Committee V
East-West Perspectives on Science and Spirit: Time and Consciousness

DRAFT--5/15/91
For Conference Distribution Only

TIME AND THE UNIVERSE: COSMOLOGIES EAST AND WEST

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The Eighteenth International Conference on the Unity of the Sciences
Seoul, Korea August 23-26, 1991

revised 8 February 1991

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The topic of this paper is time in the largest sense: time as the measure of events in the cosmos. This conception of time derives from one basic approach to reality - one metaphysic in the classical Aristotelian sense. Before exploring the specific nature of this "cosmological" concept of time, we should identify the metaphysic that requires it and contrast it with alternative metaphysics, with possibly different concepts of time.

THREE METAPHYSICS

In the history of Western thought, the nature of reality has been grasped mostly in terms of substances. Thales set the precedent when, in the sixth century BC, he explained the multiplicity of phenomena in reference to common origins in water. His contemporary Anaximander believed that fire, earth and air played an equally important role and said that the original substance was undefined, limitless and all-encompassing. Anaximenes claimed that the primeval substance was a mixture of water and earth; a mixture that, warmed by the sun, generated plants, animals and human beings by spontaneous creation. With the atomist theory of Leucippus and Democritus substance became identified with matter and became not only the fundamental but the sole constituent of reality. Other thinkers held different views: Heraclites, fo example, thought that the principal feature of the world was change. Nevertheless, he regarded fire - in the Greek sense a variety of substance - as the most important element. Plato himself looked on entities he termed forms or ideas as fundamental, and Neo-Platonists came to view entities as ideal substances, the only true elements of reality.

Although the doctrines of materialism and idealism were elaborated with great sophistication by atomists, Aristotelians and Platonists, and the emphasis on matter, form or idea suffered countless variation, in the final analysis the world was said to consist either of the material particles Democritus termed atoms, or of the ideal realities Plato named forms. Western thought tended to view the ultimate choice in creating a coherent concept of reality as that between a materialist and an idealist metaphysic.

By the dawn of the modern age both materialism and idealism encountered proble s when pressed to explain the totality of observable phenomena. A third kind of metaphysics emerged, affirming that, while some of reality is material, other elements of it arei ideal. Me≈aphysical dualism achieved its clearest expression in the thought of Descartes, specifically in the affirmation of two radically distinct kinds of substances: the "thinking" (**res cogitans**) and the "extended" (**res extensa**). Dualism produced multiple spin-offs, including a seeming certainty associated with some facets of experience ("cogito ergo sum" -the basic existence of the **res cogitans** is indubitable), and a separation between humans, who possess both the thinking and the extended substance, and the rest of nature, which is populated by machine-like entities made up of the extended substance alone.

Western thought ended up with three basic metaphysics. First, there is materialistic monism, in light of which matter is real and mind is but a derivative of it. Second we have dualism, the view that both matter and mind are fundamental elements of reality. And third there is ideal (or transcendental) monism, the doctrine that views mind and consciousness as the supreme reality and matter as an epiphenomenon.

These metaphysics suggest different conceptions of time. The materialist metaphysic is committed to an objective, cosmological time concept. Time is given by changes in the successive spatial configuration of material things - multiples of atoms, or of other elements. Idealism must resort to the subjective experience of time for defining its nature: if consciousness is all that exists (and even if consciousness is primary and matter derivative), time is duration in the flow of events that make up the stream of experience. Dualism, in turn, if it is consistent, must allow the above concepts of time to coexist, assigning one to mind (**res cogitans**) and the other to matter (**res extensa**).

It follows, then, that the materialist metaphysic, in viewing the cosmos as the adventure of material entities in space and time, implies that the cosmological concept of time defines the sole (real and meaningful) variety of time. On the other hand the idealist metaphysic relegates cosmological time to a kind of epiphenomenon: the cosmos is but a construction of conscious experience and time in that construction is itself constructed - at best a secondary, derived reality. Finally, a consistent dualist theory cannot consider either cosmological of subjective time as basic or as epiphenomenal. If such a theory allows that these kinds of time coexist in some relation, then - since the cosmos is the wider framework for consciousness - cosmological time must be the "whole" in relation to subjective time viewed as the "part." Thus cosmological time is either the sole reality, or an epiphenomenon, or else the envelope for a different kind of time.

In the late 20th century these metaphysical alternatives remain valid, but they are not as constraining as they were often considered to be in the history of Western thought. Matter is by far not as "material" as Democritus used to think, or even Newton. Ideas, in turn, are not as distinct from matter as Descartes held: in cosmological as well as particle physics these terms can no longer be clearly distinguished. Pure idealism survives in some doctrines of theology and in some quarters of philosophy but, aside from the mystical speculations of a few quantum physicists, it is banned from science and from common sense.

Without restricting itself to classical materialism, this study takes contemporary science as its conceptual framework, and hence it embraces the cosmological concept of time. It notes that, in science's modified variant of the materialist metaphysic, time experienced in consciousness can be derived as a phenomenon produced by a "material" brain. In the dualist perspective subjective time is allowed to exist in addition to cosmological time, but the latter is the broader concept (though the two may not be held commensurable). The exploration of cosmological time is mistaken - and its results essentially meaningless - only in the context of the classical idealist metaphysic. This can be readily acknowledged. With due apologies to the classical idealists, we proceed.

THE DEVELOPMENT OF THE COSMOLOGICAL TIME CONCEPT

We examine here the cosmological concept of time in the specific sense in which it is suggested by contemporary scientific cosmologies. Though the cosmological concept of time remains cosmological, its content varies with given cosmologies. This variety of time may be finite or infinite, unidirectional, reversing or periodic, depending on whether the defining cosmology assumes that the universe is closed or is open, whether it has infinite duration or has a definite beginning and a definite end, or is cyclically recurring.

The notion of a universe moving from one point in time to another unidirectionally may appear self-evident to the modern mind but was in fact an innovation introduced into the cyclic universe conceptions of ancient myth by the materialist metaphysicians of classical Greece. In their search for the fundamental "one" that would underlie and give meaning to the perceived "many" the Ionian natural philosophers postulated an original substance which would diversify in the course of time. Aristotle introduced great sophistication into Greek natural philosophy but did not question the fundamental notion that the universe, and all that exists in it, has developed from an original state to the present state, evolving in the process from a condition of unity and homogeneity toward one of differentiation and multiplicity.

With the rise of modern science in the 17th and 18th century, this basic notion appeared in various guises. In the standard form of the Newtonian synthesis, time was allowed to flow equitably through all eternity, but this flow did not imply irreversible changes in physical nature. Time was not a factor in the equations of motion: the motions were time-reversible. Newton did, however, require an original force to put the great cosmic mechanism into motion: a Prime Mover he identified with God.

Two centuries later Darwin, and the biological revolution that unfolded in the 19th century, required that time be directly introduced into the natural world. Species evolution is progressive and, except for local and temporal deviations, time-irreversible. This contradicted Newtonian mechanics but accorded with another branch of 19th century physics: classical thermodynamics. Introduced by Sadi Carnot and William Thompson and elaborated by Ludwig Boltzmann, the famous Second Law provided for a basic irreversibility in nature, and therewith for an inescapable temporal dimension. Free energy, once dissipated, can never be recycled again. Consequently in the universe as a whole energy must inevitably run down. This reinjected a temporal horizon into cosmology: in the ultimate state of universal "heat-death" no irreversible processes could any longer take place: time as we know it must come to an end.

Contemporary cosmologies know that the second law of classical thermodynamics is valid only for closed systems, and they question whether or not the universe as a whole is a closed system. Nevertheless, physics shows that the evolution of the observable universe involves a series of time-irreversible processes, and this means that physical processes must have had a beginning and must ultimately have an end.

TIME IN THE STANDARD UNIVERSE MODELS

In the standard models of the universe both the temporal and the spatial horizons are finite. Temporal finiteness is due on the one hand to the "Big Bang," the singularity that marks the birth of the observable universe, and on the other to the ultimate decay of matter in spacetime. Spatial finiteness follows from the Big Bang: the cosmic radius is defined by the rate of expansion of matter and radiation from the original singularity.

According to received theories, the Big Bang was the closest thing known to science to a "free lunch," - creation ex nihilo. It occurred following density fluctuations in a bubble constituted as a Minkowski space. Density fluctuations in this hypervacuum were small; the space of the bubble was almost, though not entirely, homogeneous. As an instability set in and one of the fluctuations "nucleated," an exponential expansion took place inflating the bubble by a factor of 10^20 to 10^50 in the Planck-time of 10^-35 second. Long-wave quantum fluctuations of curvature and of the scalar field were finely tuned and, growing rapidly, introduced the density perturbation necessary for the subsequent formation of galaxies. At the end of Planck-time, a single supercooling effect obtained, creating the conditions for a more orderly process of expansion and cooling, and with it the synthesis of quarks, hadrons, and leptons.

While the Big Bang processes themselves are beyond the range of observational evidence, there is evidence that the radius of the universe is indeed increasing. The light of other galaxies reaching the earth exhibit the "Doppler effect," the red shift indicating that they are flying apart. If the actual density of matter in space does not exceed the critical value of 10^-30 gram/cm^3, this expansion will continue infinitely. Yet, even if infinite in space, the universe appoears to be finite in time. Standard cosmologies suggest that space will be ultimately filled with maximally cooled radiation. Irreversible processes being impossible in that state, time will have come to an end, or at least lost all meaning.

This conclusion is not a return to 19th century heat-death conceptions but an independent conclusion derived from currently held standard cosmologies. It appears that in an open universe the baryon number, previously believed to be one of the basic constants of the universe, will be surrendered: baryonic matter will decay into radiation. The time-scale of the pertinent events is the following.

In about one trillion (10^12) years, no more stars will form as all but a small smattering of the available hydrogen and helium will have burned up within active stars. In consequence the galaxies will become more red as their stars cool, and will then fade as the stars become white and eventually black dwarfs, neutron stars, and then black holes. Because energy will be lost through gravitational radiation, and because stars will move close enough to each other to create collisions in which some stars will be precipitated toward the center of the galaxy and others expelled into extra-galactic space, the galaxies themselves will diminish in size. In the same way galactic clusters will shrink; and ultimately both galaxies and galactic clusters will implode and form giant black holes.

At the time horizon of 10^34 years, the matter component of the universe will consist mainly of black holes, radiation, and positronium. Black holes themselves will decay in the process of "evaporation" described by Hawking. A black hole resulting from the collapse of a galaxy will evaporate in some 10^99 years, and a giant black hole containing the mass of a galactic supercluster will vanish in 10^117 years. Beyond this time horizon the universe will contain matter only in the form of positronium, neutrinos, and gamma ray photons. (This estimate is based on the decay of the proton, an assumption that follows from current "grand unified theories" but has not been verified by experiment. If protons do not decay, or have a half-life of more than 10^31 years, the time-scale will be longer but the final destiny of the universe will not be affected. Even protons will evaporate in black holes after 10^{122} years: the ultimate time horizon of the standard universe.)

Whether the universe is open or not depends on the amount of black matter in space. There is only indirect evidence for such matter: it comes from unexplained velocities in the movement of galaxies within galactic clusters. The fact is that galaxies move far too rapidly within the clusters to be held together by the gravitational attraction of the stars. If the continued existence of the clusters is to be explained, one must assume that their matter-content exceeds the amount of matter in active stars by a factor of 300. If most of the matter in the universe would be in the form of optically visible baryons, the ratio between mass and light--the M/S ratio, so defined that it is one for the sun--would be less than 72. However, since the galactic clusters do not break apart, the ratio must be at least 300. And if the universe is to be closed, with the current expansion of the galaxies being reversed, the ratio would have to be 1,000. Despite the proliferation of "cold dark matter" (CDM) models, and the postulation of the required type of particles (known as "weakly interacting massive particles" or WIMPs), there is as yet no certitude as to which is ratio is in fact the case.

We can, however, consider the temporal fate of the standard universe also under the assumption that M/S = > 1,000. In that event galactic expansion will come to a stop and contraction begin at about 10^{11} years. When the universe will have contracted to 1/1,000 its present size, background radition will have reached 1,000 degrees K.

At 1/1,000.000 the current size stars will explode as the background temperatures will reach temperature levels comparable to those within active stars. At the one billionth mark the background temperature will have reached about a billion degrees and atomic nuclei will break up into protons and neutrons. Finally, at a universe one-trillionth its present size temperatures will be of the order of a trillion degrees and protons and neutrons will break down into quarks. Final contraction will then consume even the quarks, as the universe once more assumes the condition of a singularity in spacetime.

TIME IN PULSATING UNIVERSE MODELS

The standard model of the universe is questioned today on several grounds. First, physicists are dissatisfied with the hypothesis of both Big Bang and Big Crunch because, as standardly formulated, they call for singularities in the description of physical reality. The Big Bang requires infinite density and infinite temperature, and thus infinite energy. It also requires going back to t = 0, to an infinitely small universe forbidden in Einstein's theory of gravitation. There is, however, a possibility that neither the Big Bang nor the Big Crunch represent true singularities.

The latest theories suggest that the universe always conserves the minimum quantum dimensions. The initial state of such a "quantum universe" has a tiny but non-zero expectation value (expressed as L_p^2). It is also possible to show that the universe, if it is closed, does not come to a final Big Crunch; it reaches only a state of maximum compaction from which it can escape. In this case the universe would be cyclic. It would go from an explosive instability through a full cycle to an imploding instability--and on to the next explosion.

A pulsating universe is also possible if MS = $<$300 and the universe is open. This possibility has been demonstrated in a cosmological model put forward by Gunzig, Geheniau and Prigogine. [1] In the new theory matter and global curvature emerge self-consistently in the presence of universal gravitational interaction from an intrinsic instability in a Minkowski vacuum. The gravitational feedback response to the quantum fluctations of the matter field is either damped or exponentially enhanced, depending only on whether the corresponding mass is greater or lesser than a given threshold (given by the formula $KM_{th}^2 = 2887\eta^2$). This is the borderline between stable and unstable fluctuations in the Minkowski vacuum. When exceeded, the feedback from the matter field creates mini-black holes and the unstable vacuum transits to the so-called De-Sitter space, where inflation occurs in the course of which the mini-black holes evaporate. Inflation derives from the very same condition as the instability of the vacuum; the above-mentioned critical threshold controls the transition from the one to the other.

In this cosmology the beginning of a new universe--more precisely the beginning of a new cycle of the pulsating universe--is marked by two phase changes: the first is the transition from the unstable vacuum to the (exponential) inflationary condition, and the second the transition from inflation to the more moderate (geometric) expansionary phase leading to the observed Robertson-Walker universe. The Big Bang is a recurrent event consisting of two local phase-transitions within the framework of the pre-existing multicyclic universe.

The Gunzig-Gehenau-Prigogine "Non-Big Bang Self-Consistent Cosmology" derives correct values for the present black-body radiation, and for the universe's specific entropy, uniquely from three fundamental constants: the Planck constant h, the speed of light C, and the gravitational constant K. [2]

The conception of a pulsating universe is not the exclusive province of western science: it is also a heritage of oriental philosophy. It is there in Chinese thought as the holism of "Ch'i," the primordial unity which contains the seeds of yin and yang, the dialectical opposites that, in their incessant interaction, give rise time and time again to the diversity of the manifest world. It is present in an explicit form in Hindu cosmology. The ancient cosmology mirrors the latest pulsating open universe concept astonishingly closely. The universe is said to be composed of two primordial realities: Akasha and Prana. Akasha is the underlying substance of all that exists, while Prana is the arch-energy that acts on and forms everything. At the beginning of creation there was only Akasha; and at the end there will be only Akasha again. As yogi Swami Vivekanda phrased it, it is Akasha that becomes the air, the liquids, the solids; it is what becomes the sun, the earth, the moon, the stars, and the comets. Akasha also becomes the human body, the animal body, the plants, every form that we see, and everything that exists. In the end of each cycle the solids, the liquids, and the gases all melt into Akasha again, to reemerge from it in the next cycle. [3]

Akasha is the ground of reality and Prana is its force: its infinite and omnipresent manifesting power. It is Prana that manifests itself as motion, as gravitation, as magnetism; it is what is expressed as the actions and the nerve currents of the body, and even as the force of thought. Prana is the sum total of all the forces in the world. At the end of a cosmic cycle all forces resolve back into Prana, just as all things die back into Akasha.

At the end of a cycle of creation the energies that are displayed in the universe quiet down and become potential: they become Prana. At the same time the configurations of matter that exist in the universe die back: they become Akasha. While the cycle unfolds, Akasha is not passive: it is cosmic memory. All things that take place in the universe, and all things that ever will, are indelibly recorded in it.

THE VARIETIES OF COSMOLOGICAL TIME

The various cosmologies sketched above harbor specific conceptions of time. The principal alternatives are the following:

Finite unidirectional time. This is implied by the standard model of the open universe. Time, as the temporal succession of events, begins with the Big Bang and ends with the evaporation of the last galactic cluster-sized black holes.

Finite time with reversal of direction. This time concept is implied by the standard closed universe model. As in the open standard universe, time begins with the Big Bang and at first proceeds unidirectionally. Its directionality reverses, however, when universal gravitation overcomes the inertial forces of inflation and galactic expansion halts and then shifts into contraction. In the phase of contraction time is presumably reversed. (This assumption is open to question, however, since the sequence of events during the contraction phase will not precisely reverse the sequence of events in the expansion phase. Thus a unidirectional time could hold throughout both phases, with only the evolution of matter reversing into devolution.)

Infinite periodically recurrent unidirectional or reversing time. This conception corresponds to the pulsating universe concept both in contemporary science and in classical Eastern thought. The universe is cyclic, and the temporal succession of events recurs in each cycle. If the pulsating universe is open, time is consistently unidirectional throughout the cycles. If it is closed, time reverses in the course of each cycle, and re-reverses at the birth of each new cycle. There being an infinite series of finite cycles, time itself is infinite across the cycles.

There is as yet a further possibility: **Finite periodically recurrent unidirectional time.** The possibility that time in the last-named scenario may be finite is a theoretical possibility. Although there is no currently received cosmology requiring a finite sequence of cycles, there is indirect evidence to suggest that the cycles themselves may represent a (finite) learning curve. Such an assumption is indicated if the mystery of the observed fine-tuning of the universal constants has a solution in the framework of a pulsating universe.

The mystery concerns the noted fitness of the physical universe to life (and not only the more understandable fitness of life to the physical universe). The puzzling facts include an even cosmic background radiation of 2.7 K (which requires a fine-tuning of the expansion rate of the very early universe in all directions to a precision of less than one part in 10^40); the precise strength of gravity (which is exactly such that stars can exist long enough to provide energy for life to evolve on suitable planets); the mass of the neutrino (which, if any at all, must be small enough to have prevented the universe from collapsing soon after inflation due to the increased gravitational pull on its expansion); the precise strength of the weak nuclear force (which is exactly enough to expel complex elements from stars in supernovae thereby making them available in newly forming stars); and, last but not least, the value of the strong nuclear force (of which a mere two percent increase would have resulted in all hydrogen burning up before transmuting into helium, and subsequently into the heavier elements indispensable to life).

It would seem that, despite the probabilistic nature of the majority of the physical processes, the constants of the universe have been "fitted to," if not actually designed for, the evolution of the complexity required for life. George Wald called this a "profound enigma"; George Greenstein spoke of "an astonishing sequence of stupendous and unlikely accidents"; and Paul Davies noted that, unless they were deliberately created, the very special systems and structures we observe amount to a miracle. [4]

Faced with the facts, and unwilling to assume either design, unlikely accident, or miracle as the explanation, some physicists speculate that a large number of universes may co-exist with ours. In that event the fine-tuning of the constants in our particular universe would not be so baffling: given that the number of additional universes is large, probability would dictate there being at least one universe with constants that allow the evolution of life. The other universes would have to be "stillborn": their prevailing physical laws could not allow anything complex to evolve in them.

The above explanation is not entirely felicitous: it requires a large number of universes merely to reduce the probability of there being one which is such as we actually observe. Following up current scientific (and also ancient philosophical) pulsating universe conceptions, it appears more logical to conceive of a single universe undergoing successive cycles and perfecting the tuning of the constants across the cycles. A learning curve across multiple cycles could explain the fine-tuning of the constants in our particular universe (more exactly, in our particular cycle of a pulsating universe) provided only that some "memory" of the preceeding cycles is cónserved in the succeeding ones. In that case the observed fitness of the physical universe to the higher reaches of evolution would not be the result of a happy accident setting the constants in favor of life at the instant of a single Big Bang 20 billion years ago, but would have evolved gradually over successive cycles. [5]

In a speculative extension of the interconnected multicycle conception it is reasonable to hold that the cycles themselves do not follow infinitely. The progressively finer tuning of the physical constants defines the prevailing natural laws in each cycle and these laws become more and more favorable to life: they allow evolutionary processes to explore progressively higher regions of complexity. Evolution within the cycles would approximate a series of oscillations with each oscillation achieving a higher zenith than the one before. Logically, the cycles would converge toward an omega cycle where time comes to a stop.

The conditions that would obtain at the conclusion of the omega cycle (if indeed in an open multicyclic universe such a cycle is ever reached) explode the conceptual boundaries of science. But mystical and religious intuition resonates with the suggestion. By force of intuitive vision rather than of empirical evidence, the concept of finite periodically recurrent unidirectional time leading to a Nirvanic state of ultimate timelessness can be added to the repertory of alternative conceptions of time underlying cosmologies both East and West.

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