules. Culture builds, sorts, and develops the genetic impulses or epigenetic rules into a morality. Still, at root morality is a biological adaptation.

There are two topics to do with evil and theodicy that I will discuss in the light of sociobiology. First, I will ask if God need be or is moral. Then I will look at the origin of the passion over theodicy and why it matters so much.

The base of ethical claims interests the philosopher Michael Ruse. To recognize morality as a biological adaptation, he maintains, undermines its traditional support. The Christian has to believe in an independent and objective moral code. It cannot change or depend on human conditions. For morality to work, people must think it is objectively true, coming from something higher than and outside of themselves. Christians feel this absolute, moral other as a force on them, and so follow its moral dictates. This belief, Ruse thinks, biology destroys. He adds: "Morality is just an aid to survival and reproduction, and has no being beyond or without this" (Ruse 1989, 268).

Human morality is a product of human evolution and is peculiar to our species. The morality of any other species, if it has one, developed for its own social and evolutionary needs. Human morality does not apply to them.

This insight leads in two directions.

Since morality is a product or function of biological evolution, why should God have a morality? Perhaps morality does not apply to God; God is amoral. People think God has their morality because they project their morality onto God. This is a biologically motivated activity.

The second direction assumes God does have a morality. Then, since human morality is peculiar to our species, it asks if God's morality is like a human one. The challenge is to discover what is God's morality.

There are good reasons for rejecting this second approach. From an evolutionary point of view, there are problems with God's having a morality. It would show as a tendency throughout the world, since God is its creator and sustainer. (a) This could make God's morality common across species. We do not see this. Different species have different moralities, as we understand the term. Cannibalism (the praying mantis) and incest among many species, for instance, differ from human ideals. (b) One could also say the process of evolution should bring out God's morality, especially in the human. Evolution is the way God is working to create life. However, the genetic survival pressures that produce human morality need not reflect or recreate God's morality. God does not have a digestive tract because we do.

Thus God need not have a morality. This removes the idea that divine creation and sustaining plant God's morality in the world. The world is morally neutral. Like God it is amoral. Neither does it have an end or *telos*. God does not have a purpose for the universe because having a purpose requires having a morality. That end defines what is the good.

That God is amoral affects theodicy. Theodicy tries to understand why God contains or does or allows the evil and suffering of the world. This quest assumes, first, that God has the power to stop the evil and suffering. This is an important point which any responsible theology must address. Second, it assumes God has the morality to which humans aspire. It assumes God loves us in the same way parents love their children. If you really love someone, you fervently want to shield them from evil and suffering if possible, especially from extreme cases. So it assumes God has our highest sense of morality. That God does not share our morality removes much of the force to the problem of evil.

The above argument has important implications. Theologians cannot start with God's being moral. If they want to defend God's being moral

in the highest human sense, they need to make a case for it. Their defense, on the other hand, cannot rest on the natural world.

Besides helping with theodicy, sociobiology also suggests why theodicy is important. Traditional answers to the problem of evil do not fully satisfy our pain and anger. We feel the enormity of suffering and evil. It is natural therefore to ask about God's responsibility for them. Like Job, we continue crying to the heavens. We believe God has the same morality and sense of justice to which we aspire. We also believe God has the power to do anything. If God really loves people, God would not let all this misery happen. So we hold God responsible for evil and suffering. Other questions pale in comparison. Despite all the wisdom poured into theodicy, the questioning persists.

Why? It is this driving desire that needs exploring. Why are there these strong feelings and fervent questions of God?

Biology is responsible. First, we suffer because we are biological beings. Suffering and evil have the weight we give them because we have evolved to do so. Biology makes us want a world free from them. We want this for our survival. Second, biology promotes belief in a caring power beyond the world. The trumpet call of this power is to a morality in tune with what genetic survival requires. God is all-loving because that is part of the morality our biology wants us to project onto God.

So for the sake of survival, biology makes us cry out for release from suffering and evil. The force and persistence of our crying out to God in the face of evil and suffering directly reflects human survival. It is the strongest drive in us. Biology also makes us create an all-loving, all-powerful God. Biology, therefore, places us in the contradiction of theodicy. The problem of evil comes from tactics biological evolution has instilled in us.

If there is merit in sociobiology and its implications for theology, there is much interesting construction to do. Taking the perfectly good from God, while not from the human ideal, is a severe step for a Christian theology. This requires considerable exploration. Sociobiology raises many other questions too. What is the relation of God to the world if not one of morality? In what ways ought one to think of God transcending the world? What is the good to which humans might aspire? Further, where does the power behind the good come from to encourage humans to strive toward it? Sociobiology requires telling a new theological story about God, the universe, and humanity.

Section 3

Time, Complexity and Organization

THE ROLE OF THE "ELEMENTS OF THE WORLD" AS A PARADIGM IN PYTHAGOREAN THINKING AND IN THE EPISTLE TO THE COLOSSIANS

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I. In the teaching of Teilhard de Chardin protology (the doctrine of creation) is connected with eschatology through the christology. This fact could be a starting point in the dialogue between science and theology. When Teilhard made the Cosmic Christ the main idea of his Christian philosophy of nature, he referred to the Epistle to the Ephesians as well as to the Colossians. Certain parts of the Epistle to the Colossians are good sources for Christian theology since they contain some material for dialogue with the sciences, and we can find in them a theological confrontation with a kind of natural philosophy. Of course, we could not speak about an exact science, in the modern sense of the term, in the 1st century AD. At that time science was still imbedded in a speculative natural philosophy. But that philosophy of nature with which the Apostle is engaged in a debate, can be regarded as a prototype of the later sciences. According to E. Schweizer[1] a Pythagorian fragment, which has come down to us, is the best representation of this philosophy[2]. In this fragment a certain thought of evolution predominates. It starts with cosmology and anthropology of primitive forms and ends with the possibility of the immortality of the human soul. The succession is the following complexification from the monad through the four elements (earth, water, fire, air) to developing spherical forms (point 25), isomorphism in the cosmos, a tendency towards counter balancing, and changes after disturbing the balance (pt. 26); the condition of the emergence of life, heat and sunshine (pt. 27), the emergence of human souls from ether, the immor-

tality of it following from its etherial character (pt. 28), the developing of human perceptual faculties (pt. 29); the "anatomy" of the human soul: the "parts" of it are mind, intellect and emotion, the mind being an exclusively human property (pt. 30); the wandering of the soul after death upwards or downwards (pt. 31); demoniac and good spirits (pt. 32); and the worship of heroes and gods, the sanctification of man (by means of) ascetism, cultic washing and initiatory rites (pt. 33).

What is the historical background for the ideas of this fragment? It is the concept of Empedocles - originated from Heraclitus - about a cosmos combined from the opposites of Love and Fight. The function of the first one is the uniting of the parts ("roots", "members", later: "elements"). The second one has a dividing, contrasting function.

δοιη δε θνητων γενεσις, δοιη δ' απολειψις
[(There are) two aspects to the genesis of mortals,
two aspects to their disappearance].[3]

This Empedocleian concept has been interpreted by the Pythagoreans. Their text is available in the form of a Peripatetic tradition - that is the reason for the "pseudo-"attribute before it - but its content is really Pythagorean.

E. Schweizer mentions two solution-experiments[4] aimed at delivering humankind from the cosmological determinism mentioned above. One of them is the teaching of the Jewish-Hellenist Philo according to which a reconciliation of the opposite parts of the cosmos takes place yearly at the occasion of the Jewish New Year Feast. The other solution is the religious-philosophical conviction formed by Pythagoreans out of Empedoclean thoughts.[5] In this it is true that humans are exposed to the fight and to the domination by "the elements of the world". Surely, from a dualistic cosmogony the result is a deterministic anthropology. But, on the other side, man has an opportunity by the way of ascetism and initiatory rites to rise from the captivity of "the elements of the world" to ethereal hights and so to immortality.

II. How does the author of the Epistle to the Colossians react to this?[6] What kind of counter-arguments does he have? New Testament exegesis has pointed out that the Epistle to the Colossians does not employ a single but a twofold theology[7] against false teachings in the congregation. One of them is the so-called Christ-hymn, the other the admonition in 2:8-23 to the members of the congregation not to worship "the elements of the world".

The hymn was taken over by the author from an older tradition with short but important amplifications. The admonitions were formulated by him. The hymn consists of more verses than the admonitions and glorifies the cosmic Christ. Christ took part in the work of the world of nature with the world of grace. His redemptory work has reconciled the individual parts of the cosmos with each other. Christ unifies in his being the Creator and creation indivisibly but discernibly: This is in accordance with the complementarity of his twofold nature (Chalcedon); his reconciling function extends not only to individuals, and not only to the Church, but also to the whole universe (1:8), and in this sense it is "cosmic". It is an error to interpret this view as pantheism. The phrase "cosmic Christ" does not imply his being melted with the cosmos, but that the effect of his death on the cross extends to the whole cosmos.

In his admonition the author uses the metaphor of triumph (1:15) in order to deliver the readers of the Epistle from the dominion of and service to "the elements of the world". According to this metaphor the glorified Christ, in the course of his ascension, defeated and disarmed "the element of the world" and the spiritual powers (in the biblical religion these were the demoniac powers) and carried them with him as prisoners of war. Therefore it is absolutely unnecessary that members of the Christian congregation should desire to be delivered from "the elements of the world" - as the false teachers suggested - by means of eating, sexual ascetism, observing extraordinary days (feasts) or an extensive adoration of the angelical-spiritual powers. Instead, they have to trust in the redemption and victory whereby Christ has delivered them from cosmic elements and from serving and adoring creatures in fear, and they have to trust and to adore the Creator as it is fitting in the life of God's children.

III. How can we use these thoughts conceived in the 1st century AD in view of the relationship between theology and science at the end of the 2nd millenium?

(1) It is not the task of theology to analyse the material reality of the world, to determine its elements and to fix its number. This is the task of science. Therefore, there is no necessity of conflict between the latter one and theology. Theology does not analyse "the elements of the world", but it interprets their wholeness.

(2) Science and the philosophy of nature consider the unity of the world in an evolutionary or complementary unity of fight and equali-

zation (perhaps even oscillation). The dualistic wing of the philosophy of nature sees the world in the dialectic tension of its originally irreconcilable parts (elements). Theology (and the Christian faith) considers the world as unity, because God is the Creator and Reconciler of all. The world may have many elements, spheres and driving powers, but these all are parts of the one Creation with the same origin and ultimate purpose. This concept guarantees not only the unity but also the value (environment) of the world.

(3) According to science and the philosophy of nature man is determined by his constituting elements. That is a view we may call a "not more than ..." attitude, which reduces anthropology to biology, biology to chemistry and chemistry to physics. An anthropological determinism develops out of a dualistic cosmogony, because according to this man is a being enclosed in the constitutive elements of nature, and is different from them. On the other hand, Christian theology has a knowledge about man, according to which he is not only a natural but also an historical-sociological and religious being. The principal question of Christian anthropology is not what are the constitutive elements of man, but to whom he belongs. Christian theology gives two answers to these questions. The first answer is: Man is not who he should be, but he is alienated from his own destination (Col. 1:21). Theology calls this alienation sin. The other answer is that Christ's reconciling-redemptory act on the cross has not put an end to the natural conflicts between the elements - as the New Year liturgy of Philo or the Philia of the Pythagoreans have done - but it brings to an end man's alienation from God . That is the Christian meaning of redemption: It delivers us not only from the principle of evil, but from the slavery of "the elements of the world". Thus, in his belonging to God, man is free.

(4) Man, who is liberated from the slavery of "the elements of the world", has demythisized surrounding nature. Therefore it can be a subject of scientific research. At the same time man considers nature - together with himself - as Creation, and is able to see its value, and feels responsibility towards it.

(5) Christians trust that God re-creates corrupt creation, as a consequence of the fullness of redemption.

TIME OF PLANETS AND TIME OF LIFE
THE CONCEPT OF A "TREE OF TIMES"

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1. BEING AND BECOMING

Reversibility is one of the conceptual and methodological corner stones of physics from Descartes to Einstein. This concept assumes a reversible time mode in every kind of motion such that under a given set of particles and forces a motion or a trajectory can exactly be repeated. The time course is steady, uniform and absolute. This is one of the main messages of Newton's 'Principia'. This great, even gigantic (as it was called by Newton's contemporaries) achievement has swept away all previous time concepts, because it has made possible classical physics with all its concequences from the steam engine over atomic energy to the computerized roboter. The change in paradigm, the introduction of an absolute time by Newton removed a 2000 year old concept, the concept of Aristotle; for him motion and becoming where the prime realities and time was simply the reflection of these processes in the human mind, it was "the calculable measure or dimension of motion with respect to before-and-afterness".[1] The Newtonian time is derived from circular motions like the planetary motions, from regular oscillations like the vibration in a quarz crystal or from the atomic vibration of the caesium atom. The more the absolutely precise clock is approximated, the more the ideal of an absolute and reversible time is verified. At the moment a second is defined as the duration of 9.192.631.770 periods of the 133-caesium atom.[2]

and died out. In the human mind new ideas are created and may become determining factors in future history. Irreversibility has become a topic of science since the middle of the last century and the introduction of the second law of thermodynamics. Life by definition is far away from thermodynamic equilibrium. It occurs in an irreversible time scale, as we say today, it is a dissipative structure. There is an unbridgeable gap between Newtonian physics and the second law of thermodynamics which the great Ludwig Boltzmann tried to fill with his H-theorem, however unsuccessfully.[6]

In reality none of two modes of time will occur completely separately. Every cyclic process is subject to small disturbances which can finally give rise to a collapse of the system. And indeed the new development of chaos physics has begun with the prize question of the Swedish Academy in 1890: "How stable is our planetary system?" This question was finally answered by the French mathematician Henri Poincaré, who resolved that even *the three body problem* is mathematically nonintegratable and that even the planetary system has *its history*. He created the mathematics of *bifurcation dynamics* which nowadays has led to the concept of *deterministic chaos*. Thus, sooner or later a rotatory motion will lead to a discontinuity of the system and its time mode. The most suitable description for these situations is the model of the strange attractor which has originally been proposed by meteorologists in order to explain phenomena of nonpredictable turbulence.[7] As a model one may assume a planet circulating around a sun; this undisturbed "eternal planetary system" may be approached by a second sun of equal gravitational force. At a certain distance the planet is attracted equally by both attractors and "does not know" around which sun it should circulate. It begins to jump in irregular intervals from a trajectory around the regular sun to a trajectory around the new sun, and back. This is a chaotic motion. Whereas the cyclic motion or sinusoidal oscillation is governed by the irrational number $\pi = 3{,}141592...$, the chaotic transition is governed by the Feigenbaum number $\delta = 4{,}669201....$ With these two universal numbers the relation between the two modes of time can in principle be described. After the transition through a chaotic situation the hypothetical planet might end up in the field of the new attractor, this means it will leave the gravitational influence of its original attractor and perform a regular cyclic motion around the new attractor, thus moving again in the structurized time mode. Also during the jump there will be a residual cyclic nature of the motion. The two time modes cooperate and are dependent on each other. There is a gearing between t_r and t_i. The twofold structure of time proposed here can in principle be applied to all temporal systems.

3. THE STRUCTURE OF TIME AND THE MANDELBROT SET

As mentioned above no cyclic system will be completely undisturbed. Even a hydrogen atom one day will fall into some sun or black hole and be subject to nuclear reactions. All cyclic processes are iterations. The mathematics of iterative processes have made great progress in the last decade. The so-called Mandelbrot set is generated in such a process. It is described by the equation $X_{n+1} = f(X_n) = X^2_n+k(i)$ in which k is a constant containing an irrational number i. With certain relations of X and k the Mandelbrot set is formed in subsequent bifurcation processes and leads to figures which are self-similar and to fractals with chaotic dimensions. Mandelbrot[8] defines *fractal time*: "The number of errors M between the points in time 0 and r measures the time by counting those points of time at which something remarkable happens. It is an example of fractal time."[9] This definition of time is of course completely different from the Newtonian time which is uniform and does not care about *remarkable events*. The *fractal time*, however, is the time mode required for the description of *new events*, for characterization of the mechanisms of self-organization. Science nowadays has come to a point when it finally can pose the old question: How does *the new* arise? Newtonian science can only ask the question: How is the world organized, how does it function? With the prevalence of the *science of dynamic systems* in our days, be it *statistical dynamics, cosmology, biology, medicine, neuroscience*, one asks the question: How is *the new* formed? Science is now far enough advanced to leave the question of *Being* and pass to the question of *Becoming*. In a way this looks like a return to Aristotelian thinking and the abandonment of Kantian philosophy. I do not think this is completely true, each concept has its realm of validity, depending on whether one considers structures (t_r) or developments (t_i). Thus elements of the philosophy of Aristotle and of Kant's transcendentalism should be adapted to a new philosophy of life. We have tried the first steps into this direction.[10]

4. TIME BECOMES SPACE

The two modes of time discussed here, t_r and t_i, had already been characterized by presocratic philosophers such as Anaxagoras[11] who says: "From which things the existing objects have their origin in those things also their dissolution will take place according to the law, because they give to each other balance and satisfaction for their transgressions according to the order of time." This is t_r. On the other hand Heraclitus

says[12]: "One cannot step twice into the same river." This is t_i. With the gradual mechanisation of our concepts of this world the cyclic mode of time of Anaxagoras prevailed more and more. For the more colourful concepts of time in ancient philosophy this meant a reduction. Such a reduction, is, however, a prerequisite for the formulation of classical physics. Physics only functions with linear trajectories that are reproducible: Time became a neutral measure. Only in the second half of the 19th century with the introduction of entropy (1886) irreversible processes were again envisaged and since that time we must ask again the old question: What then is this time? The following answer, however unsatisfactory, was given by Augustine: "*When nobody asks me, I know it. If, however, I wish to explain it to somebody who had asked me, I do not know it*"[13].

One thing is for certain: the cosmos has the form of a process. Therefore, one must ask: a process from where and to which end? Only if we could know the future of this process as well as we know its past could we describe this process completely. However, the future is impossible to predict, because the time course it follows is irreversible, unrepeatable and, therefore, unpredictable. We, therefore, must formulate: the cosmos is an unfinished process which does not know its own future.

Furthermore this must have some meaning for the concept of truth. Truth itself can then only be formulated as a process which does not know its own future. The process of truth is not closed and therefore concealed. The concept of truth has, of course, been historicized early enough to be a simple "gentleman's agreement" between men from Hume through Nietzsche to the historicism of Dilthey. If we stick to the old relation between being and truth as in the more modern ontologies of M. Heidegger and N. Hartmann, we must now reformulate the problem of being. M. Heidegger, following Leibniz denounced the basic question of metaphysics:"*Warum ist überhaupt Seiendes und nicht vielmehr Nichts?*"[14] ("Why after all is there Being and not rather non-Being?") We now must ask: "*Why after all is there something occuring rather than nothing?*" We only know that time once it has started in any of the possible substrates - cosmological, thermodynamical, biological or historical - will proceed and force all systems to co-proceed according to the individual criteria of the systems. Therefore, the "unbewegte Beweger" (unmoved mover) of Aristotle is no longer necessary or that entity might be reduced to the original hypothetical big bang. *Being* is the motor of evolution in general from simple matter to the human brain, from the human brain to the inventions and creations of this apparatus. Time cannot be conceived as "Zeitigung des Seins" (time measurement of Being),[15] nor, vice versa, as temporalization of space "Verzeitlichung

von Raum"[16]. Cyclic time, t_r, is the basis of all structures as we have mentioned above. When irreversible time, t_i, is decelerated and bent back on itself, forced to become reversible, it becomes structure. And structure is space. Thus, when t_i is broken into a medium or by a medium, it becomes space. Time and space are two aspects of one and the same, two aspects of being, in the same way as energy and matter in relativity theory are two aspects of the same, two aspects of being. This then would be the process of the universe.

6. THE TREE OF TIMES

How can this process of time be understood? Even a short view on temporal phenomena teaches us that time is branched. When we look at the structure of a tree, at the delta of a river, at the form of a lightening discharge, at the evolutionary tree of the biological species we will observe the same catalogue of forms. Although on a different time scale these structures are branched. Mathematically we would say: they go through bifurcations. At any point of bifurcation the system has a choice to go into one of two or more directions. This choice is a real choice. The system is strictly deterministic on the straight path. It goes through a zone of chaos where it cannot be predicted which of the alternatives it will take. There have not been two equal lightning discharges in the history of this earth; biological evolution could never be repeated in the same way; it is a singularity. According to this tree model one can construct the structure of time. In the steady structurized regions the mode t_r prevails until the system is sufficiently disturbed and goes through the situation of a strange attractor. It can branch or at least transform itself. Thus time evolves in a tree like fashion. I call this the *tree of times*. For instance a cosmological event like a large meteorite or a vulcanic eruption may cause a flood at the North Sea coast forcing the Germanic tribes to leave their land, and to threaten the Roman Empire like the Cimbers and Teutons did in the 2nd century B.C.. Thus the cosmological time course is transformed into a political sequence. The subsequent war had many economical, personal and perhaps religious consequences. The various branches of this tree are not coherent; the mourning widow of the Roman legionaire knows nothing about meteorites.

7. SUMMARY AND CONCLUSION

I have tried to show that time is composed of two modes, a cyclic, periodic mode which stabilizes structures and systems (t_r) and a proges-

Scientific research since its beginning has found regularities in nature, has formed theories by generalization from these observations and thus was able to find natural laws which give a description of the macro- and microcosmos. Since the middle of the 19th century science has begun to conceive the world as a process. Typical of this is the Darwinian theory and the theory of the Big Bang. Science in its procedure has operated essentially phenomenologically. Only in very recent times, has science dared to pose the question: *How and by which mechanism is the new formed*? When I posed this question in my science, molecular biology, I noticed that it cannot be dealt with without considering a new concept of time. These conjectures now have led to the result that *the twofold structure of time is able to describe being.*

NOTES

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3. L. Wittgenstein, *Tractatus logico-philosophicus* 6.5, (Suhrkamp Verlag) Frankfurt ^{8}1991.
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6. L. Boltzmann, "Über die Unentbehrlichkeit der Atomistik in der Naturwissenschaft", *Annalen der Physik und Chemie 396* (1897) 232-247.
7. E.N. Lorenz, "Deterministic Nonperiodic Flow", *J. Atmos. Sci. 20* (1963) 130ff.
8. B. Mandelbrot, *Die fraktale Geometrie der Natur*, (Birkhauser Verlag) Basel 1987.
9. F. Cramer, *Chaos und Ordnung - Die komplexe Struktur des Lebendigen*, (DVA) Stuttgart ^{4}1991.
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11. Anaxagoras, Fragment 1, H. Diels, *Die Fragmente der Vorsokratiker*, Hamburg 1957.
12. Herakleitos, Fragment 91, H. Diels, *Die Fragmente der Vorsokratiker*, Hamburg 1957.
13. Augustinus, *Confessiones*, Lib. XI.
14. M. Heidegger, *Was ist Metaphysik*?, Bonn 1929.
15. M. Heidegger, *Sein und Zeit*, Tübingen 1949.
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this type of argument is altogether unjustified. In relativity theory no less than in prerelativistic physics, time has the function of parametrizing processes of change (or "causal chains") and can be distinguished from the spatial dimensions in an objective way.

Though this point has now been admitted by most commentators, there is a persistent notion that in a different sense relativity theory *does* treat time like space. Thus it is often said that special relativity presents us with a *static* conception of the universe, a four-dimensional "block universe" in which the whole of history - from beginning to end - is present "at once". In such a universe "everything is determined", or "fixed", and there is no distinction between Past, Present and Future (see, e.g., [7, 9, 10, 12] for elaborations, with various variations, on this point; and [8] for an extensive discussion).

The argumentation for this hinges on the properties of the simultaneity relation in special relativity. The frame-dependence of simultaneity makes it impossible to use this relation to divide spacetime in an observer-independent way into a future and a past part. All such distinctions are relative to an observer, or - put differently - to a frame of reference. This is then used to conclude that nothing in reality corresponds to an absolute difference between past and future; the universe is just one four-dimensional whole without a "now" dividing it. As already mentioned, an alternative formulation often found is that all events in the universe are equally "determined". Indeed - so the reasoning goes - what is still in the "future" for one observer, is already past for a different one (moving with respect to the first), and therefore "fixed", "determined".

Against this type of reasoning the objection sometimes is levelled that simultaneity in relativity is merely conventional, and therefore not suitable for making distinctions between real states of affairs. But this objection is not compelling. Simultaneity in relativity has immediate physical significance: it represents the orthogonality relation with respect to time-like inertial worldlines and its use gives physical laws a form which reflects spatial homogeneity and isotropy. Accordingly, there are good physical grounds for rejecting the notion that simultaneity is conventional in an interesting sense [1, 2, 4, 5].

Nevertheless, the argument that the theory of relativity implies "determinism" is not at all convincing. The right way to contest it follows from the following observation about the nature of relativistic time (and physical time in general). Simultaneity is a *relation* between events, which applies independently of any consideration of the ontological status of these events themselves. Whether or not events at spacetime points can be said to have the absolute properties of being past or future, this distinction is not relevant for the application of the simultaneity concept.

Regardless of where events are situated in the history of the universe, the same rules can be applied to determine simultaneous events: the notions of Past and Future simply do not occur in these rules.

The remark just made applies to all temporal concepts from physics. There is nothing in physical theory, or in the temporal notions that function in and derive from such theory, which corresponds to absolute temporal properties. Physical laws do not contain an absolute difference between Past and Future, or between what is "determined" and what is still "open". Physics does not operate with a Now, in the sense of a preferred point on the time axis, which could be used to make such a distinction. Physical laws are always about *relations* between events. The laws by themselves do not lead to absolute assertions of the form "it is time t_1", but to conditional statements of the form "for all t, if A happens, then so will B (under certain conditions) at t'". Time, as a parameter occurring in physical laws, inherits this relational character. The structure of physical time reflects and quantifies *ordering relations* of processes of change. It is then only possible to define "past" and "future" events in a relational way, that is, with respect to a given event. This general point of the relational character of physical time is important for a discussion of its philosophical significance both in classical and relativistic physics.

There is a simple but fundamental reason for the lack of absolute temporal notions in physical theory. Physics cannot operate with a preferred "nowpoint", since its basic aim is to give descriptions by universal laws, valid for *all* times and places. In the formulation of physical laws one disregards the specific properties of events, and retains only what is common to all processes of a certain kind. Consequently, the Now from direct experience, whether or not it reflects something objectively real, has no role to play in physical laws. The laws of physics by themselves cannot reveal "what time it is".

From the fact that no absolute temporal distinctions occur in physical theory, it therefore cannot be concluded that no corresponding differences exist in reality. Physical time is something quite independent of these distinctions, whether or not they refer to something really existing. It follows that the structure of physical time by itself cannot serve as a basis for conclusions about absolute temporal differences between events. The complete identification of physical time with the time from the philosophical (*metaphysical*) doctrine of the flow of time involves a conflation of purely relational and absolute concepts. If one wants to use physical theory in arguments about the "flow of time", one must make *assumptions* about the connections between physical time and the time occurring

in the metaphysical doctrine. Such assumptions are external to physical theory and cannot be derived from it.

To avoid confusion one should note that the concept of "determinism", as used above in connection with the doctrine of the flow of time, is really a misnomer; it denotes something quite different from physical determinism, as usually understood. Physical determinism holds if physical laws, together with appropriate boundary and initial conditions, allow only one solution. From the fact that in this formulation there is no reference to any difference in ontological status between events, but only to law-like relations between them, one can see that this is a sense of "determining" which is quite different from the absolute one mentioned above. If there is a causal relation between two events A and B, such that e.g. "A determines B" in the physical sense, then this constitutes a connection between A and B which is independent of whether these events are past or future.

Summing up, the structure of physical time has no immediate bearing on the question of whether absolute temporal distinctions apply to reality. To answer this question one has to make additional, non-physical, assumptions.

2. POSSIBLE CONNECTIONS BETWEEN PHYSICAL AND METAPHYSICAL TIME

What suppositions can be made about links between physical time and the time from the doctrine of the shifting Now? As noted, even in classical physics there is no justification, based on physical theory itself, for an ontological, absolute, distinction between Past and Future. But in classical physics we have absolute simultaneity, which easily harmonizes with such a distinction and with everyday intuitions about the flow of time. It therefore seems natural to identify continually changing Newtonian simultaneity hyperplanes with the shifting Now. However, it should not be forgotten that in classical physics too, this identification is an assumption extraneous to physical theory itself.

In the context of relativity theory it is also possible to insist on such an absolute flow of time. For example, one might suppose that the Now is associated with the shifting simultaneity hyperplanes of a preferred frame (in agreement with the definition of "cosmic time" in Friedmann universes; F.A. Muller [8] proposes another relativistic generalisation of absolute Newtonian time-flow).

Another option, one that stays closer to the spirit of relativity theory, is to "relativize" the doctrine of time flow [2, 3]. The idea is to conceive

of the flow of time as a flow *per worldline*. Here every worldline has its own "nowpoint", which "progresses" independently of the other points (subject to certain consistency conditions). The history of the universe, ordered by the successive positions of the now-points, then no longer possesses a complete linear order. There is only a partial ordering relation, which directly reflects the partial order generated by the physical "earlier than" and "later than" relations. This proposal, which amounts to a relativistic adaptation of the idea of a flow of time, adds a minimum of structure to that what is already contained in the physical (relativistic) picture - it does not need the notion of a preferred frame of reference. The resulting "many-fingered" flow of time therefore seems to be the metaphysical doctrine which supplements the physical description in the most economical and natural way.

3. RELATIONS BETWEEN PHYSICS AND THEOLOGY: COMPLEMENTARITY AND COMPLETION

It is hazardous and ill-advised for theology to intrude into the territory of physics. But there seem to be at least two possibilities of peaceful coexistence.

First, there is the position according to which theology sees reality *from a different perspective* than physics. Specifically, one might posit that theology focuses on the level of norms and values. Although it might eventually turn out that norms and values, and other similar features of reality as we know it from direct experience and introspection, "supervene" on the physical level of description, one can then still maintain that the physical, factual, and the normative level are two autonomous levels of description. This position is well-known from discussions about the relative autonomy, with respect to physics, of disciplines like biology and psychology. The (anti-reductionist) position which, on the one hand, allows that the physical description, on its own level, may be complete and that other levels may eventually turn out to supervene on the physical one, but which, on the other hand, maintains that the various levels of description are autonomous, I would like to call the position of *complementarity*.

But there is a second possible relation between physics and theology. Perhaps there are elements of reality which for reasons of principle are outside the reach of physics; such elements could then fall into the province of theology. In this view theology would be able to *complete* the physical picture. Of course, if one adheres to this point of view, one has

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1. Origins of Time and the Universe
2. Origins of Mind, Culture and Morality
3. Time, Complexity and Organization
4. Origins of Biological Complexity and its Evolution
5. Time and History
6. The Notion of Complexity
7. Science and Theology in General

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