COSMOLOGY AND RELIGION

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Through most of human history, cosmology and religion have been closely intertwined, and such was still the case during the scientific revolution. More recent developments in physics and astronomy, however, resulted in cosmological views that challenged the belief in a divinely created world. The uneasy relationship between religion and scientific cosmology never ceased, and in the twentieth century religious issues even played a role in debates between rival cosmological theories. Does the universe have a beginning in time? If so, is it an argument for theism? Questions of this kind were widely discussed and they are still discussed in the twenty-first century, where new cosmological ideas have reinvigorated the cosmology-religion debate and made it even more complex.

INTRODUCTION

In order to chart the historical interaction between cosmology and religion, it will be useful briefly to contemplate the bewilderingly different meanings of the two terms. As to "cosmology" in its more restricted and today generally accepted sense, it is the scientific study of the physical universe as a whole, its structure, material content and evolution. In the past cosmology (or sometimes cosmogony or cosmography) often referred to the solar system, or sometimes to the Milky Way and the poorly understood nebulae. Henri Poincaré's *Hypothèses cosmogoniques*, a work published in 1913, was thoroughly scientific but concerned mostly with the formation of the planetary system and thus does not qualify as cosmology in the modern sense of the term. In still other contexts the word cosmology is used in meanings that are completely different from the scientific study of the physical universe and more related to world views, ideologies, or grand metaphysical speculations of a religious nature. Anthropologists and historians of ideas speak of

Mormon cosmology, Buddhist cosmology, and the cosmology of the theosophy movement; they investigate the cosmology of the native Hopi Indians and that of the Australian aboriginals.[1]

If the term cosmology is ambiguous and used in widely different meanings, so is it the case with the even more ill-defined term religion. Although religious views are often associated with the belief in a transcendent, personal and sovereign God, there are also several non-theistic religious systems (such as Buddhism and Taoism). All the same, from the point of view of history of science, Christianity and to a lesser extent other monotheistic religions (Judaism, Islam) have been by far the most important. According to most monotheistic religions, God created the universe as well as the laws governing it, and he continuously maintains its existence. For this reason, there is a potential connection between the Christian God – or Yahve or Allah – and the universe studied by physicists and astronomers. Since scientific cosmology was largely born in environments strongly influenced by Christian values, in what follows, religion will be largely identified with Christianity. Even with this simplification, there has never been a simple correspondence between cosmological positions and religious beliefs.

Although cosmology is a standard subject in the vast literature dealing with science and religion, a disproportionate part of the scholarly historical and historiographical studies focuses on early modern science and the Copernican revolution. Twentieth-century cosmology appears only peripherally or not at all.[2] There are only few reliable surveys of the cosmology-religion relations through history, and even fewer of the modern period in which cosmology became a branch of the astronomical and physical sciences.[3] Moreover, a major part of the scholarly, nonscientific literature on modern cosmology is written from a theological or philosophical perspective with little attention given to the historical context. For example, the concept of cosmic creation as it appears in big-bang cosmology has been scrutinized by theologians and philosophers, in most cases without taking into account the historical development of the concept.[4] It is also worth noticing that a substantial part of the literature is written from an apologetic perspective or otherwise colored by the authors' religious or antireligious preconceptions.[5] By instead

[1] See Hetherington, *Encyclopedia of Cosmology*, for a comprehensive overview of both scientific and nonscientific cosmologies.

[2] Brooke & Cantor, *Reconstructing Nature*, a widely acclaimed work, has nothing to say about scientific cosmology and its interaction with religion.

[3] McMullin, "Religion and Cosmology"; McConnell, "Twentieth-Century Cosmology." For fuller accounts, see Jaki, *Science and Creation*, and Kragh, *Matter and Spirit in the Universe*.

[4] Examples are Craig & Smith, *Theism, Atheism, and Big Bang Cosmology*, and Grünbaum, "A New Critique of Theological Interpretations." See also the general discussion in Halvorsen & Kragh, "Theism and Physical Cosmology."

[5] Jaki, *Science and Creation*; Jastrow, *God and the Astronomers*; Gingerich, *God's Universe*.

approaching the relationship historically, the mutual influence of cosmology and religion will appear more persistent and perhaps more interestingly unstable.

FROM RENAISSANCE TO ENLIGHTENMENT

The scholastic philosophers of the thirteenth century were much concerned with cosmology. However, to them cosmology belonged basically to theology and so was largely unrelated to what astronomers could say about the heavens. Nonetheless, some of the topics discussed at the time turned out to be relevant for much later developments in scientific cosmology. In order to reconcile Christianity with Aristotle's natural philosophy, for example, the theologians were faced with the thorny problem of the age of the world. The fundamental dogma of God's creation of the world seemed irreconcilable with Aristotle's claim that the world at large was uncreated as well as indestructible.[6] In his *De Aternitatis Mundi* from about 1270, Thomas Aquinas distinguished between a temporal beginning of the universe (*creatio originans*) and its creation, where the latter and theologically more fundamental concept referred to the existence of the universe as such. Aquinas thus suggested that the claim of a divinely created universe did not rule out the possibility of an eternal universe where God is continuously creative (*creatio continua*). This conceptual redefinition of "creation" was controversial at the time but eventually it became part of official Catholicism and adopted also by many Protestant theologians.

Christian belief was all-important to the cosmological discussions during the scientific revolution. Although the epic controversy between Copernicus' heliocentric world model and the traditional geocentric model was mostly concerned with the planetary system, it also included cosmological issues. It was taken for granted that God had created the universe, but how he had done it and what he had created was a matter of fierce dispute. According to René Descartes, a Catholic yet a Copernican, God had originally created the material world as a chaos of particles in motion, and at the same time installed the mechanical laws that would turn the chaos into a cosmos. Descartes boldly and somewhat heretically suggested that whatever the initial conditions the laws would necessarily lead to the world we observe. Therefore, after the original creation there was no need for God to intervene in the further construction of the world. The laws would take care of it. A non-theistic version of Descartes' deterministic claim has reappeared in modern cosmology under the name "indifference principle."[7]

Isaac Newton disagreed with Descartes' indifference principle. Armed with his new mechanical theory and its fundamental law of gravity he proposed a cosmology consisting of an immense number of stars held in mechanical equilibrium. But Newton insisted that it was "unphilosophical" to believe with Descartes that only the laws of nature were responsible for how the cosmos arose out of the primordial chaos. Newton argued that even an infinite sidereal system would need a divine power to keep it gravitationally stable. Unable to provide a physical explanation of the

[6] Lindberg, *The Beginnings of Western Science*; Grant, *Science and Religion, 400 B.C. to A.D. 1550*.

[7] McMullin, "Indiference Principle and Anthropic Principle in Cosmology."

stability of the universe, he appealed to God's continual intervention. This was the first appearance of the so-called gravitation paradox that would continue to haunt Newtonian cosmology over the next two hundred years.[8] It was reconsidered by the German astronomer Hugo von Seeliger, who in the 1890s proposed to solve the problem by modifying Newton's law of gravitation at very large distances. To Seeliger and his contemporaries, God was no longer at disposal.

Nor did God play any significant role in the grand cosmological scenario developed by young Immanuel Kant in his *Universal History and Theory of the Heavens* from 1755. Although Kant piously presented his theory as theistic, in reality it was naturalistic or deistic. In agreement with Descartes he claimed that the mechanical laws were sufficient to explain the evolution of the universe, which to him included not only phases of continual creation but also phases of degradation. Kant's infinite universe was evolving in endless cycles with enormously long periods separating constructive and destructive phases. With respect to the size of the universe, he claimed that only an infinite universe would accord with God's omnipotence.[9] While Kant's philosophical theory of the universe still referred to divine creation, in Pierre-Simon Laplace's cosmogony fifty years later God had disappeared. Laplace's nebular theory was about the origin of the solar system, not about the universe at large. Nonetheless, during the latter part of the nineteenth century it merged with Kant's cosmology into the popular but also theologically controversial Kant-Laplace nebular hypothesis or world view.[10]

VICTORIAN BELIEFS AND NONBELIEFS

Speculations about a huge number of habitable and indeed habited globes are old, going back to the atomist (and atheist) cosmology of ancient Greece. With the acceptance of the Copernican universe this belief, known as pluralism, became increasingly popular and based on the religious assumption that the omnipotent God would not have created so many stars and planets without making them inhabited by intelligent beings. Despite the complete lack of evidence, from about 1650 to 1850 pluralism was broadly accepted and considered almost a Christian doctrine.[11] Kant, in his *Universal Natural History*, was convinced that life was abundant throughout the infinite universe, and his conviction was shared by many others. On the other hand, pluralism was not easily integrated with Christian belief, for the former could as well be taken for support of deism, or even atheism, instead of theism. Moreover, there were theological problems. How could pluralism be reconciled with the central dogma of Christ's birth and resurrection? Did pluralism

[8] Jaki, "Das Gravitations-Paradoxen des Unendlichen Universums"; Harrison, "Newton and the Infinite Universe."

[9] See Kragh, *Matter and Spirit in the Universe*, 12-5 for a summary of Kant's cosmology.

[10] Numbers, *Creation by Law*.

[11] For the history of belief in extraterrestrials, see Dick, *Plurality of Worlds*; Crowe, *The Extraterrestrial Life Debate*; and Dick, *The Biological Universe*. See also Wilkinson, *Science, Religion, and the Search for Extraterrestrial Intelligence*, for the religious aspects of pluralism.

require the heretical notion of numerous Christs spread over the entire universe? Is incarnation not a unique event in space and time? During the second half of the nineteenth century belief in pluralism declined and so did its religious justification.

The two fundamental laws of thermodynamics discovered in the mid-nineteenth century shared with Newton's law of gravity that they were universally valid. They supposedly held true for any closed system and therefore also for the universe as a whole. When the law of energy conservation emerged in the 1840s, some of its founders interpreted it apologetically, as an argument for theism and against godless materialism. About a decade later, energy conservation was supplemented with the second law of thermodynamics established independently by William Thomson and Rudolf Clausius. It followed from this law that the degree of order and organization in any closed system inevitably decreases as the world irreversibly evolves towards a state of death. In Clausius' formulation based on the concept of entropy, the world will tend towards a maximum state of entropy corresponding to a "heat death" from which it will never return. As Clausius and Thomson were pleased to point out, the authoritative second law contradicted the materialistic and atheistic notion of a recurrent cyclical world.

For half a century or so, the heat death scenario was hotly debated if more among philosophers, theologians, and social critics than among astronomers and physicists.[12] The scientific prophecy was generally welcomed by Christian writers, whereas it was resisted by writers of a materialist, positivist or atheist inclination. The apparent agreement of the second law with Christian dogmas was strengthened by the so-called "entropic creation argument" implying a beginning of the world.[13] The universe cannot have existed in an eternity, for then the present world would be in a state of maximum entropy, which it is not. From the inference to a beginning of the universe it was tempting to conclude that it must have been created by a supernatural power, in other words God. This kind of argument, sometimes claimed to be a scientific proof of God, was first stated explicitly in 1869 by the German philosopher Franz Brentano, and over the next decades it was much discussed by scientists as well as nonscientists. The heat death and the entropic creation argument rested on the assumption that the second law was applicable to the universe at large and not only to isolated parts of it. Critics within the materialist camp denied that this was the case, or they simply rejected the second law as a general law of nature.

The extensive discussion involved one of cosmology's old and central questions, namely whether the universe is finite or infinite. If the latter were the case, such as maintained by materialist thinkers, it was far from obvious that the second law applied to the universe as a whole. By and large, materialists and atheists were convinced that the universe is infinite; most theists were equally convinced that it is finite, meaning that it contains only a finite number of celestial bodies. However, there was no one-to-one correspondence, and some Christian scientists, Thomson among them, were in favor of an infinite, divinely created universe.

[12] Hiebert, "The Uses and Abuses of Thermodynamics"; Jaki, *Science and Creation*; Kragh, *Entropic Creation*.

[13] Details and references in Kragh, *Entropic Creation*.

With the discovery of radioactivity in 1896 a few scientists realized that the new phenomenon might be used as a cosmic clock, an alternative to the problematic entropy.[14] The Austrian physicist Arthur E. Haas may have been the first to suggest, in a lecture of 1911, that the existence of radioactive elements such as uranium indicates a universe of finite age. After all, how could there still be radioactive elements if the world had existed for an eternity? According to Haas, who was a Catholic and hostile to materialism, the argument from radioactivity was a supplement to the entropic argument for a divinely created universe. Twenty years later, radioactivity would play an important role in Georges Lemaître's formulation of the first big-bang model of the universe.

A CLOSED UNIVERSE

Astronomers were of little help with regard to the question of the size of the universe. They were interested in observable material objects such as planets, stars, and nebulae, and tended to see space itself as an abstract concept of no relevance to astronomy or physics. Most astronomers in the *fin de siècle* period believed that the material universe was approximately the same as the Milky Way, which they conceived as a huge stellar system surrounded by empty space. The alternative view going back to Kant was the "island universe" according to which the spiral nebulae were separate from but roughly of the same kind as the Milky Way. The nebulae were distributed throughout the infinite cosmic space. Although religious views rarely turned up in the astronomical discussions, generally materialists and atheists were in favor of the island universe theory while the Milky Way theory appealed to a Christian audience. Whether adhering to one view or the other, the large majority of astronomers assumed space to be flat or Euclidean, which made it almost impossible to think of space itself being finite.

Non-Euclidean geometries had been known since the 1830s, but only as mathematical constructs. As early as 1872 the German astrophysicist Karl Friedrich Zöllner suggested that cosmic space might be slightly positively curved and therefore closed. Although with no boundary, the universe would be finite both with respect to space and the number of stars in it. However, it was only with Einstein's general theory of relativity, and his cosmological model of 1917 founded on it, that the idea of curved space truly entered physics and astronomy. The model universe that Einstein derived from his field equations was static, homogenously filled with matter, and spatially closed. He thought, erroneously, that this was the only model allowed by the general theory of relativity. During the 1920s the closed Einstein universe attracted much interest, not only scientifically but also because of what was thought to be its philosophical and religious implications.

Neither Einstein nor other contributors to the new cosmological theory associated it with a religious world view. Nonetheless, it entered the discussion in the interwar period concerning materialism, idealism, and religion. In 1921 the Norwegian theologian Kristian Schelderup examined in detail the relationship between Einstein's theory and Christian dogmas, suggesting that the closed and static universe made it necessary to revise the fundamental dogma of a divinely created world. Other commentators argued that the finite universe contradicted

[14] Kragh, "Cosmic Radioactivity"; Kragh, *Entropic Creation*, 174-8.

materialism whereas it was consonant with idealistic and Christian thought. The deeply religious Arthur Eddington (who was a Quaker) supported the Einstein universe for scientific reasons but also because its finitude and static nature agreed with his religious sentiments.[15] To him, God had not created the universe a finite time ago. Eddington's view was in broad agreement with the one of Ernest William Barnes, a mathematician and theologian who in 1924 was appointed Bishop of Birmingham. In a remarkable book of 1933, *Scientific Theory and Religion*, Barnes analyzed relativistic cosmology and its theological implications. He was generally happy with the closed Einstein model, not only because it was spatially finite but also because it made it difficult to see God as a transcendent maker of the world.[16] Barnes also addressed the old question of pluralism, arguing that the existence of multiple habited worlds was not a problem for Christian faith.

Although most cosmological models in the interwar period were based on Einstein's equations, there were also very different and more unorthodox hypotheses. For example, the American physicist Robert Millikan, a Nobel laureate of 1923, defended the idea of an eternal and regenerating classical universe. Millikan found an irreversible universe governed by the entropy law to be unacceptable and un-Christian, and instead he postulated an ever-evolving universe with continual creation of matter. As a Christian he believed that the world was created by God, but that creation took place continually rather than being limited to the beginning. In a book of 1934 titled *God and the Astronomers*, William Ralph Inge, Dean of St. Paul's, supported Millikan's idea of an eternal balance between creative and destructive processes in the universe. His preference for a kind of cyclic universe was unusual for a Christian thinker.

LEMAÎTRE'S PRIMEVAL ATOM

By the early 1930s it was realized that Einstein's field equations describe dynamical cosmological models and also models with a zero or negative space curvature (flat or hyperbolic geometries). The expanding model that Lemaître proposed in 1927 evolved asymptotically from a closed Einstein universe and thus did not have a definite origin in time. It was adopted and further developed by Eddington, who considered it a conceptual advantage that the "Eddington-Lemaître model" did not include a sudden origin of the universe. However, in May 1931 Lemaître proposed just what Eddington found repugnant, namely a universe with a beginning in an explosive event some billion years ago, the first example of a big-bang theory. The Belgian cosmologist pictured the origin of the universe as a violent radioactive explosion of a "primeval atom" containing all matter squeezed together in a huge atomic nucleus. Significantly, his primeval atom was quite different from nothingness; the original explosion or firework marked the beginning of the universe, not its creation.

[15] Stanley, *Practical Mystic*.

[16] Bowler, *Reconciling Science and Religion*, 260-77; Kragh, *Matter and Spirit in the Universe*, 113-9; Valente, "A Finite Universe?"

Given that Lemaître was a Catholic priest, and that the creation of the universe is a dogma in Christian thought, it may be tempting to suspect that the explosive universe was motivated by Lemaître's desire to reconcile cosmology and Genesis. This was indeed what some later critics claimed, but the allegation is not supported by historical evidence.[17] Much like Eddington, Lemaître was careful to distinguish between science and religion.[18] At several occasions he made it clear that the concept of cosmic creation belonged to theology or metaphysics, and not to the domain of science. At the 1958 Solvay conference he said about the primeval atom theory that it was perfectly neutral with respect to religion. It was not inconsistent with theism, but nor was it inconsistent with atheism.

While Lemaître's big-bang theory was positively received in the popular press, astronomers and physicists either ignored the theory or rejected it as wishful speculation. Eddington never converted to the big bang. In regard of the apparent congruence with Genesis one might expect that theologians and religious people embraced the theory, but this was not generally the case. Barnes referred to the primeval atom theory in his book of 1933, but without taking it seriously as either a scientific hypothesis of a naturalistic theology. John E. Boodin, an American philosopher of religion, complained that Lemaître's theory presupposed a material proto-universe and for this reason failed to explain the creation of the universe in scientific terms. He did not realize that this was not what Lemaître had in mind, and that his theory was not about creation but about beginning and evolution. It took some time until the primeval atom theory was presented apologetically. The British mathematician Edmund T. Whittaker, a convert to Catholicism, accepted the entropic creation argument and claimed that modern cosmology provided further support for Christian faith. In *Space and Spirit*, a book of 1946, Whittaker stated that the finite age of the universe was strong evidence for a universe created by an omnipotent God. Yet he cautiously added, in agreement with Lemaître, that creation itself was outside the scope of science.[19]

Despite Lemaître's unequivocal statements, after World War II it was often claimed that his primeval atom theory, or the big-bang theory generally, was an attempt to reconcile scientific cosmology with the Christian creation dogma. In a controversial address to the Pontifical Academy of 1951, pope Pius XII stated that modern physics and astronomy provided incontrovertible evidence for the existence of a transcendent creator.[20] According to the pope, there was no essential difference between the creation story in Genesis and modern cosmology, for the latter only confirmed what Christians had known all along. He came dangerously close to using big-bang cosmology as a scientific proof of God. Although the pope did not mention Lemaître by

[17] Kragh & Lambert, "The Context of Discovery." Possibly inspired by the *Fiat lux* in the opening lines of Genesis, in a paper of 1930 Lemaître speculated that light might have been the primordial stuff of the universe.

[18] On Lemaître and religion, see Lambert, *The Atom and the Universe*; Lambert "Religious Inferences," and chapters in Holder and Mitton, *Georges Lemaître*.

[19] Boodin, *A Cosmic Philosophy of* Religion; Whittaker, *Space and Spirit*.

[20] Pius XII, "The Proofs for the Existence of God"; Kragh, *Cosmology and Controversy*, 256-9.

name, he most likely had Lemaître's cosmology in mind. However, Lemaître did not share the pope's apologetic interpretation of physical cosmology, which he thought was fundamentally mistaken. At the time of the pope's address, Lemaître's fireworks theory had been substantially transformed into a much improved version primarily by the Russian-American nuclear physicist George Gamow. Whether in this new version or the original primeval-atom version, in 1948 a new and catchy name had been coined for it – the big bang.

In the 1930s a kind of big-bang theory completely different from Lemaître's was proposed by the British astrophysicist and cosmologist Edward Arthur Milne, professor of mathematics at the University of Oxford. Without taking into regard general relativity or curved space, Milne developed a world system according to which the universe was expanding, infinite in extent, and had originated in a space-point rather than in an extended object. Milne was convinced that the universe was created by a transcendent and omnipotent God, who therefore had to be part of scientific cosmology.[21] Although omnipotent, God was also a rational being who could not have created what Milne considered to be impossible or irrational. For example, he could not have created a law of gravitation different from Newton's. Nor could he have created a finite universe originating in a condensed material body, as in Lemaître's theory. Milne seriously believed that only his own world system was consistent with God's will and power. He developed his cosmo-theological ideas most fully in the posthumously published *Modern Cosmology and the Christian Idea of God*, an idiosyncratic work which was not appreciated by either theologians or scientists. Like Barnes in 1933, Milne offered his view of pluralism and how the souls of extraterrestrials might be saved. He suggested that the problem of interplanetary redemption might be solved by means of radio astronomy.

THE STEADY-STATE CHALLENGE

From about 1948 to 1965 the cosmological scene was dominated by a controversy between two very different theories of the universe.[22] Most astronomers agreed that the universe expanded in accordance with Einstein's dynamical field equations, implying that the average density of matter slowly decreased. However, the relativistic expanding universe did not imply a universe of finite age born in a big bang, a hypothesis which still around 1960 was widely considered speculative and for which there was no strong evidence. The steady-state theory proposed by Fred Hoyle, Thomas Gold, and Hermann Bondi in 1948 was radically different as it rested on the basic assumption that the large-scale features of the universe were independent of cosmic time. The steady-state universe was spatially flat and therefore infinite, and it was eternal both in the past and in the future. There was no entropic heat death in it. Moreover, since the mass density remained constant despite the universe being in a state of expansion, matter had to be created

[21] Urani & Gale, "E.A. Milne and the Origins of Modern Cosmology"; Kragh, *Matter and Spirit in the Universe*, 200-27.

[22] Kragh, *Cosmology and Controversy*, is a full account of the controversy.

continually throughout the universe. The constant rate of matter creation (about 10^{-43} g/s/cm^3) followed from the theory and so did the constant expansion rate.

The controversy between the two world pictures was primarily concerned with observations and theoretical predictions, but methodological and other philosophical arguments also played an important role. It was one of those rare episodes in the history of modern science in which philosophers intervened and at least some of the involved scientists listened to them. The steady-state theory was widely considered controversial, among other reasons because of its element of spontaneous matter creation which seemed to violate the fundamental law of energy conservation. This element was seen as provocative by many philosophers and scientists, and it was also of relevance from a religious perspective.

Religious issues rarely appeared in the scientific literature on cosmology, but they nonetheless played a considerable role in the controversy and especially in how it was perceived by the lay public. Hoyle's best-selling popular book from 1950, *The Nature of the Universe*, was based on a series of BBC broadcasts in which he coined the name "big bang" for the kind of theory he much disliked. Although he did not associate big-bang cosmology with theism, or steady-state cosmology with atheism, he presented religious belief as childish, superstitious, and anti-scientific. Only later in his career did he explicitly claim that big-bang cosmology was religious fundamentalism in scientific disguise. The three steady-state pioneers were atheists and either hostile or indifferent to organized religion (Bondi was an active member of the secular or atheist British Humanist Association). Although they were careful not to draw religious or antireligious conclusions from their studies of the universe, the steady-state theory caused concern in a large part of the British religious community, where many saw it as antagonistic to Christian faith. In the United States, there was no similar cosmology-religion debate.[23]

Did the steady-state theory really make God unnecessary? Theologians were quick to point out that an infinitely old universe was in no way incompatible with Christian belief, such as Saint Thomas had pointed out centuries ago. In *Christian Theology and Natural Science*, a book from 1956 written at the height of the cosmological controversy, the physics-trained priest and philosopher Eric Mascall argued that the question of a cosmic beginning was of little concern to Christian theology. He even suggested that the steady-state theory with its postulate of continual matter creation might be interpreted as support of the Christian notion of an ever-active God who was transcendent as well as immanent. Several later theologians have made the same point, namely that the old idea of *creatio continua* fits remarkably well with the classical steady-state theory of Hoyle and his allies.[24] In a sense, the theory was baptized.

There simply is no and was no one-to-one correspondence between views about cosmology and views about religion. This is illustrated by some of the relatively few scientists who in the period

[23] McConnell, "The BBC, the Victoria Institute, and the Theological Context."

[24] Grünbaum, "A New Critique of Theological Interpretations"; Kragh, *Matter and Spirit in the Universe*, 242-6; Mitton, *Fred Hoyle*, 133-9; McConnell, "The BBC, the Victoria Institute, and the Theological Context."

either supported the steady-state theory or expressed sympathy for it. Among them were the theoretical physicist William McCrea and the radio astronomer Bernard Lovell, who both were devoted Christians. Lovell's God was a constantly intervening universal being whose existence was in perfect harmony with continual creation of matter. With regard to the big-bang theory, some of its advocates (such as Lemaître and Haas) were Christians, while others were not. During the 1950s the theory's foremost supporter was Gamow, with whom the big bang was widely associated. Since his youth Gamow had been an agnostic or an atheist, and he disliked institutional religion.[25]

The rival cosmologies and their claimed religious associations became an issue in the ideological battlefield of the Cold War. In communist Russia finite-age cosmological models, and especially closed models of the big-bang type, were seen as politically suspect and contrary to the atheistic world view of Marxism-Leninism.[26] According to this world view with roots in nineteenth-century materialism, the universe was infinite in time, space, and content of matter. Theories of the kind defended by Lemaître and Gamow were accused of being apologies for divine creation, which made them unwelcome and politically incorrect. Perhaps strangely, the infinite and eternal steady-state universe was also unwelcome. What made the steady-state theory unpalatable to orthodox Marxists was its element of continual creation of matter.

THE STANDARD MODEL AND BEYOND

During the early 1960s observations from radio astronomy had already indicated that the steady-state theory was wrong, but not yet that the big-bang theory was right. The turn came in 1965 with the discovery of the cosmic microwave background and, slightly later, measurements of quasars and the abundance of helium in the universe. Based on these and other discoveries most physicists and astronomers agreed that the universe had started its expansion in a hot and dense big bang. Although rival cosmologies did not disappear, they were marginalized. Hoyle and collaborators developed new versions of the steady-state theory, and the Swedish physicist Hannes Alfvén suggested an alternative "plasma cosmology" which avoided the origin in a big bang. Although the alternatives of Hoyle and Alfvén were entirely different, they had in common that they pictured the now standard big-bang theory as doctrinaire and quasi-religious because of its presupposition of divine creation. According to Alfvén, a main reason for the popularity of the big bang was that it justified the Christian dogma of creation *ex nihilo*. Objections of this kind have survived to this day, but they play no role in scientific cosmology.

The standard big-bang theory as known about 1980 has proved to be viable, but of course it was not the end of the story. Over the next decades it was modified and extended in various ways, of which the early inflation phase, the existence of dark matter, and the accelerated expansion caused by dark energy were the most important. The current cosmological standard model or paradigm

[25] Harper, "George Gamow"; Kragh, *Cosmology and Controversy*.

[26] Kragh, "Science and Ideology."

is known as the ΛCDM theory, where CDM stands for cold dark matter and Λ refers to Einstein's cosmological constant generally thought to be responsible for the dark energy blowing up the universe. In addition, the last two decades have seen several proposals based on quantum gravity which question whether the big bang was the absolute beginning of the universe. According to some of these theories, the big bang is just one of an endless cycle of bangs and crunches, whereas "pre-big-bang" models relying on string theory picture our universe as emerging from the collapse of a previous eternal state. In none of the scenarios can one speak of a single cosmic creation in the temporal or theological sense.

The acceptance of the standard big-bang model did not mean an end to the discussion concerning cosmology and religion. Quite the contrary, theologians and philosophers took a stronger interest in cosmology in the final decades of the century, a field they discussed in specialist journals such as *Zygon* and *Science and Christian Belief*. At the same time the cosmology-theology issue began to appear frequently in conferences on science and religion with participants from physics, cosmology, theology, and philosophy, and sometimes also from history of science. Among the early conferences of this kind was one in Denver in 1974 and another in Oxford in 1979. They were followed by a conference on "Cosmos and Creation" held at the University of Surrey in 1982.[27]

Among the more speculative and much-discussed contributions to modern cosmology are the anthropic principle and the multiverse hypothesis. In 1973, the astrophysicist Brandon Carter had first articulated the cosmological anthropic principle, which in its simple form states that what we observe about the universe must be compatible with the existence of humans and other forms of advanced life. Carter's controversial principle exists in a variety of versions, which have in common that the era of life is claimed to be a privileged time in the history of the universe.[28] Some of the versions are teleological in nature and have been used to argue that the fine-tuned cosmic coincidences, which have made life possible, suggest a divinely designed universe. There is no agreement on this point, but to some, such as the Anglican priest and former theoretical physicist John Polkinghorne, the anthropic principle is additional evidence for theism. Generally, Carter's principle has revived interest in natural theology and the old design argument.

The multiverse is another novelty of relevance to the cosmology-religion debate. Although speculations about multiple worlds are old, the modern multiverse based on string physics and inflation theory became popular only at the turn of the century.[29] In its most radical version this class of theories leads to the existence of a huge number of causally separate universes characterized by different laws of physics and constants of nature. Understandably, multiverse theories are controversial not only for scientific and philosophical reasons, but also for theological

[27] Yourgrau & Breck, *Cosmology, History, and Theology*; Peacocke, *The Sciences and Theology*; Shallis, et. al., "Cosmos and Creation."

[28] Barrow & Tipler, *The Anthropic Cosmological Principle*.

[29] Carr, *Universe or Multiverse?;* Kragh, "Contemporary History of Cosmology."

reasons. The multiverse is generally seen as an alternative to Christian belief in a divinely created world, such as Christoph Schönborn, archbishop of Vienna, stated in 2005. However, neither in this case is there any simple correspondence between cosmological theory and religious faith. As argued by some theologians and Christian scientists, God could have simply chosen to create a multiverse rather than a universe.

CONCLUSION

Cosmology has been increasingly naturalized and its links to religion gradually weakened since the seventeenth century. Still, the claim of Stephen Hawking and others that modern cosmology has proved theism to be wrong or has made God wholly irrelevant is unwarranted.[30] The origin of the universe remains a concept of common concern to scientists and theologians, and so does the eschatological question of the end of everything, and the meaning of the apparent fine-tuning of the universe. The historical study of the cosmology-religion relationship does not provide answers to these questions, and it also does not result in a definite answer of how cosmology relates to religion. As pointed out by John Brooke and other historians, there is no single master-narrative which encapsulates the changing and locally dependent interactions between science and religion.[31] The same lesson holds good for the cosmology-religion relationship. Historically based suggestions are more often negative than positive. Thus, history of science offers no support for the view that progress in cosmology has either supported or undermined the theological claim of a divinely created universe.

BIBLIOGRAPHY

Barrow, John D., and Frank J. Tipler. *The Anthropic Cosmological Principle*. Cambridge: Cambridge University Press, 1986. (Link to IsisCB)

Boodin, John E. *God: A Cosmic Philosophy of Religion*. New York: Macmillan, 1934.

Bowler, Peter J. *Reconciling Science and Religion: The Debate in Early-Twentieth-Century Britain*. Chicago: University of Chicago Press, 2001. (Link to IsisCB)

Brooke, John H. *Science and Religion: Some Historical Perspectives*. Cambridge: Cambridge University Press, 1991. (Link to IsisCB)

Brooke, John H., and Geoffrey Cantor. *Reconstructing Nature: The Engagement of Science and Religion*. Edinburgh: T&T Clark, 1998. (Link to IsisCB)

Carr, Bernard, ed. *Universe or Multiverse?* Cambridge: Cambridge University Press, 2007.

[30] Hawking, *A Brief History of Time*. Of course, theologians disagreed that Hawking's cosmological model had made God superfluous (Russell, "Finite Creation Without a Beginning").

[31] Brooke, *Science and Religion*; Brooke & Cantor, *Reconstructing Nature*.

Craig, William L., and Quentin Smith. *Theism, Atheism, and Big Bang Cosmology*. Oxford: Oxford University Press, 1995. (Link to IsisCB)

Crowe, Michael J. *The Extraterrestrial Life Debate, 1750-1900*. Mineola: Dover Publications, 1999. (Link to IsisCB)

Dick, Steven J. *Plurality of Worlds: The Origin of the Extraterrestrial Life Debate from Democritus to Kant*. Cambridge: Cambridge University Press, 1982. (Link to IsisCB)

Dick, Steven J. *The Biological Universe: The Twentieth-Century Extraterrestrial Life Debate*. Cambridge: Cambridge University Press, 1996. (Link to IsisCB)

Gingerich, Owen. *God's Universe*. Cambridge, MA: Belknap Press, 2006. (Link to IsisCB)

Grant, Edward. *Science and Religion, 400 B.C. to A.D. 1550: From Aristotle to Copernicus*. Baltimore: Johns Hopkins University Press, 2004. (Link to IsisCB)

Grünbaum, Adolph. "A New Critique of Theological Interpretations of Physical Cosmology." *British Journal for Philosophy of* Science 51 (2000): 1-43. (Link to IsisCB)

Halvorsen, Hans, and Helge Kragh. "Theism and Physical Cosmology." In *The Routledge Companion to Theism*, edited by Charles Taliaferro, 241-255. London: Routledge, 2013. Revised version of 2017 in https://plato.stanford.edu/entries/cosmology-theology/.

Harper, Eamon. "George Gamow: Scientific Amateur and Polymath." *Physics in Perspective* 3, no.3 (2001): 335-372. (Link to IsisCB)

Harrison, Edward. "Newton and the Infinite Universe." *Physics Today* 39, no. 2 (1986): 24-32. (Link to IsisCB)

Hawking, Stephen W. *A Brief History of Time: From the Big Bang to Black Holes*. New York: Bantam Books, 1988. (Link to IsisCB)

Hetherington, Norriss S., ed. *Encyclopedia of Cosmology: Historical, Philosophical, and Scientific Foundations of Modern Cosmology*. New York: Garland Publishing, 1993. (Link to IsisCB)

Hiebert, Erwin. "The Uses and Abuses of Thermodynamics in Religion." *Daedalus* 95 (1966): 1046-1080.

Holder, Rodney D., and Simon Mitton, eds. *Georges Lemaître: Life, Science and Legacy*. Heidelberg: Springer 2012.

Jaki, Stanley. *Science and Creation: From Eternal Cycles to an Oscillating Universe*. Edinburgh: Scottish Academic Press, 1974. (Link to IsisCB)

Jaki, Stanley, 1979. "Das Gravitations-Paradoxon des Unendlichen Universums." *Sudhoffs Archiv* 63 (1979): 105-122. (Link to IsisCB)

Jastrow, Robert. *God and the Astronomers*. New York: W. W. Norton & Company, 1992. (Link to IsisCB)

Kragh, Helge. *Cosmology and Controversy: The Historical Development of Two Theories of the Universe*. Princeton: Princeton University Press, 1996. (Link to IsisCB)

Kragh, Helge. *Matter and Spirit in the Universe: Scientific and Religious Preludes to Modern Cosmology*. Singapore: Imperial College Press, 2004. (Link to IsisCB)

Kragh, Helge. "Cosmic Radioactivity and the Age of the Universe, 1900-1930." *Journal for the History of Astronomy* 38 (2007): 393-412. (Link to IsisCB)

Kragh, Helge. *Entropic Creation: Religious Contexts of Thermodynamics and Cosmology*. Aldershot: Ashgate, 2008. (Link to IsisCB)

Kragh, Helge. "Contemporary History of Cosmology and the Controversy over the Multiverse." *Annals of Science* 66 (2009): 529-551. (Link to IsisCB)

Kragh, Helge. "Science and Ideology: The Case of Cosmology in the Soviet Union, 1947-1963." *Acta Baltica Historiae et Philosophiae Scientiarum* 1 (2013): 35-58. (Link to IsisCB)

Kragh, Helge, and Dominique Lambert. "The Context of Discovery: Lemaître and the Origin of the Primeval-Atom Universe." *Annals of Science* 64 (2007): 445-470. (Link to IsisCB)

Lambert, Dominique. *The Atom and the Universe: The Life and Work of Georges Lemaître*. Cracow: Copernicus Center Press, 2015.

Lambert, Dominique. "Religious Interferences at the Origin of Cosmology? The Case of Georges Lemaître." *Forum* (Supplement to *Acta Philosophica*) 4 (2018): 149-168.

Lindberg, David C. *The Beginnings of Western Science*. Chicago: University of Chicago Press, 1992. (Link to IsisCB)

McConnell, Craig S. "Twentieth-Century Cosmology." In *Science and Religion: A Historical Introduction*, edited by Gary B. Ferngren, 314-321. Baltimore: Johns Hopkins University Press, 2002. (Link to IsisCB)

McConnell, Craig S. "The BBC, the Victoria Institute, and the Theological Context for the Big Bang – Steady State Debate." *Science and Christian Belief* 18 (2006): 151-168.

McMullin, Ernan. "Religion and Cosmology." In *Encyclopedia of Cosmology: Historical, Philosophical, and Scientific Foundations of Modern Cosmology*, edited by Norriss Hetherington, 579-595. New York, Garland Publishing, 1993. (Link to IsisCB)

McMullin, Ernan. "Indifference Principle and Anthropic Principle in Cosmology." *Studies in History and Philosophy of Science* 24 (1993): 359-389.

Mitton, Simon. *Fred Hoyle: A Life in Science*. London: Aurum Press, 2005. (Link to IsisCB)

Numbers, Ronald L. *Creation by Law: Laplace's Nebular Hypothesis in American Thought*. Seattle: University of Washington Press, 1977. (Link to IsisCB)

Peacocke, Arthur R., ed. *The Sciences and Theology in the Twentieth Century*. London: Oriel Press, 1982.

Pius XII. "The Proofs for the Existence of God in the Light of Modern Natural Science." https://www.papalencyclicals.net/pius12/p12exist.htm

Russell, Robert J. "Finite Creation Without a Beginning: The Doctrine of Creation in Relation to Big Bang and Quantum Cosmologies." In *Quantum Cosmology and the Laws of Nature: Scientific Perspectives on Divine Action*, edited by R. J. Russell, N. Murphy, and C. J. Isham, 291-326. Vatican City State: Vatican Observatory Publications, 1996.

Shallis, Michael, Bernard Carr, John Polkinghorne, and Stanley Jaki. "Cosmos and Creation." *Irish Astronomical Journal* 15 (1982): 223-62.

Stanley, Matthew. *Practical Mystic: Religion, Science, and A. S. Eddington*. Chicago: University of Chicago Press, 2007. (Link to IsisCB)

Urani, John, and George Gale. "E. A. Milne and the Origins of Modern Cosmology." In *The Attraction of Gravitation: New Studies in the History of General Relativity*, edited by J. Earman, M. Janssen, and J. D. Norton, 390-419. Boston: Birkhäuser, 1994. (Link to IsisCB)

Valente, Kenneth G. "A Finite Universe? Riemannian Geometry and the Modernist Theology of Ernest William Barnes." *British Journal for the History of Science* 38 (2005): 197-217.

Whittaker, Edmund. *Space and Spirit: Theories of the Universe and the Arguments for the Existence of God*. London: Thomas Nelson and Sons, 1946.

Wilkinson, David. *Science, Religion, and the Search for Extraterrestrial Intelligence*. Oxford: Oxford University Press, 2017.

Yourgrau, Wolfgang, and Allen D. Breck, eds. *Cosmology, History, and Theology*. New York: Plenum Press, 1977. (Link to IsisCB)