God and Physical Reality
Issues in Theology, Physics and Cosmology

Dirk Evers

Preliminary Remarks

I understand my way of relating science and theology as a variant of what can be called *hermeneutic naturalism*.[1] Neither does Christian theology deal with specific objects of a supernatural reality nor is it the continuation of science with other means. While science seeks *explanations* of factual phenomena by tracing them back to their causes and effects, faith seeks *understanding* of our existence without reducing it to factual knowledge. Any Christian theological endeavour is a hermeneutic, interpretative task which aims at existential orientation on the background of what we know from our reality through science and everyday life and what we receive from our participation in the Christian faith, its promises, hopes, and challenges. It is only possible from a perspective of participation in faith. Consequently I see the empirical sciences and theology as two different and in their central endeavours non-overlapping realms of the human quest for orientation.

In this paper I will concentrate on how we can relate scientific cosmology to our notions of God and human existence. I will first deal with methods, results and conjectures of modern scientific cosmology (I. Physical Cosmology) in order to present a brief sketch of our contemporary view of the cosmos and then discuss theological issues in the light of these theories (II. Theological Questions). I will do the latter by concentrating on five core issues: 1. Where is God's place in the universe? 2. Does the cosmos have a purpose? 3. How is God involved in physical processes (including remarks

[1] Cf. Hermeneutik und Naturalismus ed. B. KANITSCHEIDER et al., Tübingen: Mohr Siebeck, 1998.

on providence)? 4. Is the cosmos infinite and eternal? 5. What can so-called "theories of everything" justifiably claim?

Physical Cosmology

The object of scientific cosmology is the structure and dynamics of the universe as a whole. Therefore cosmology deals with a singular object and the singular event of its emergence. How can science at all formulate theories about this unique object? We cannot explore the cosmos by travelling and measuring it directly. With our satellites we cannot leave our solar system and can only get data from—on a cosmic scale—our immediate surroundings. And we cannot test our theories about the universe by doing experiments with universes in a laboratory. The only data we have is cosmic radiation as it hits the earth or is received by our orbital instrument. Cosmology is based on the measurement of this electromagnetic radiation[2] measured from preferably every angle and over a wide spectrum as precisely as possible and on the conclusions drawn from this data on the basis of what we know about the physics obtaining here on earth and its nearer surroundings.

Then what kind of data do we have? With reference to the coordinates from which we receive radiation we can distinguish between two kinds of electro-magnetic radiance: 1) a continuous *background radiation* which is roughly the same in all directions; 2) *discrete sources of radiations* like the stars but also objects that radiate with invisible wavelength. With reference to the frequency of radiation we can distinguish between 1) radiation of a *continuous spectrum* like thermal radiation and 2) radiation with a *discrete spectrum*, be it emission spectral lines, be it absorption spectral lines. That is all the data we have plus the laws of physics we can conjecture and test in our terrestrial and orbital laboratories.

The most important physical theory that provides a basis for the development of models of our universe is *gravitation theory*. Gravitation is

[2] In the near future astrophysicists might be able to receive a new kind of waves, i.e. gravitational waves. The effects are very low. Although gravitational waves have not yet been unambiguously and *directly* detected, there is significant *indirect* evidence for their existence.

the physical force most important for cosmology, because it is effective over long distances, but it is different e.g. from the electromagnetic force only effecting other electrically charged particles in that it cannot be insulated or neutralized. While macroscopic matter is in average uncharged because positive and negative charges neutralize each other, gravitation affects all matter. Thus the large scale structure of the universe is regarded as gravitation-dominated. After the first cosmological models of modern times like those of Copernikus, Brahe and Kepler, which were only descriptive and did not reach beyond our solar system, the first theory that could be applied to the whole cosmos was Newtonian theory of gravitation. It was the ubiquity of gravitation in Newtonian physics that provided a physical basis to treat the universe as one coherent physical object.

But unfortunately Newtonian gravitation applied to the cosmos led to contradictions which Newton already discussed with Bentley and other contemporaries. It was clear that a finite cosmos would collapse with all its masses being attracted to the centre of its space. Therefore Newton considered an infinite space with a homogeneous distribution of matter and with local systems like our solar system being stabilized by rotation. But later investigation showed that within such an infinite Newtonian cosmos very small inhomogeneities would lead to local collapses which would then trigger larger and larger agglomerations of matter.

Another point was the so called gravitational paradox. Because the gravitational force cannot be shielded there should be an infinite gravitational potential energy at any point in space. This obviously is not the case. Therefore some physicists considered an anti-gravitational force which should dampen gravitation over long distances, while others tried to find a distribution of matter that could be stable, for example a centre of higher density of stars around which the density should decline the farther away one moves from the centre, and that until infinity. But no theory was really satisfying.

So, physical cosmology got stuck for a long time and only became a respected part of physics when a new gravitational theory was found.[3] It

[3] For an exhaustive study of the history of cosmology from 1917 to 1970 when the standard big-bang model became widely accepted, cf. H. KRAGH, Cosmology and Controversy. The Historical Development of two Theories of the Universe, Princeton NJ: Princeton University Press 1996.

was provided by Einstein's theory of general relativity. I cannot go into details here, but will just point to one core notion of general relativity, that is that matter determines the geometry of spacetime with a curved metric. As early as 1917 Einstein presented cosmological applications of his theory and discussed the stability of different cosmological models.[4] As a consequence of his theory of general relativity a matter-filled cosmos shows a spacetime curvature which allows for a closed cosmos of a finite volume that has no borders or edges. It is something like a four-dimensional sphere. Thus Einstein could avoid the gravitational paradox of infinite gravitational potentials but still his cosmos was susceptible to gravitational collapse. In his model Einstein treated matter on a large scale as an inert homogenous isotropic gas with negligible relative movement. He then invented a universal cosmological constant Λ which like the pressure in a gas should work against gravitation and keep the curvature of spacetime constant.

Later Einstein called his cosmological constant his greatest blunder and dropped it from his equations. That was due to the fact that in 1922 a young Russian mathematician, Alexander Friedmann, showed that there are solutions of Einstein's equations that replace the cosmological constant by an expansion of cosmic space so that the volume of spacetime is a function of cosmological time.[5] After Eddington had shown in 1930 that Einstein's model of a static universe with pressure was unstable against local irregularities[6], Friedmann's expanding cosmos became the predominant model.

Friedmann already had differentiated between a cosmos in which the density of matter is such that gravitation predominates and the curvature of spacetime is positive and a cosmos in which the effect of the expansion dominates so that the curvature of spacetime is negative. Only in the first case is the cosmos closed and its volume finite, in the second case it is

[4] A. EINSTEIN, Kosmologische Betrachtungen zur allgemeinen Relativitätstheorie, Protokolle der Sitzungen der Preußischen Akademie der Wissenschaften 1917, 142–152.

[5] A. FRIEDMANN, Über die Krümmung des Raumes, Zeitschrift für Physik 10 (1922), 377–386; cf. A. FRIEDMANN, Über die Möglichkeit einer Welt mit konstanter negativer Krümmung, Zeitschrift für Physik 12 (1924), 326–332.

[6] A. EDDINGTON, On the Instability of Einstein's Spherical World, Monthly Notices of the Royal Astronomical Society 19 (1930), 668–678.

infinite from the beginning, but its so called scale factor will increase over time so that space itself will be stretched. In all Friedmann models the cosmos might have a beginning because there was a time when all matter must have been infinitely dense, so that the scale factor was 0 and space compressed into an unextended point. This is called a singularity, and apparently relativistic physics is not able to describe the universe at this point as a consistent physical object. Anyway, the singularity can be seen as something like the starting point of spacetime as such. Friedmann already spoke of "the era since the creation of the world,"[7] and his remarks were the first to indicate that something like a "beginning" of the cosmos could be part of a physical theory[8].

It soon became clear that such a model—apart from the fact that we now have stable solutions in our gravitational theory—can be used to interpret the empirical data we receive from our observation of the cosmos. What Einstein and most theoretical physicists didn't know was the fact that the light from many galaxies shows in its spectrum a red-shift indicating that they move away from our galaxy. Only after 1929, when Edward Hubble could show that this red-shift increases the farther away a galaxy is from our own, it became clear that this effect could be an indication for an expansion of the cosmos. This correlation between distance and red-shift is a regular one, described by the Hubble constant.

If we want to describe what the universe looked like in its early states we have to assume that the matter we find in the universe today must have been densely compressed in the beginning. Compressed matter heats up: the closer to the starting point of the universe the higher the energy. Thus our cosmos must have been denser and hotter in the distant past. The expansion of the cosmos then could be seen as driven by a big explosion, for which the Astronomer Fred Hoyle coined the term "Big Bang" in a radio interview.[9]

To describe this hot Big Bang we need a second fundamental theory, the theory of matter and energy which nowadays is basically quantum theory. In an early stage the very hot universe must have been densely filled

---

[7] FRIEDMANN, Über die Krümmung des Raumes, 384.

[8] Although Einstein's theory of relativity speaks of the relativity of time in cosmological models we do have cosmic absolute time, which is the proper time since the Big Bang measured by inert comoving observers.

[9] Cf. H. KRAGH, Cosmology and Controversy, 192.

with radiation. Atoms were dissolved and there were free protons, electrons, neutrinos, their respective anti-particles as well as photons. The free photons of the omnipresent radiation were easily scattered off by electrons. While expanding the universe cooled down until its average temperature reached 4000 K which might have been roughly 400,000 years after the Big Bang. At this point protons and electrons would combine to neutral hydrogen. The photons of radiation only interact very weakly with neutral hydrogen, so that from that time on they could move freely through the cosmos as background radiation. Today it should be cooled down through the expansion of the universe. This is the so-called cosmic microwave background, which Arno Penzias and Robert Wilson found in 1965. It is a radiation coming from all directions, which cannot be attributed to a certain source and which shows the spectrum and temperature the theory predicted with an impressive precision.

This cosmic microwave background is the second observational indicator for the Big Bang theory. A third one is closely linked to that and is the *abundance of light elements* such as hydrogen, helium and lithium. As the universe cooled, the nuclei of light elements combined. The standard theory for the primordial nucleosynthesis in the early universe predicts a certain amount of helium (4) (He^4) to be found in the universe, i.e. 24%. This is in accordance with the amount of He^4 that is measured in optical and radio-spectra.

Thus the overall picture is relatively clear. The universe started extremely dense and hot while its space began to expand from a highly compressed state thus allowing the concentrated energy it contained to cool down. In the extremely dense and hot state soon after the beginning the energy density was so high that everything was dissolved in plasma of high energy. With further cooling the different forms of matter crystallised, so to say. About 1 second after the Big Bang the neutron-proton-ratio froze out at a ratio about 1:6. Neutrons decayed with a half-life of 615 seconds, but already 100 seconds after the Big Bang when the neutron-proton-ratio was about 1:7 the temperature was low enough, so that protons and neutrons combined to form deuterons, the heavy form of hydrogen. Then further reactions produced helium nuclei and some lithum. The helium nucleus is very compact so that after it is formed the average energy of the free particles and photons was not sufficient to split it up again. Almost all the neutrons in the Universe ended up in normal helium nuclei and small traces of lithium.

All other elements with larger and heavier nuclei can only be bred after the formation of stars. Only inside stars are temperatures and energies high enough that fusion can occur between hydrogen and helium to form nuclei of carbon, oxygen, silicon, sulphur and iron. Elements heavier than iron are produced in two ways: in the outer envelopes of *super-giant stars* and in the explosion of *supernovae*. When such massive stars explode they will disperse these elements bred in their inner core into the voids of the cosmos where they will form e.g. solar systems with planets containing these elements. All carbon-based life on earth is literally composed of this stardust.

We have already spoken about the first seconds, even split seconds after the Big Bang, a very bold way of talking. But can we say something about the age of the universe as a whole? Astronomers estimate that the cosmos began between 12 and 14 billion years ago. Astrophysicists estimate the age of the universe in two ways: 1) by looking for the oldest stars; and 2) by measuring the rate of expansion of the universe and extrapolating back to the Big Bang. Latest results of the WMAP-Project (Wilkinson Microwave Anisotropy Probe) suggest that the universe is 13.7 billion years old with an estimated error margin of less than 1%.

But still we do not know which metric, which geometry cosmic spacetime has. As we learned from the Friedmann universes, matter plays a central role in cosmology. If the density of matter is less than the so-called critical density (which is dependent on the actual rate of expansion of the universe), the universe is open and infinite. If the density is greater than the critical density, the universe is closed and finite. If the density just equals the critical density, the universe is flat, but still infinite. The value of the critical density is very small: it corresponds to roughly 6 hydrogen atoms per cubic meter for the present rate of expansion. Therefore one of the key questions in cosmology today is: what is the average density of matter in our universe? While the answer is not yet known for certain, it appears to be very close to the critical density. As far as we can 'see' into the universe with our instruments, we have no indication for any significant curvature. Also the Cosmic Microwave Background suggests that our universe is flat or nearly flat in its geometry.

But when we estimate the amount of matter and energy in the universe, we see that the critical density is not at all reached. The different methods take into account first of all the amount of radiation and of ordinary baryonic matter (mainly protons, neutrons, electrons). But then cosmologists have already discovered evidence for more matter which is not visible but shows effect in the way galaxies rotate and bend spacetime around them. This is called dark matter. It might consist of invisible stars like Brown Dwarfs, of supermassive Black Holes or of new forms of matter produced shortly after the Big Bang which we do not know yet called Weakly Interacting Massive Particles or WIMPs. The latest figures given by the WMAP project suggest that there are 4% atoms and 22% dark matter, but together supplying not more than 26% of the critical density.

But since 1998 there is new evidence that Einstein's cosmological constant was not such a great blunder as Einstein thought it was. It was discovered that there is a certain type of super-novae whose relative brightness is related to their distance. Together with their red-shift their radiation provides information about the rate of expansion and the density of the universe. The results were a sensation. The super-novae appear to be too weak for a universe expanding at a constant or even decelerating rate. On the contrary, our universe seems to expand at an accelerating rate. This implies a positive cosmological constant that works against gravitation and accelerates expansion, and at the same time adds to the energy-matter density of the universe so that it is dense enough for a flat geometry. About 74% of the mass/energy density of the universe is composed of "dark energy" that acts as a sort of anti-gravity. This energy, distinct from dark matter, is responsible for the present-day acceleration of the universal expansion. This scenario is now called the *Cosmic Concordance* or the ΛCDM-model (Cold Dark Matter with a positive Cosmological Constant Λ).

But what is the cosmological constant or dark energy and how does it fit into our physics? We don't know yet. Some associate this term with the energy density of the vacuum because according to quantum physics even the void, the vacuum cannot be just nothing but its energetic ground state should fluctuate around a certain value. But it is difficult to determine this value. Others promote what is called quintessence-theories which see Λ not as a constant but as a negative pressure field which is closely linked to matter and changes over time.

Anyway, the Cosmic Concordance suggests that our universe will expand to all eternity with accelerating speed. Its geometry is flat or nearly flat. But the observations allow for either a small positive or negative curvature. Even if it is positively curved thus having a finite volume, it must be many times as large as the part of the universe we can investigate with our instruments, i.e. from which we receive electromagnetic radiation. In the case of real flatness or slight negative curvature it is infinite in volume, which provides semantic problems I will discuss later.

But the Cosmic Concordance leaves open a number of important questions. It provides no reason for the fact that the universe is so uniform on the largest length scales and in its microwave background, which shows fluctuations less than 1 in 10.000. As early as 1973 Collins and Hawking demonstrated that even very small disturbances in the homogeneity or the isotropy of the universe in its beginning have the tendency to increase and reinforce so that there should be much more inhomogeneity than we observe today. This question becomes even more pressing when we become aware of the fact that opposite regions of the space we can see now were more than light transit time apart and could not have been in a causal relation with each other to establish the apparent isotropy—they were beyond each other's "horizon". At any time the cosmos was larger than its causally coherent regions. The isotropy then must have originated immediately from the singularity. But this is the point which classical physics is not capable to describe anymore.

On the other hand the existence of stellar objects and galaxies soon after the Big Bang requires at least small fluctuations in the very early distribution of matter so that in denser regions matter would concentrate and eventually form galaxies. In 1992 the Cosmic Background Explorer (COBE) satellite indeed detected very small anisotropies in the cosmic microwave background. These cosmic microwave temperature fluctuations are believed to trace fluctuations in the density of matter in the early universe, as they were imprinted shortly after the Big Bang. Where do they come from and why do they show such a regularity on different scales?

To answer these and other questions of the standard model of Big Bang theory Alan Guth, Andrej Linde, Paul Steinhardt, and Andy Albrecht invented the so called *inflation model of cosmology*. It proposes a period of extremely rapid (exponential) expansion of the universe shortly after the Big

Bang, during which the energy density of the universe was dominated by a cosmological constant term that later decayed to produce matter and radiation that still fill the universe today. The inflation theory links important ideas in modem physics, especially quantum physics, to cosmology stating that initial small quantum perturbations in a quantum vacuum were rapidly inflated to the spacetime cosmos which then started to expand according to the standard model. According to inflation theory, this inflationary phase has smoothed all inhomogeneities, has produced a flat universe with a density close to the critical density and left over the anisotropy necessary to provide the starting point for the emergence of the large scale structure of the universe.

But quantum physics might also be used to say more about the very beginning of the cosmos, the origin of the initial singularity. If the entire cosmos itself can be understood as to be subject to quantum mechanics then there might be an initial pre-inflationary state out of which the universe emerged spontaneously according to probabilities which can be described by quantum mechanical laws. Such spontaneous transitions are called tunnel effects. Classical, non-quantum-mechanical physics (which includes relativistic physics) breaks down at very small distances in space and time and at very high densities because quantum effects must be taken into account. This distance is called the Planck length ($1.6 \cdot 10^{-35}$cm), the time is the Planck time ($5.4 \cdot 10^{44}$sec). That means that when the universe was less than $5.4 \cdot 10^{-44}$sec "old" it could be perceived as a single quantum object having emerged out of a most general initial state.

One candidate for such a theory was proposed by Andrej Linde of Stanford University and is called *Chaotic Inflation*. According to chaotic inflation, the initial state is a kind of indetermined spacetime foam out of which universes start off in a completely random manner. In some universes or regions of them the energy density will be higher than in others and inflation could ensue, producing the observable universe by blowing up a bubble of this primordial spacetime foam. This speculative cosmology is difficult to test because there is no possibility of getting information from outside our own one bubble of spacetime.

Others speculate about many Big Bangs which initiate each other so that even out of black holes within our universe tunnel effects could bring about new universes which are not part of our universe anymore but exist in their own spacetime.[10] Lee Smolin assumes that new universes which are spawned within black holes might retain a memory of the laws in the mother universe. Alan Guth and Edward Harrison even think about producing mini Big Bangs in a laboratory. Is our universe the result of an experiment of physicists in another cosmos? Others propose what is called a Big Bounce model where space and time exist forever and matter filled universes emerge through spontaneous contractions of spacetime which eventually tunnel into an inflationary universe. And still others try to think about non-spacetime connections between the "multi-verses" so that our universe shows certain features only if it is one among many universes—all highly speculative theories yet, which promise still surprising future developments.

II. Theological Questions

Having sketched a rough picture of the overall scenario of the standard theory and its speculative extensions I will now turn to the theological questions raised with regard to the cosmos and its creator. I will concentrate on five fundamental issues which I will discuss in the light of modern cosmology: Where is God's place in the universe? Does the cosmos have a purpose? How is God involved in physical processes, and what can we say about divine foreknowledge and providence? Is the cosmos infinite and eternal? Finally I will reflect on the enterprise of physics to develop a "theory of everything" and try to identify areas of future discussions between physics and theology.

1. Where is God's place in the universe?

Einstein's theory of relativity not only became the foundation of modern cosmological models, it also was a revolution of the traditional Newtonian understanding of time and space. That is an often neglected fact, because in cosmology an absolute time and an absolute space are reintroduced by referring to matter as to an inert homogenous isotropic gas so that we have an age of the cosmos as well as an inert frame of reference representing its

[10] For this class of theories cf. M. REES, Our cosmic habitat, Princeton NJ: Princeton University Press, 2001.

space. Einstein's breakthrough to relativity gave up the apparently self-evident notions of absolute space and time as independent from the observer and from the matter they contain. According to Einstein's theory there is no absolute container space and there are no objective distances of time between events. And the velocity of bodies cannot increase infinitely but finds its absolute upper bound in the speed of light. The notion of absolute space is replaced by absoluteness of the speed of light which is the maximum speed with which distant events can interact. As we have seen, mass and energy change the structure, the curvature of spacetime. In general relativity distances in space and time have become dynamic physical parameters which are closely interlinked to the physical energetic processes. Newtonian container physics where the physical objects inhabit space and time like a tenement (as Bernhard Riemann said[11]) is dissolved into a process of interacting events.

For theology this is a liberating view. If absolute space is presupposed, God can either be identified with *space as such* as Newton did[12] or one has to assign to him a place somewhere *within space*—a view which became ridiculous within the framework of modern cosmology, whose history the Tübingen theologian and protestant heretic David Friedrich Strauß at the end of the 19th century described as the story of God's 'housing shortage.'[13] But in modern cosmology which requires Einstein's general theory of relativity as a relational theory of space and time we neither have to

[11] As early as 1854 the German mathematician Bernhard Riemann voted against the notion, that the metric of space were fixed independently of the physical processes happening in it and that reality would move into this metric space as into a tenement: "daß die Metrik des Raumes unabhängig von den in ihm sich abspielenden physischen Vorgängen festgelegt sei und das Reale in diesen metrischen Raum wie in eine fertige Mietskaserne einziehe" (B. RIEMANN, Über die Hypothesen, welche der Geometrie zugrunde liegen (1854), in: Gesammelte mathematische Werke, wissenschaftlicher Nachlaß und Nachträge. Collected papers, ed. R. NARASIMHAN, Berlin/Heidelberg: Springer Verlag, 1990, 304-319, 318).

[12] In his Opticks (original edition 1706, p. 315) Newton characterized absolute space as something like the divine sensory (*tanquam sensorium divinum*).

[13] „... als die Welt sich in eine Unendlichkeit von Weltkörpern, der Himmel in einen optischen Schein auflöste: da erst trat an den alten persönlichen Gott gleichsam die Wohnungsnoth heran" (D.F. STRAUSS, Der alte und der neue Glaube. Ein Bekenntnis, Leipzig: Hirzel, 1872, 105).

insinuate a mythological world-view where God is enthroned in a spatial heaven nor do we have to identify God's sensory with space itself thus blurring the difference between creator and creation. God exists relating to the relational unfolding process of space and time.[14]

And we can envision this relation between God and creation as a complex and contingent relation. We can confess God as the *origin* of creation who willed that there be something rather than nothing and that this something included the possibility of complex life forms and self-aware individuals. And at the same we can see God as the *future* of creation, as its attractor or fixed-point, who calls and lures creation to bring forth and to unfold its potential. And we can see God as *presently* interacting with creation and humankind on a historical level. God reveals God self and transforms human beings by inspiring them and by identifying with a certain living, suffering and dying human individual as the Christian faith confesses.

When we ask "Where is God?" we can answer: God is not in space and time but God is related to space and time in a complex and manifold relation, as space and time themselves are related to the processes that happen in creation. God is present in this complex relationship on different levels, as the ground and future of creation and as the transformer of human beings.

2. Does the cosmos have a purpose?

If this theological frame is in any way appropriate, then God is not "producing" creation as human beings intentionally produce machines or other objects of utility. God is involved in the process of creation. Does creation still have a purpose for which God has designed it intentionally? But what is purpose? The Oxford Dictionary says: "The object for which anything is done or made, or for which it exists; the result or effect intended or sought; end, aim." Has creation an object or end to be attained? Is creation made *for* something? Does creation exist in order to bring something about? I would rather say No, because the purpose of creation is creation itself.

---

[14] One could develop that further within a process-philosophical framework as Ian Barbour tries to do exploring Whitehead's distinction between God's *primordial* and *consequent* nature, cf. I. BARBOUR, Religion and science. Historical and contemporary issues, San Francisco: Harper, 1997.

Creation is not means to an end but an end in itself, as Kant would say. The cosmos has no other purpose than just to exist.

Therefore God's creative agency by which God originates, sustains and attracts creation is not—to use a distinction already made by Aristotle—*poiesis* but *praxis*. *Poiesis* is an action directed towards producing things (greek: *ergon*) that can be used for purposes like a vessel made by a potter to carry water. This kind of action receives its purpose, its *telos*, from outside, from the agent. *Praxis* is an action which has its purpose, its *telos* in itself, which is its own *ergon* (Aristotle coined the term *energeia* for this from which our word *energy* is derived)[15]. Especially moral and political actions which strive for the good life fall under this category. In this sense God's creative action is *praxis* not *poiesis*. God is no craftsman, mechanic, designer or technician who manufactures creation and its products. There is indeed no divine watchmaker. And we as created beings are not an *ergon*, a work in order to achieve a purpose, but an *energeia*, an end in itself.

But are not space and time and the fundamental properties of physical reality just means to put forth living beings and finally humans? When we see creation as the complex process modern cosmology reveals, however, then nothing is designed "in order to" but everything is interrelated, and the complexity of the interrelatedness on all levels lets more and more complex structures and properties emerge in a contingent way. Space, time and fundamental properties of physical reality are necessary conditions to bring about living beings as we have them here on earth. But that reveals more about our dependency on our natural conditions than about a purposeful designer. All we can say is that the process of creation began and developed in such a way that in aeons of time out of rather simple structures and driven by flows of energy far from equilibrium a complex ecosystem of living beings emerged on our planet, including human beings who ask about themselves and what it means to be human.

But does not the Anthropic Principle or similar considerations suggest that the cosmos is created on purpose, e.g. that it is designed *in order to* bring about carbon-based life? As has been widely demonstrated, the initial conditions and correlations of the universe are extremely sensitive to

[15] Nicomachean Ethics A 1. 1094 a 3–22.

minimal changes[16]. Constants of cosmic relevance such us the gravitational constant or the weak nuclear force could not be even slightly different to allow for the development of a fertile cosmos. Commentators have argued that this fine tuning can be seen as a hint towards a divine designer who purposely designed the universe in order to—and now the different schools split up—create a fertile cosmos, to bring about carbon-based life or to bring intelligent observers into being. But, as David Hume already stated, this is what later has been called a natural fallacy from is to ought: there is no way to infer on logical or scientific grounds from the way things are to the way things should be. And that the fine tuning of the universe is somehow linked with us is an assessment based on values, on rather narcissistic values by the way, but it is not an inference based on facts or probabilities. There is no way to argue from is to ought, from facts to purpose, at least not in the case of natural processes.

Thus the reference to the fact that extremely little changes in the physical constants or in the initial and boundary conditions would lead to a very different and most probably infertile cosmos is very weak if not counterproductive. How do we know what is possible under different conditions and what not? Many properties of our physical reality emerge rather surprisingly for our scientific understanding. Maybe if we change the ratio between gravitation and weak force just enough a new effect could come into being we do not know of and which would provide very strange but maybe very fruitful new possibilities. Who knows? And furthermore: if it is really the case that such an exquisite design is necessary in order to make a creation that is fertile, then God had no choice. If God wanted to create a universe in which something could happen, God had to accept the inevitable. Then God could at most be, as Einstein said, "Spinoza's God who reveals himself in the orderly harmony of what exists,"[17] but not the

---

[16] Cf. J.D. BARROW / F.J. TIPLER, The Anthropic Cosmological Principle, Oxford: Clarendon Press, 1986; J. LESLIE, Universes, London: Routledge, 1996; M. REES, Our cosmic habitat, Princeton NJ: Princeton University Press, 2001 and many others; in German cf. the extensive study of R. VAAS, Ein Universum nach Maß? in: Theologie und Kosmologie, ed. J. HÜBNER / I.-O. STAMATESCU / D. WEBER, Tübingen: Mohr Siebeck, 2004, 375–498.

[17] Cf. M. JAMMER, Einstein und die Religion, Konstanz: Universitäts-Verlag, 1995, 31.

personal God of traditional theistic belief. And in Spinoza's view God and nature (Deus sive natura) are interchangeable. It was this God who is identical with the rationality of nature that Einstein wanted to find in his physics, as he once expressed in an interview: "What I am really interested in is whether God could have created the world in a different way; in other words, whether the requirement of logical simplicity leaves any freedom at all."[18] But if there were no choice for a creator and no freedom why have one?

The fine tuning of cosmological properties and constants only shows that we emerged out of the whole cosmic process being closely dependent on it and inseparably interwoven into it. The really astounding thing about modern cosmology is that it has shown that we came into being in a long process and in a very special niche in a vast and mostly hostile void. It does not reveal that we are the intended product of a forcefully implemented project. At every stage of the development things could have been very different. And on the other hand nothing in our cosmological theories has to be corrected if we imagine that human beings never came into existence. The dimensions of our lifespan, our habitat and our consummation of energy are irrelevant for cosmic spacetime and the energy-mass-balance of the cosmos as a whole. The cosmos is a necessary condition for our existence but it is indifferent with respect to our fate.

Thus the harvest of modern cosmology seems to me highly ambiguous. It can raise feelings of reverence and mystic feelings of the sublime, but it also can lead to agnosticism and existentialism as for example in the cases of Bertrand Russell and Jaques Monod. When the venture of modern cosmology started, science wanted to rescue the phenomena of the heavens, wanted to disclose the true picture of the cosmos and its lawful relationships and was convinced that by doing so it would decode God's book of nature and thus reveal the purpose of creation and the significance of human existence within reality. But science flourished at the cost of the

---

[18] Mid-1940s, remark reported by Ernst Gabor Straus, then Einstein's assistant, cf. C. SEELIG, Helle Zeit, dunkle Zeit. In Memoriam Albert Einstein, Zürich: Europa-Verlag, 1956, 72: „Was mich eigentlich interessiert, ist, ob Gott die Welt hätte anders machen können; das heißt, ob die Forderung der logischen Einfachheit überhaupt eine Freiheit lässt.".

questions that launched it and kept it going.[19] The immensity of cosmic space and time, its hostile void, the contingent history of life on earth developing in a narrow and endangered niche with no relevance for the general cosmic process provide no answer to the human quest for meaning in life.

But in a theological perspective this can be turned into a positive argument. Creation can be understood as an act of grace rather than an act of necessity. It cannot be reduced to *poiesis*, to a process of production where means are adapted to supply for already designed ends. It is not a stage provided for us, it is an endeavour in which we participate. When we ask for purpose in creation and in our lives, we ask for life as an end in itself and for the fullness of life which arises out of creation, but is not inscribed into the laws and formula of cosmology. And as well as in a theological perspective creation cannot be reduced to a product. God the creator cannot be reduced to a craftsman.

3. How is God involved in physical processes?

If that is correct, what role does God play in cosmology then? How is God present and involved in physical processes? And if creation is not the realization of a conceptualised project, what can we say about divine foreknowledge and providence?

God is not the designer, we said, God is not the craftsman or engineer of creation. As we saw modern cosmology describes the cosmos as a processual development in whose due course different levels of complexity emerge. Therefore I think we have to differentiate God's agency according to the different domains we can identify in this process. On the very basic level of space, time and energy-mass we can understand the creator as the ground of reality, as the one who makes the difference between nothing and something, between the impossible and the possible. Modern cosmology implies a beginning of creation and be it in the form of an undetermined initial quantum state. And modern cosmology presupposes contingent initial and boundary conditions. With regard to this basic level of creation God can be identified as the one who brings something into being that has

[19] Cf. H. BLUMENBERG, Die Genesis der kopernikanischen Welt, Frankfurt a.M.: Suhrkamp, ²1989, p. 97: „Wissenschaft floriert zu Lasten der Fragen, zu deren Beantwortung sie in Gang gesetzt wurde".

an existence in its own right and is not just predetermined by the creator. Physically this is represented by the laws of conservation, the principles of symmetry in particle physics, the structure of spacetime and causal interrelatedness and the arrow of time. Theologically we can ascribe this basic level of reality to God's loyalty towards a creation that exists in its own right.

But, as I will argue when I discuss the so called Theories of Everything, the initial and boundary conditions together with the structure of space, time and mass-energy do not determine the whole process of creation. And I will also argue that those laws of nature that emerge on higher levels in creation cannot be reduced to those in effect on lower levels. So what traditional theology described as *creatio ex nihilo*, as creation out of nothing, has to be complemented with what the tradition called *creatio continua*, continuous creation. On a higher level God can be seen as the one who calls and lures creation to develop new levels of structure and systems and thus to explore domains of its potential. Tradition called this *God's cooperation* with creation or the *concursus divinus*, the divine concurrence, which happens in a "tender way" (*suaviter*) that does not coerce or force creation.[20] It is defined not as God's predetermination of the processes of creation, but as the cooperative and gentle presence of God as the source of new possibilities. Cosmologically this can be identified with the processes through which eventually complex living systems could emerge out of he possibilities provided on our planet. At least in one case we know of, in a small and exquisite cosmic niche, the conditions were such that chains of complex molecules could be enriched in a watery solution. And out of simple reproductive dissipative systems forms of primitive life emerged which strove towards self-preservation against entropy. Thus evolution is not the execution of a predetermined plan, but must be seen as the joyful and painful evolution of the abundance of living beings which are born, live and die. And under contingent conditions eventually a certain strand of primates developed into human beings which invented speech, organised themselves in societies and generated what we sum up as culture, including music, religion, literature and science. At this point a new level is reached,

---

[20] Vgl. D. HOLLATZ, Examen theologicum acroamaticum (1707), p.I, c.VI, q.18, 654: „Concurrit DEUS ad actiones & effecta creaturarum non concursu praevio, sed simultaneo, non praedeterminante, sed suaviter disponente."

on which God interacts with creation. Christian theology speaks of God's history with humanity, of God's covenant with Israel and God's revelation in Jesus Christ. God's spirit inspired human societies and individuals and transformed them. Thus faith, love and hope came into creation as human responses to God's creativity.

God's providence is God under way with human beings and with creation as a whole. In and through creation God provides means, possibilities and inspiration for life. And within our personal and communal lives God provides orientation for the ways we device and shape our existence. And all this happens gently and tender, often too tender and gentle for us because death, wickedness and evil are not powerfully eradicated, but transformed from within.

4. Is the cosmos infinite and eternal?

As we have seen our cosmological models imply certain features of the universe as a whole regarding the finitude of cosmic space and time. As things stand modern scientific cosmology sees both questions closely linked, but is no able to answer them conclusively. Depending on the ratio between the mass/energy-density of the universe, the cosmological constant and the velocity of expansion gravitation will either curve spacetime positively with the cosmos having a finite volume and ending in a final collapse (big crunch) or the universe has a flat or negative curvature with the cosmos having infinite volume and expanding forever. According to up-to-date data the first case, a closed universe, is the least probable model.

Even in the case of an endless expansion of the cosmos, however, all cosmic energy and matter would be dispersed to the point that all star formation and radiation would end. Locally, galaxies might collapse into black holes, but due to Hawking radiation even black holes would slowly lose their mass. It is presumed that even protons are not eternally stable, so that all baryonic matter would in the end decay and all order and structure of the universe would be dissolved into an ever dispersing radiation field with decaying minimal fluctuations. This undifferentiated cosmic soup would be devoid of organized structures. In this case the world would end, to speak with T.S. Eliot, "not with a bang, but a whimper".

But the claim that the cosmos is indeed a physical object being actually infinite, has its own epistemological problems and antinomies.[21] Infinity is not just very big, but without any measure and thus subject to what the mathematicians call the paradoxes of infinity, e.g. that a subset of an infinite set can be equipotent to the original set. What do we do when we claim the existence of an actual physical infinity? An infinite universe should not contain just many galaxies, but countably infinitely many. If we presuppose that there is a finite probability for the existence of our life-form in a galaxy, then the variations of life-forms could not exhaust infinity and there should be dispersed but infinitely many galaxies that show life-forms like ours and maybe even identical individuals. We leave the realm of empirical physics and impinge on metaphysics when we claim that our mathematical theories and models represent reality as such. Empirical cosmology in a strict sense can deal only with that part of the cosmos that is in some way accessible to us. Whether the infinite terms of the theory represent some property of reality can only be decided on non-empirical grounds, or as Kant said: infinity is too big for any empirical notion.[22]

I cannot discuss this further, but I think this is an important question for future discussion. Can actual infinity in space and time be a proper feature of physical objects? Does it devaluate our transitory and contingent existence because in infinity everything possible is somehow realized? How can theological eschatology relate to this?

5. Theories of everything?

Finally I want to reflect on the attempt of theoretical physics to develop a "theory of everything." A theory of everything is a theory that unifies the four fundamental forces of nature, i.e. gravitational, strong, weak and electro-dynamical force. There have been a few such theories proposed by theoretical physicists over the last century with superstring theories and theories of supersymmetry as major candidates, but yet none has been able to stand up to experimental scrutiny. The primary problem in producing a theory of everything is that quantum mechanics and general relativity are

---

[21] Cf. now J.D. BARROW, The Infinite Book. A short guide to the boundless, timeless and endless, London: Vintage, 2005.

[22] A spatially infinite and unlimited world is „für allen möglichen empirischen Begriff zu groß" (I. KANT, Kritik der reinen Vernunft, B 515).

radically different descriptions of physical reality, and the obvious way of combining the two leads to the so called renormalization problem in which the theory does not give finite results for experimentally testable quantities.

Still the hope is that in the end such a theory would fully explain and link together all known physical phenomena with regard to space, time and matter. To my opinion this hope is an illusion. There are other parts of physics e.g. in thermodynamics or in technical sciences, but of course also in other sciences like biochemistry, biology and neurosciences that could not possibly be reduced to extrapolations of such a theory of everything. It cannot say much about amoebae, let alone about Shakespeare, Beethoven or Kierkegaard and their work, and it will not include a full description of the physicist and his or her theory of everything. Therefore a "theory of everything" as the integration of certain aspects of physics would not be, as Hawking had claimed, "the ultimate triumph of human reason—for then we would know the mind of God."[23]

Furthermore such a claim rests on a problematic idea about the ontological status of *natural laws*. It was René Descartes who borrowed the term "natural law" term from ethics and applied it to physics implying that there are ontologically independent laws to which nature has to obey. Behind this concept is the notion that God is like an omnipotent monarch while the elements of physics are his subjects that have to follow rules which reside in God's mind. But the world is not the realisation of a formula. Mathematical theories are *our* ways of trying to come to grips with regularities in nature. They are our inventions as means of explanation to establish reliable certainties of expectations. They do not exist as such. Or as Nietzsche once wrote: "We cannot say that there are laws of nature. There are only necessities: nobody to order, nobody to obey, and nobody to trespass."[24]

Especially cosmologists who according to Landau are always in error but never in doubt tend to present their science as a science about reality as such. But science works with conjectures and refutations. It is, and here

[23] S.W. HAWKING, A Brief History of Time, Toronto: Bantam Books, 1989, 185.
[24] F. NIETZSCHE, Die fröhliche Wissenschaft, in: Werke in drei Bänden Bd.II, ed. K. SCHLECHTA, München: Hanser Verlag, [5]1966, 116: „Hüten wir uns, zu sagen, daß es Gesetze in der Natur gebe. Es gibt nur Notwendigkeiten: da ist keiner, der befiehlt, keiner, der gehorcht, keiner, der übertritt".

cosmology and theology meet, an ongoing strive for truth of finite human beings. Thus a God's eye view of reality, a theory of everything that includes both, the investigated object as such and the investigator with all her or his facets of life, is not accessible, neither for the natural sciences nor for theology. Faith seeking understanding will be aware of the limits of scientific approaches to reality while science seeking certain explanations will point theology to unrealistic concepts of God and creation. In this sense the dialogue between theology and scientific cosmology remains an ongoing and challenging endeavour.