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16 Astrophysics and religion

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Physics of the universe

Astrophysics, including scientific cosmology, aims at answering the question: how did we come to be here? The issue is not some speculation about the Big Bang and what was before, but the history of the universe up to the formation of the Earth. As far as we know today, the universe started as an unimaginably hot and dense gas of elementary particles. Dark energy inflated space including the gas and still expands the universe today. About a microsecond after the beginning, the particles combined to nucleons, the constituents of ordinary matter. Matter opposes the cosmic expansion by its gravity. Dark matter dominates ordinary matter in the average by more than a factor of five. Ordinary matter accumulates in places of higher density of dark matter.[1] The dark components of the universe are not really understood. It is remarkable that they balance each other so that the expansion is not obstructed completely by the pull of gravity, but structure formation started fast enough before the universe got too dilute. If gravity were stronger compared with stress of dark energy, the universe would have collapsed before life on Earth could have evolved. On the other side, if gravity were too weak, ordinary matter in the dark matter troughs would not have developed further and galaxies with stars and planets would not exist. Astrophysicists talk about a ‘fine tuning’ of the physical components and constants. Fine tuning is for me first of all amazing. I try to not ‘explain away’ the amazement by some quick philosophical or theological hypothesis like a multiverse or God.

Ordinary matter accumulating in dark matter compactions initiates a firework of complex developments. In the coolest and densest regions, the gas condenses into cores having stellar masses. These cores of a light year diameter cool over a hundred thousand years until the gas pressure is too small to support them. They collapse not into stars, but, conserving their angular momentum, into thin rotating disks much bigger than the orbit of Neptune. It is not fully understood, how the spin is slowed down and the matter finally precipitates to the protostar developing in the center. During that time some matter in the disk, including gas and dust from previous stars, merges into planets. When the temperature and density in the center of the protostar become high enough, the hydrogen atoms in the gas fuse into helium, providing a long-lasting source of stellar energy. A star is born.

The history outlined above is generally accepted but not complete at all. The details matter as manifest in the diversity among the eight planets of our solar system. The few thousand exoplanets known today are even more diverse. When I started as a scientist, the outline was like an outline of today's outline. We know a lot more today, but a lot more that we don't know. Am I frustrated that we don't know everything? Not at all, it was an interesting walk through a magic garden full of detections and surprises. The thought pleases me that there is also plenty more to discover for future generations of astrophysicists.

And again, there is a lot of fine tuning also in the history of stars. If for example the weak nuclear force that controls hydrogen fusion was 20 % weaker, the intermediate product, deuterium, would be unstable and decay before fusing into helium. The fusion reaction would be short-circuited. Stars could not tap nuclear energy and would collapse into black holes. Another example is the gravitational force. If it were stronger, nuclear energy would be released faster, stellar evolution time be shorter and the Sun may have burnt out by now.

Stars are forming in great numbers. About 10 protostars reach maturity every year in the Milky Way, our galaxy. Multiplied by the great number of galaxies in the observable universe, it adds up to some 30,000 new stars per second. Stars were already forming in the early universe at higher temperature and densities and different chemical composition. There is no reason to assume that they will not form in billions of years in the future. It seems to be the most common thing in the universe and to be a very robust development. All forces of physics — gravity, electromagnetic, weak and strong nuclear force — are involved. Molecules, thus chemistry, play an important role. Solid state dust grains and high-energy particles have their part. Knowledge from many parts of physics and chemistry must be applied to understand. In view of this bewildering complexity, I cannot consider the many processes known to collude in star formation as just a simple matter of course. For me it is the most amazing property of the universe that even one star is born.

A recent survey on exoplanets around nearby stars concluded that the number of planets approximately equals the number of stars. The number of stars in the universe is estimated at 10^{23}. Thus, there must be many planets in the universe, and the number of planets just in the Milky Way may be some 10^{11}. So, the chances for a twin of Earth in our galaxy seem high. However, none of the few thousand presently known exoplanets seems to have conditions close enough to Earth to sustain life, since the conditions for life as we know it are many. To name a few, life on Earth needs liquid water on the surface, requiring a certain distance from the central star. That star must be single, long lived and moderately active, but not too much. The surface of the planet must be rocky and not gaseous like on Jupiter. The chemical composition of the surface and of the atmosphere must be friendly to life. Continental drifts, the terrestrial magnetic field, the tides of the oceans produced by the moon, and even occasional meteorite impacts were essential for the evolution of life. The list is much longer, still

growing, and not completely known. To estimate the number of Earth-like planets, the huge number of planets must be multiplied times the minute chances for similarity.

We don't know how many planets fit for intelligent life there are in the universe because we don't understand enough how life on Earth emerged. I have the feeling – and it is just a feeling – that there are not many and that Earth providing a favorable habitat for biological evolution for billions of years is rather special. It is like a pretty flower in the desert, a gift we have not deserved.

God of the gaps

Where does God come into the picture? Not necessarily at all. Considering the complexity of the astrophysical processes it is not surprising that there are many gaps in our scientific understanding. With gap I mean a process that cannot be convincingly explained from initial conditions by scientific laws. Of course, there is always a quick hypothesis or rather an outline of a chain of processes. Thus, the definition of a gap is not sharp. Nevertheless, Michael J. Behe claims that such gaps exist in biochemistry and the evolution of man.[2] Behe argues that the formation of certain organs of the human body (such as some essential cellular structures) cannot be reduced to small evolutionary modifications. Such a statement is difficult to prove and has been disputed. The examples presented by Behe can be reduced partially to evolutionary steps and appear not to be "irreducibly complex" [3].

When new instruments became available to scientists in the 17th and 18th century, many apparently miraculous gaps became known. Of particular interest is what the famous physicist Isaac Newton wrote in1713 in his *General Scholium*. He marvels at the orderly motion of the planets and the Moon in nested circular orbits in the ecliptic plane, having all the same sense, so that they do not interfere with each other and concludes:

> This most beautiful System of the Sun, Planets and Comets, could only proceed from the counsel and dominion of an intelligent and powerful being.[4]

Today's mechanistic explanation as presented above yields a different answer: The planets formed in the accretion disk of the Sun. Some of the volatile gas fell into the protostar or was blown away later by the solar wind. The massive planetary bodies remained in their orbits until today. No appeal to a wise creator is necessary. However, we have now to explain how the gas lost its angular momentum and how the solar wind is accelerated. My experience in astrophysics is that new gaps appear when an old gap is closed.

Newton's fallacy was to use the notion of God to explain a gap in science. This was not unique at that time when the idea of divine creation was understood literally. Amazing phenomena in astronomy, biology, geophysics and other sciences were explained by an omniscient, omnipotent, and gracious Creator.[5] Newton's theological statement assumes that God exists and explains the magnificent, but unaccountable

scientific observation by the ‘God hypothesis’. If this religious explanation is compared at the same level with the corresponding physical theory, the latter wins because it perfectly fits in with the successful methodology of physics. “I had no need of that hypothesis,” Pierre-Simon Laplace answered Napoleon when asked why he did not mention God in his stability theory of the solar system.[6]

Some natural theologians, as they are known still today, went even further and considered scientific gaps as proofs for the existence of God. Already Blaise Pascal (1623-1662), a French physicist, philosopher and theologian, vigorously rejected this idea of proving God by gaps in science:

> I admire the boldness with which these persons undertake to speak of God. […] To tell [unbelievers] that they have only to look at the smallest things which surround them, and they will see God openly, to give them, as a complete proof of this great and important matter, the course of the moon and planets, and to claim to have concluded the proof with such an argument, is to give them ground for believing that the proofs of our religion are very weak.[7]

For me gaps are blank or gray spots in the scientific picture of world. They just indicate that our scientific knowledge is incomplete. To introduce God at these points, would be jumping to another category, to the field of religion, where another methodology applies. So we have to discuss first what religion could mean in the context of science. Is there more than science?

Participatory perceptions

To answer the above question and to understand Pascal’s objection, we have to focus now on the basis of religion from the perspective of a scientist. Religion has many aspects and many forms. There are the great world religions, but also partitions within them that contradict each other. Religion includes dogmas, ethics, rites, community, culture and sometimes ideology and hate. If I want to understand religion as a scientist, I need to go back to its roots. The roots of any religion that deserves this name are in the experience of some divine reality. Similar to science, human experiences are at the basis of a religion. Religion includes the subsequent rational reflection and metaphoric interpretation of such experiences.

The Bible is full of reports of presumed experiences of God. I just mention as examples the narratives of the Burning Bush, in which God reveals himself to Moses, or the moving story of the Disciples from Emmaus, who described their emotions during a vision of Jesus as feeling their hearts burning. The two biblical texts describe extraordinary experiences in the context of ancient worldviews. I would be lost if there were not more recent, although less spectacular reports. William James in his seminal book *The Varieties of Religious Experience* presented among many others the following account of a mystical vision by Richard Maurice Bucke, a prominent Canadian psychiatrist:

> I had spent the evening in a great city, with two friends, reading poetry and philosophy. We parted at midnight. I had a long drive in a hansom [cab] to my lodging. My mind, deeply under the influence of the ideas, images, and emotions called up by the reading and talk, was calm and peaceful. […] All at once, without warning of any kind, I found myself wrapped in a flame-colored cloud. For an instant I thought of fire, an immense conflagration somewhere close by in that great city; the next I knew that the fire was within myself. Directly afterward there came upon me a sense of exultation, of immense joyousness accompanied or immediately followed by an intellectual illumination impossible to describe. Among other things, I did not merely come to belief, but saw that the universe is not composed of dead matter, but is, on the contrary, a living Presence; […] I knew that what the vision showed was true.[8]

Mystical visions are rare, even the kind of the above more recent example. According to most records, they changed people's lives. Were they real? Real is what has an effect, is continuously recognized as real and does not turn out to be an illusion. Thus, they were real to the persons concerned.

Spiritual perceptions are broader and more frequent phenomena than life-changing mystical experiences and explicit experiences of God. Spirituality includes all forms of contemplation and meditation, the feeling of emptiness, mountain peak experiences, nature mystics, experiences of union and fullness. Such experiences may not be considered religious by the person concerned and not necessarily related to a supernatural being. Religious is here a possible interpretation based on tradition and previous experiences.

There is a specifically religious spirituality, though, relating to a reality transcending the person. It includes, for instance, sensing Divine providence, experiencing answers to prayers, being blessed with health, food, or life. Finally, some people feel addressed by words, be it a sermon, a poem or a passage from the Bible. It is such religious spirituality that is most commonly referred to as religious experience.

What can I say about such experiences as a physicist? The experience of Bucke was apparently not perceived by others, such as the hansom driver. It was not repeatable nor quantitatively measurable. Neuroscientists could have measured some activity of the brain. Yet, for Bucke it was not an entirely interior perception, but was related to the outside world, in fact to the whole cosmos; although it was clearly an experience that is not part of astrophysics. We may consider it as subjective, but it included a particular perspective of the outside world.

Bucke's experience may have been like a resonance in physics, where a passive object is said to resonate if it interacts with a wave and begins to vibrate with it. The body of a violin, for example, resonates with the oscillations of a string. It captures part of the energy via the bridge and transmits the oscillation with its much larger surface to the air so that a sound wave is emitted loud enough for the human ear to perceive.

How can humans perceive more than physics and science in general? An excess in perception is only possible through a way of cognition that is not objective and is ultimately inapt for scientific inquiry and interpretation. Such perceptions are indeed discussed in recent psychology. In particular I refer to ‘embodied cognitions’[9], where not only the brain, but parts of the body are involved. An embodied cognition is the result of an interplay between sensory impression, emotions, and feelings. Embodied cognitions are alluded to in the popular expression of ‘gut feelings’. They describe a situation where objective knowledge and rational deliberations leave a person undecided, but holistic considerations of a wider field of experiences including the body are convincing. Antoine de Saint-Exupéry provocatively claimed: "It is only with one’s heart that one sees clearly. What is essential is invisible to the eye."[10] Human perceptions not only involve the classical sensory organs like eyes and ears, but also include feelings, moods, emotional tensions, mystical experiences, environmental conditions, previous occurrences, or many of them together. It is a cognition in which the human being participates in an integral way.

Can I take cognitions seriously that are non-objective and possibly erroneous? My fascination for astronomy originates in non-objective ‘wow’ perceptions of the starry sky in a moonless night. Embodied cognitions dominate also in the experiences of art, love, grief, and many other manifestations of live. People experience non-objective perceptions differently, and some people prefer to ignore them. Thus, non-objective perceptions require an outside object and a person willing to participate. I refer to them as participatory perceptions. The lack of objectivity raises immediately the question of reality. Some critical distance to such perceptions is appropriate. Without critical reflection embodied cognition soon become subjectivistic like, for example, a widower who loses himself in mourning for his wife. Yet human beings cannot live without participatory perceptions. Most of my decisions in life, my motivation, and ambitions are based on them. It is part of the reality of life, in which I participate.

We live in a world where there is more than causality and chance. Yes, there is a gap in science; the gap is where we live. Life cannot be comprehended by physics. It is the gap where God is experienced. God in Biblical theology and most other religions is a reality in life not in science.

Relation of astrophysics and religion

Is the relation between science and religion a competition or a conflict? Or do science and religion rather complement and even enrich each other? The battles between Biblical fundamentalists and their atheistic opponents have dominated the media. In my classes I often encounter agnostic physicalists opposing religion. The methodology of physics requires that the measurements are explained by physical laws and chance, by causality and randomness. This is known as weak physicalism and is restricted to interpreting physical data. Physicists use it as a working hypothesis. It is surprisingly successful in most cases,

but is not a proven law and there are less or unconvincing cases such as the fine tuning of the universe.

Strong physicalism is another thing. It claims that all phenomena in the whole universe can, at least in principle, be explained by physics, if not now then by future physics. This would include also the human mind, awareness, and participatory experiences like Bucke's mystic perception and other experiences of the Divine. Strong physicalism is in line with the great successes of physics in the past centuries, but it is a rather daring speculation and assumes that in the world there is nothing outside of physics. It implies a materialistic worldview. [11]

On the other hand, if participatory perceptions are taken as relating to some reality, God comes into the picture. Such perceptions are not objective and thus less reliable than scientific measurements. The empirical bases from which science and religion develop, differ. They both may refer to a common reality, but start out from different perspectives. Astrophysics and religion are dissimilar approaches and are separated from the beginning. They cannot be unified, but be brought into a common view at certain meeting points.

Astrophysics and religion may meet when somebody is amazed about the functionality of the universe. The more I know about the universe, the more I am astonished that it works. Science provides the knowledge; the human being takes part with astonishment and parallels it with similar experiences in life. I do not recognize God directly in the Big Bang, in the cosmic fine tuning or the hospitality of the Earth. Yet, these remarkable properties of the universe remind me of the Creation Narrative in the first chapter of the Bible, where at the end of each day it says, "and God saw that it was good" (Genesis 1:1-31). The perception of the universe as being "good" in the sense of expedient is not a direct scientific result as the quality of good is not defined in science. God is not visible in stars or star formation, but I can guess at him, like a transient face in the clouds that I don't see anymore in the next moment when I try to focus on it.

Another meeting point of astrophysics and religion is the horror of decay. Stars pass away when they have used up their nuclear fuel, planets like Earth become inhabitable; galaxies shrink to black holes and even ordinary matter may decay in the far future. What has formed, will decay.[12] This cosmic property finds parallels in the human existence. Having suffered a painful loss, I have felt supported even in the face of a dire catastrophe. To be carried in life is the experience I associate most closely with the presence of God. Based on that experience, I may interpret the whole universe as being carried along as well.

At these meeting points, metaphors become important as bridges between science and religion. The amazement is a participatory perception of reality that is not quantitative, but best described by a metaphor: the universe appears to me in the form of a gift. [13] The gift is undeserved and not forever, like a fiefdom given by a mighty king for a certain time. Among other things, the gift includes the benevolent developments of the universe, the life-sustaining planet Earth, the warmth of the Sun, and our time to live. The metaphor of the given universe has a theological name: Creation. The term

is often used as a dogma. It can mean more than that, though, when related to participatory perceptions of the universe. Then it can relate scientific results to the experience of human beings, and mediate between astrophysics and religion. The metaphor of creation interprets the universe and its meaning.

Notes

[1] Joseph Silk, *The Big Bang* (New York: Henry Holt, 2001).

[2] Michael J. Behe, *Darwin's Black Box – The Biochemical Challenge to Evolution* (New York: Free Press, 2006).

[3] Michael Lynch, "Simple evolutionary pathways to complex proteins", *Protein Science.* 14, no. 9 (2005): 2217–2225.

[4] Isaac Newton, *The Mathematical Principles of Natural Philosophy*, vol. 2 (London: 1729) p.388. English transl. 2019 The Newton project, Rob Iliffe, newtonproject@history.ox.ac.uk.

[5] William Paley, *Natural Theology*, eds. Matthew Daniel Eddy and David M. Knight, (Oxford: Oxford University Press, 2006).

[6] Victor Hugo*, Œuvres complètes*, *Histoire* (Vol. XII), *Choses vues*, (Paris: Robert Laffont, 1987): 686.

[7] Blaise Pascal, *Pensées* English transl. (Dutton: New York, 2006): 242, http://www.gutenberg.org.

[8] William James, *The Varieties of Religious Experience* (New York: Longmans, 1914): 399.

[9] Francisco J. Varela, Evan Thompson, Eleanor Rosch, *The embodied mind: Cognitive science and human experience* (MIT Press: Cambridge, 1991). Recent review by Robert A. Wilson and Lucia Foglia, "Embodied Cognition" ed. Edward N. Zalta, *The Stanford Encyclopedia of Philosophy*. 2016 http://plato.stanford.edu/ archives/sum2016/entries/ embodied-cognition/ For an extension into the animal world see Jesse J. Thomas, *Embodiment, How Animals and Humans Make Sense of Things: the Dawn of Art, Ethics, Science, Politics, and Religion* (Indianapolis: Dog Ear Publ., 2018).

[10] Antoine de Saint-Exupéry, *The Little Prince* Engl. transl. K. Woods, (Reynal and Hitchcock: New York, 1943): chap. 21, 82.

[11] Andreas Losch, "Our world is more than physics – a constructive-critical comment on the current science & theology debate," *Theology & Science* 3 (2005): 275-290.

[12] Arnold O. Benz, *The Future of the Universe: Chance, Chaos, God?* (New York: Continuum, 2001). See also Arnold O. Benz, "Theology in a Dynamic Universe," *Zygon: Journal of Religion and Science* 36 (2001): 560.

[13] Arnold O. Benz, *Astrophysics and Creation – Perceiving the Universe through Science and Participation* (New York: Crossroad Publishing, 2016): 147, 151, and 178.