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Chapter 2

Meaningless Space? Astrophysics and Theology

Arnold O. Benz

The size of the universe has always been beyond human imagination. Our scales, be it the human body or the distance of a day trip, are many orders of magnitude smaller and useless in comparison with cosmic dimensions. This inhibits relating human space and cosmic space. How can we orient ourselves in this unimaginable cosmic space? The lack of relation and orientation leaves us without firm ground under the feet; the question of meaning is lurking within fathomless space. This condition is not new. The threat of meaningless space has been with us now for four centuries. In this chapter I demonstrate that the universe's ten billion light-year size is a necessary condition for our existence. Does this make space meaningful? Meaning, I argue, does not result from scientific explanations, but from an interpretation in a larger frame of reference. A theology of space interprets space as a gift of creation, establishing a relation between Creator and creatures.

Frightening Space

In disputes between the geocentric and heliocentric world models in the sixteenth and seventeenth centuries, the meaning of space was a major issue. Cosmic space was spanned by planetary orbits and the respective motions of the Sun or Earth. In the geocentric model of Claudius Ptolemy, Earth was at rest, but the Sun moved in a circle. Nicolaus Copernicus proposed in 1543 a model where the Sun was at the center and the Earth moved around it like the other planets. In both models, the stars were fixed on a sphere just beyond Saturn at a distance estimated at the time at ten to twenty thousand Earth radii. The astronomers of the seventeenth century underestimated the distance to Saturn by a factor of a hundred.[1] Their model cosmos was tiny compared to the present conception. Its limit at the stellar sphere was at only one hundred thousand days' journey by horse. It would fit easily within a tenth of the orbit of Mercury, the innermost planet, as we know it today.

Tycho Brahe (1546–1601) and other astronomers of his time rejected the heliocentric model proposed by Copernicus. At that time, parallax motions of stars due to the yearly orbital motion of Earth were not observable. If stars were at the distance of Saturn or just beyond, their apparent position in the sky would draw an observable circle in the course of a year while Earth was making an orbit. Brahe, the best observer at the time, did not observe such a motion. Thus, he concluded correctly, that the Earth did not move around the Sun, or the stars must be at least 700 times farther away than Saturn. The heliocentric model would require a gigantic space beyond Saturn. Such a size was not conceivable for Brahe. It would be much larger than required for the stage of the human drama, believed to be the purpose of the universe. Thus, the empty

space beyond Saturn would have *no meaning*. How could God have created such an enormous universe, when only a minute part of it would be useful? So Brahe developed a model with a stationary Earth in the center encircled by the Sun, while the planets orbit the Sun. This compromise left the stellar sphere not far beyond Saturn and was consistent with observations until the late seventeenth century.

At the time of Blaise Pascal (1623–1662) the heliocentric model was getting more and more established among scientists. However, he experienced the progress of science not as a triumph of human cleverness, but as an indication of his insignificance. He notes: "The eternal silence of these infinite spaces frightens me."[2] The silence may be understood as the absence of any relation of this additional space with mankind. He could not imagine how the enormous space between Saturn and the stars had any meaning. We note here that meaning is not a scientific term based on measurement and causality, but expresses a relation. Pascal perceived the absence of any relation to humanity and thus without meaning as frightening. If most of space were without meaning, the meaning of the whole cosmos and even of humanity would be questionable.

When Friedrich Wilhelm Bessel measured the first parallax in 1838, he discovered that the nearest stars are not 700 times but about a million times farther away than Saturn. The distance to the closest star, Proxima Centauri, is measured today at a distance of six billion ($6 \cdot 10^9$) Earth radii. If Earth were as large as a pinhead, the nearest star would be the size of a cherry at a distance of 4,000 km. In today's view of the world, Brahe's problem is actually more than a factor of a thousand times worse than he feared.

The size of the accessible universe made another jump in the 1920s and increased by an additional factor of a million when the distance to the Andromeda galaxy became measureable. Finally, a further factor of ten thousand came into play with the discovery of the microwave background in 1965. It originated at the time when the early universe became transparent, 370,000 years after the Big Bang. Since that time radiation was not absorbed anymore and it propagated freely in space. As the universe was opaque before, this surface 13.7 billion ($13.7 \cdot 10^9$) years ago is today's horizon for visual light. Since the time when background radiation was emitted, the surface has moved to 45.7 billion light-years from us and constitutes the limit of the observable universe today. It is at a distance of a hundred million billion (10^{17}) times the alleged radius of the stellar sphere (and thus of the universe) at the time of Tycho Brahe. Cosmic space has grown from the still unimaginable distance to Saturn by an unimaginable factor.

Space in Today's Universe

The size of the observable universe is related to its expansion with nearly the speed of light since the Big Bang 13.7 billion years ago. Space began to expand rapidly beginning with a phase known as "inflation" and continues to be accelerated today, driven by enigmatic Dark Energy. This energy comprises three quarters of the cosmic energy; however, this concept is very poorly

understood. It may be related to the energy that has initially driven the Big Bang. There are several controversial theories on the nature of Dark Energy. One of them relates it to quantum fluctuations in a vacuum yielding a non-zero energy density. In any case, without this energy, space would not expand and the universe would still be hot and dense. Thus Dark Energy is essential for the further development of the universe into galaxies, stars, and planets. Space is not empty, but overflows with Dark Energy everywhere. Dark Energy in space has a relation to us humans because it helped to shape cosmic space where galaxies, stars, planets, and finally life could develop.

Galaxies form under the gravity of Dark Matter, another enigma of cosmic space not related to Dark Energy mentioned earlier. Dark Matter is an unknown form of matter that can be observed by its effect of gravity. Thus Dark Matter has mass, but negligible interaction with ordinary (baryonic) matter and therefore it cannot be studied from collisions. Particles yet unknown are suspected to comprise this Dark Matter. These particles dash through space without taking notice of normal matter other than by gravity. Thus they do not emit light or damage molecules in living creatures. Millions of Dark Matter particles traverse our body per second. Space is full of them. Once Dark Matter forms a gravity trough, baryonic gas accumulates like water in a bathtub. At the bottom of such troughs, galaxies of baryonic matter form. When enough baryonic matter has accumulated, stars finally form. Space between galaxies and stars is not empty, but full of Dark Matter, which is essential for the development of a galactic environment where conditions become suitable for the existence of life.

Stars convert the original hydrogen to helium, carbon, and oxygen. Massive stars burn it up further to iron. Stellar wind blows out the ashes into interstellar space. There, the heavy elements mix with original matter and form the next generation of stars. After some three or more generations, there are enough of the heavy elements to form Earth-like planets with solid surfaces, cores of iron, and atmospheres containing oxygen.

It is not a coincidence that we live long after the Big Bang. More than ten billion years are needed for a star like the sun to form and life to develop on Earth. For billions of years cosmic space has expanded, and today its observable size is 45.7 billion light-years in radius. The expansion and current size constitute cosmic space and are necessary conditions for the present state of the universe.

Was the purpose of the universe to create humans? Does space need us humans to have a meaning? I cannot think of cosmic space as the stage for humans like the paradigm of the Middle Ages. Being such a small part of it, this seems to be an outrageously anthropocentric view. Yet inversely, mankind could not have evolved in a smaller universe. The unimaginable size of the universe is necessary for our existence. Thus it is not without relation to us. It is not meaningless, since we have to accept that we absolutely depend on it.

Modern Concepts of Physical Space

It is conceivable that the region of origin of the background radiation in the early universe, which is at a distance of 45.7 billion light-years today, is not the end of the world. We cannot see behind it, but still may ask the question: How much may space continue beyond the horizon limited by the opacity of the early universe? There is a hint on this question coming from the theory of inflation, developed in the early 1980s. A phase of rapid expansion of the universe was proposed in 1981 by Alan Guth[3] to explain several cosmic enigmas. Most surprisingly, the universe appears similar in opposite directions. How can that be, as these regions cannot be causally connected? The inflation theory proposes that the universe had a phase transition shortly after the Big Bang releasing a great amount of energy. Space expanded exponentially and doubled its size every 10^{-34} seconds. The inflation speed of space reached a velocity larger than the speed of light. As space does not refer to particles and no information was obtained exceeding the speed of light, the superluminous expansion does not contradict the laws of relativity. When the energy supply was exhausted, the universe was a factor of 10^{40} to 10^{50} times larger than before. Parts of the universe that are now on opposite sides of our horizon were in contact with each other and thus similar before inflation. Rapid expansion explains the uniformity of the universe in all directions. It also suggests that the universe is much larger than today's horizon at 45.7 billion light-years, defining the limit that we are able to observe. How much bigger is uncertain; the models disagree by more than 50 orders of magnitude and may be wrong altogether.

Expanding space is a new concept and deserves a closer look at the definition of space in physics. Isaac Newton (1643–1727) defined space as absolute, changeless, and unaffected by the physical processes taking place in it. He also assumed that space is Euclidian (i.e., not curved), three dimensional, and infinite. Ernst Mach (1838–1916) questioned these assumptions and postulated that the basic parameters of physics, including space, must not be defined by philosophical concepts, but by a method to measure them. This provided the basis for Albert Einstein's (1879–1955) theories of relativity. In practice, space is measured by the time it takes a particle or wave with known speed to go from point A to point B. Usually, light is used. If space is curved by the gravitation of matter, light travels along curved geodetic lines. In these new concepts of space, the galaxies are not expanding into a preexisting space, but space expands in three dimensions like the two-dimensional surface of a balloon that is blown up.

The definition of space by specifying a measurement method requires that at least in principle such a measurement is possible, or an equivalent observation can be made. Mach even stipulated the hypothesis that space is produced by matter and cannot exist without matter. No observation of a propagating wave before the Big Bang is known or even conceivable. Thus space and time before the Big Bang are not defined in physics.

The discovery of Albert Michelson (1881) and Edward Morley (1887) that the speed of light is independent of the motion of the observer required a modification of Newton's definition of space. Einstein coupled space and time in his Theory of Special Relativity to a four-

dimensional entity. Space loses its absoluteness, but is relative to the reference system. The best-known consequence is the Lorentz contraction, according to which observers moving relative to each other measure different lengths for a given object. Thus we can choose the length of an object by moving it at a certain speed. Space becomes dependent on the observer. Moreover, in the Theory of General Relativity, space becomes dependent on the mass it includes. Its gravitation curves space. Thus the geometry of space is far from absolute, but determined by matter and the motion of the observer.

Modern string theories aim at unifying gravitation with the more basic physics of quantum mechanics. They add additional dimensions to space-time. These dimensions are not extended as the well-known three-dimensional space and time. The additional space dimensions are curved at the subatomic range, for instance into a closed loop. These theories are not confirmed and remain speculations until tested on experiments. Their final goal is to postulate space not as a given entity but as the result of basic forces and particles.

In conclusion, we should not see space as a preexisting frame of coordinates, into which the universe expands. Space is rather a part of the universe that originated, expands, and evolves with the cosmos.

Meaning of Cosmic Space

In 1977 Steven Weinberg shocked the world with his remark: "The more the universe seems comprehensible, the more it seems pointless."[4] Why did he say this? Pointless in this context means that the universe has no aim. It just happens to be here. The word pointless was translated in the German edition with *sinnlos* (meaningless), causing even more of an uproar. A pointless universe has no goal or plan, but finds its way by trial and error, chance and necessity. However, even if we consider the development of the universe to be in a haphazard manner, it still possesses meaning.

Meaning is a notion that I encounter most pressing in the connotation of the "meaning of life." The question has become a besieging one in recent times, in particular for modern individuals in Western society. In ancient times and in many societies still today, the meaning of one's life is to be part of a community, a nation, a tribe, or a clan. The fulfillment of life is met with fulfilling one's duty as a part of a larger unit. In today's Western culture the point of life is often found in personal relations or in love. These could be one's relations with a spouse, family, friends, partners, or God. Such relations yield a role and orientation in life.

What could signify the meaning of the universe or the meaning of space? Obviously the answer cannot come from physics. I cannot imagine an equation where *M*, standing for meaning of space, is the result of some parameters and constants. And the result of the equation then would be a number, such as 42.[5] As in the example of the meaning of life, the meaning of space must be seen in a relation to a superior entity or to the whole of the universe. An example of such a relation is the medieval interpretation of the universe as a theater stage for human life. Here the relation is given by stage and actors. They fit to each other according to the play.

Obviously, the medieval cosmos as a stage is a metaphoric interpretation. The important part was to establish a relation between mankind and cosmos. As in the biblical view, humanity's duty was to praise God. The universe participated in this function and thus had a meaning. It was a necessary agent allowing mankind to achieve its goal. Today humanity has lost its undisputed importance and central location in the cosmos. The current conceptions suggest the opposite: cosmic evolution is the grand play and may be the ultimate goal, with mankind taking part in it. What then could be the meaning of the universe and of space? Can galaxies, stars, and planets take the role of humans and praise God? That is what some biblical texts do indeed suggest, most clearly, in the Psalms.[6] What do they want to say? Do these images still appeal and can they interpret the findings of astrophysics?

Here we encounter interpretations different from scientific explanations. To discuss metaphoric descriptions of meaning and in particular the meaning of space, we have to turn now to methods and types of interpretation, and thus to the different epistemologies of science and religion.

Explanation and Interpretation

Scientific theories explain the relation of cause and effect or, alternatively, they give the probability that a certain event will occur. The ideal form of such an explanation is the mathematical equation or a probability. Mathematical symbols are not to be confused with metaphors. Take as an example the most famous equation of physics: $E = m\,c^2$. If the mass m is doubled, so is the energy E. If c were zero, so would be the energy. Other forms of energy may be added to the right-hand side of the equation. Einstein's formula can be integrated over a distribution of mass density. The equation can be mathematically manipulated in many ways and still make a valid statement about reality.

Metaphors cannot be added or integrated. A metaphoric interpretation of the kind "the universe is the stage of human life" cannot be expressed mathematically. If the stage is enlarged a billion times, human size is not. However, in such a metaphoric scenario, stage and humans keep the relation to each other even if the stage is enlarged. As long as humans live in this universe and have some relation to it, the imagery conserves the relation in space and time. Thus metaphoric interpretations cannot be disproved. A metaphor is not an equation and *vice versa*.

Metaphoric interpretations do not further scientific explanations. The Newtonian explanation of planetary motions did not become more precise nor was changed at all by interpreting the solar system as a stage for humans. No scientific gap of the time, such as the formation of planets, was filled. The stage interpretation was still used after Newton, as it gave orientation to the details of scientific explanations. Metaphoric interpretation looks at scientific results from some distance and gives them a perspective.

Yet there are other images that offer different interpretations. The seventeenth-century Deists interpreted the universe as a clock. The clock metaphor originated under the impression of Newtonian mechanics of the solar system in the age of the rising mechanical industry. Planets

circle the Sun in orbits that can be predicted years ahead with stupendous precision from the equations of motion including inertia and gravity. The original, the mechanical clockwork, operates automatically according to its design. It is completely determined by its cogwheels. If all of them are known, the clockwork is fully explained and understood. In a clockwork each cogwheel is necessary and thus has a meaning. The whole clock has a meaning as the clockmaker must have had a purpose to create it. If the clockwork is the basic pattern that is discovered similarly in other entities; it becomes an image. The mechanical clockwork interprets metaphorically through its characteristic function, behaving deterministically. The metaphor then suggests that the universe is predictable and rational, and has no room for randomness.

If a metaphor becomes a part of the worldview and is applied universally, it becomes a paradigm. In the eighteenth century the clockwork metaphor of the cosmos reached paradigm status, suggesting that even humans were machines.[7] The metaphor of the clockwork survives until modern times in the form of the interpretation of the universe as an enormous computer.[8] This image, however, suffers some mismatch in view of modern astrophysics and biology, describing the universe as a chaotic development where chance plays an important role. However, the postulation of an intelligent design also faces the same problem.

To believe that the universe is a divine creation is another interpretation. All things, including space and time, then have their existence from a common principle. In Judeo-Christian tradition the creative power is ultimately transcendent and not part of this universe, neither in space nor in time. From the biblical creation stories in Genesis 1 and 2, to the Psalms, from wisdom literature to the Prologue of John's Gospel, the creative force is described as caring and graceful. In accordance with cosmologies of their time and general assumption, the Old Testament creation stories put creation at the beginning of the universe.

Modern astrophysics and biology indicate that nothing in the present universe originated in the Big Bang. Everything, including galaxies, stars, and planets formed at a later stage. Nucleons, the building blocks of matter, came into existence after the beginning of time. Even space and time grow continuously. If the universe is interpreted as a creation, it must be a continuous process. In theology such an interpretation is known as *creatio continua*. Continuous creation of space is the interpretation I want to expand on in the following.

Meaningful Space

Does cosmic space have a purpose or even a meaning? This question cannot be answered by science, but depends on our interpretation of the universe and, even before that, of our own personal existence. Creation is one of the possible interpretations. From a rational point of view, meaning follows immediately assuming that the existence and evolution of the universe are God's will and for his glory. The absolute aim then defines a relation of all creatures to the absolute. We note however that this construction cannot be proven and appears arbitrary to many contemporaries.

Religious interpretations are empty constructs if not based on experience of some kind. Four centuries of modern science have shown that the empirical basis of religion cannot be gaps in scientific understanding or a design claimed to be apparent in scientific results. Gaps are continuously closed by new results, while new ones open. A religious interpretation of the universe can only be grounded on religious perceptions, such as visions, mystic experiences, or biographic incidents. Religious perceptions occur in translucent moments when the world becomes transparent for a different reality.[9] Such transcendent experiences may happen under a starry night sky, but they are always related to a personal experience of a human being.

Humans experience creation not primarily in the confrontation with scientific results, but with our own existence. Where did we come from, and where are we going? At the age of some ten years we realize that we have a personality and can say: "I am me." The time, we can say, is finite. It is the rest of our lifetime. This is the time given to us; we have no right to demand more, but it is our most precious gift. It is the way I read the story of Adam. Being made of *adamah* (dirt from the field) and given his biological body, God endowed him time to live. He also gave him space to live, namely an environment capable of life, and a partner. This is the myth of human adolescence for both men and women: finding identity, falling in love, becoming independent, making mistakes, et cetera. Everything starts with the initial gift of a lifetime and a space to live, the primary creation.

The gift of existence in time and space is a basic human experience. It is evident that some spatial conditions for life, such as fertile land, water, fruits, and livestock, must also be met, as told in the story of Adam. These conditions are also experienced as gifts and thus are part of the creation story. Probably none of the more than 2,500 planets currently known is fit for life. A planet very much like Earth is necessary, having a dense atmosphere containing oxygen, oceans of liquid water, fertile land, a magnetic shield against cosmic rays, and much more. Earth-like planets consist of heavy elements, ashes produced in previous generations of stars. Stars form from molecular gas contained in galaxies. Galaxies form in gravitational troughs produced by Dark Matter that has five times more total mass than baryonic matter and thus controls gravity on large scales. These large troughs form only in a universe expanding from a hot and dense state after the Big Bang. The expansion continues and even accelerates due to Dark Energy. It has bloated space to at least 45.7 billion light-years, the size of today's observable universe. Humanity could not have evolved in a much smaller universe. Cosmic dimensions of space are needed for life.

Being the hatchery of humanity cannot anymore be the meaning of the universe. The size of the scientifically explored universe has grown dramatically since the Middle Ages. The human species is a minuscule part of the evolving universe at a very particular place and time. If space has a meaning, then it is the same as for the universe including humanity.

If human existence is interpreted as a gift, endowed by a Creator, the universe may also logically be interpreted as a gift like Adam's garden, as it is necessary for our being. Space then

loses its frightening largeness, but becomes part of everybody's personal gift. A gift is in relation to the giver and the presentee. In this relation, space obtains a meaning.

The notion of creation implies a different quality when used for interpretation instead of explanation. According to a text by Hans Weder,[10] we perceive as creation something pivotal that we recognize, astonished, as a gift. This may serve as a definition for a modern understanding of creation. Creation is not directly noticeable in scientific results, but is recognized in a particular instant of personal amazement.

Can we perceive space as a creation? We may be amazed at how big it is, yet being related to us. Although we understand the nature of space much better than Newton, we depend on it, and our becoming would not be conceivable without it. Amazed, we may notice that space grows out of nothing and the world could not exist otherwise. Considering that this growth is beyond our control, and at present even beyond our understanding, I can perceive it as given. Thus cosmic space may be interpreted as creation according to the above definition. This is an interpretation that is not coercive; a person may choose not to be amazed and ignore the character of the gift. Yet I am overwhelmed when realizing that my little person is part of this awesome universe and would not be possible without expanding space.[11]

Conclusions

Today's astrophysics describes the universe as a widely coupled system in evolution. Space, expanding since the Big Bang and as large as observed today, is a necessary ingredient for this cosmic unfolding. In this new view of the universe, Blaise Pascal should not be afraid anymore of the vastness of space. Cosmic space may be interpreted as part of the gift of life, necessary for a universe habitable for humans. The gift interpretation is the essence of a modern concept of creation, exemplified already in the creation story of Adam. Metaphoric interpretations need to be tested on their value as paradigms of a worldview. In my opinion, continuous divine creation of space is not only a possible interpretation in views of scientific results, but is consistent and appropriate. It fits the currently known astronomical universe at least as well as others such as the clockwork, computer, or intelligent design.

The notion of creation yields meaning through the relation between Creator and creatures. It must be stressed again that in this definition creation cannot be just a dogma added to scientific results but must be related to existential experiences. Creation is based on the perception of life and space as gifts. Belief in creation is not endangered by scientific resultsbut by neglecting and forgetting the basis of this experience. Personal perceptions, such as amazement, are nexuses between space in science and space in religion.

Notes

[1] Michael Hoskin, *The Cambridge Concise History of Astronomy* (Cambridge: Cambridge University Press, 1999), 94.

[2] "Le silence éternel de ces espaces infinis m'effraie." Blaise Pascal, *Pensées.* English translation by W. F. Trotter, http://oregonstate.edu/instruct/phl302/texts/pascal/pensees-contents.html.

[3] Alan H. Guth presented his ideas for the general public in *The Inflationary Universe: The Quest for a New Theory of Cosmic Origins* (Reading, MA: Addison-Wesley, 1997).

[4] Steven Weinberg, *The First Three Minutes* (New York: Basic Books, 1977), 154.

[5] In Douglas Adam's 1979 science-fiction novel *A Hitch Hiker's Guide to the Galaxy* (London: Pan Books), a computer was set up to calculate the "answer to the ultimate question of life, the universe, and everything." The result was 42 to the base 13, but the question was forgotten.

[6] Psalm 19:1: "The heavens declare the glory of God, and the sky above proclaims his handiwork." ESV Bible online.

[7] The clockwork interpretation of the universe was applied to humans by Julien Offray de *La Mettrie* (1709–1751) in his book *L'homme machine* (anonymous 1748).

[8] Konrad Zuse, the early pioneer of computers, proposed in the 1940s that the cosmos was a huge calculator (Konrad Zuse, *Rechnender Raum*, [Braunschweig: Vieweg, 1969]). More recently Seth Lloyd developed the hypothesis that the universe was basically working like a quantum computer. Its program consists in generating the whole universe including mankind. With the complete knowledge of all physical laws it were therefore possible to develop a quantum computer modeling exhaustively the universe. We would then be able to explain and completely understand the universe. Lloyd's ideas appeared in *Programming the Universe: A Quantum Computer Scientist Takes on the Cosmos* (New York: Alfred A. Knopf, 2006).

[9] John Gatta describes nature becoming icon-like in a moment of devotion, in *Making Nature Sacred* (Oxford: Oxford University Press, 2004), 242.

[10] Based on a text by Hans Weder, in *Kosmologie und Kreativität* (S. 68; Leipzig: Evangelische Verlagsanstalt, 1999).

[11] A comprehensive exposition of the gift metaphor of creation was published by the author in *Das geschenkte Universum—Astrophysik und Schöpfung*, 2nd ed. (Düsseldorf: Patmos, 2010); English translation, *The Given Universe*, forthcoming in 2015.