IBSU Scientific Journal, 5(1): 19-44, 2011
ISSN: 1512-3731 print / 2233-3002 online

"Repugnant," "Not Repugnant at All": How the Respective Epistemic Attitudes of Georges Lemaître and Sir Arthur Eddington Influenced How Each Approached the Idea of a Beginning of the Universe

Simon APPOLLONI

Abstract

This paper investigates how the different epistemic attitudes held by scientists George Lemaître and Sir Arthur Eddington decidedly influenced how they approached their research on cosmology. It demonstrates the degree to which epistemic attitudes matter in scientific research. Though both were Christian, a belief in God or in biblically inspired narratives does not explain satisfactorily why these two Christians remained at such opposite ends of thinking with regard to the idea of a beginning of a universe, especially considering Lemaître and Eddington each put forth his case in a scientific manner. This paper suggests that had both entered into a dialogue on each other's epistemic attitude, a more constructive dialogue might have ensued perhaps initiating a greater amount of cooperation. And while these findings might seem academic, today a growing number of academics, social and environmental ethicists, and activists are embracing the big-bang theory as "a new story of the cosmos" as a means to gaining a new sense of purpose and understanding of the place of the human species in the world. This suggests that the scientists who convey the story to us today are especially beholden to be sensitive to their own epistemic attitudes which may influence their scientific conclusions.

Keywords: *epistemology; science; religion*

JEL Classification Codes: *C99*

Simon Appolloni *is a Doctoral Candidate of Centre for the Study of Religion & Centre for Environment at University of Toronto, Canada, simon.appolloni@utoronto.ca*

Simon APPOLLONI

Introduction

In 1931, physicist Georges Lemaître publicized his hypothesis that the universe was expanding, not from a steady state, but from the explosion of a dense singularity, an idea which would eventually be referred to as the 'big bang' theory. What he was describing was truly remarkable: it was a point in the history of the universe when there was no previous time or, as Lemaître put it, "the day without yesterday" (Farrell, 2005).[1] Lemaître's hypothesis was considered by fellow scientists at the time as incredible and, in some cases – given Lemaître's standing as a Catholic priest – disingenuous for the mere suggestion his hypothesis carried: the creation of the universe. Of all the responses from scientists, that of Sir Arthur Eddington stands out above the rest as being quite curious: he found the idea "repugnant."

Lemaître, who maintained that the idea of a beginning to the universe was "not repugnant at all," tried many times to convince Eddington of this in the many years that followed, but to no avail. Eddington remained firm in his conviction until the day he died, despite the fact that the hypothesis was gaining credibility within the scientific community. That scientists fail to agree on matters such as this is not unusual. What is intriguing here is the passion with which both Eddington and Lemaître maintained their views as well as the choice of words used by Eddington.

If all this still does not seem odd, consider the fact that both men were scientists of top caliber in the field of physics, that Lemaître had been a student of Eddington, that both held a deeply Christian faith (Lemaître Catholic, Eddington Quaker) and that both claimed a restrictionist approach to science and religion, meaning both refused to extend religious considerations into his scientific work (and vice versa). What is more, Lemaître actually received some insight for the idea of a beginning of the universe from Eddington's own theory on entropy. And, according to a colleague of Lemaître and subsequent writer on his cosmology, Odon Godart, it was Eddington himself who steered Lemaître's thinking towards the use of quantum physics – the set of scientific principles describing the behavior of energy and matter on the atomic and subatomatic scale – which was fundamental to Lemaître forming his hypothesis (Godart and Heller, 1985). Why, then, was the hypothesis so repugnant to Eddington?

This paper is a response to this question and, by extension, to its corollary: why Lemaître found the notion so compelling. The lion's share of

authors that I have encountered who write on the subject – and with most of the literature concentrating on the arguably more legendary of the two, Lemaître – has focused on the fact that the men were deeply religious Christians and how this fact may or may not have influenced their scientific conclusions.[2] Often, whichever position the author might take, religion is employed more or less to denote a set of doctrines and beliefs found in the Bible or a metaphysical conviction of the existence of a supernatural being, God. Although I do not dispute the significance of this line of approach or deny that there is value to it, for my query it is too superficial.

A belief in God or in biblically inspired narratives does not explain satisfactorily why these two Christians, both scientists, remained at such opposite ends of thinking with regard to the idea of a beginning of a universe, especially considering Lemaître and Eddington each put forth his case in a scientific manner, a point supported by some of the authors writing on the subject. If such were the case, and each was therefore arguing from a 'scientific' perspective, then we would still find little in the way of a viable explanation why both men pursued their respective positions so passionately. This point has led me to conjecture that something deeper lies beneath their different positions.

If, therefore, we dig a bit deeper than the tenets of their religion, such as their faith in a creed or the supernatural, and look at the epistemic attitudes, those metaphysical values that underpin their reasoning processes as well as their respective religious beliefs, we find a convincing rationale why, on the one hand, Lemaître not only arrived at his hypothesis but found it compelling, while Eddington found it repugnant. As stated earlier, a minority of authors took on this approach, but chiefly in regard to Lemaître; if we apply this same approach to Eddington as well, we gain a surprising appreciation how each man was decidedly influenced by a particular epistemic attitude that provided a framework for generating, sustaining, and applying knowledge. These epistemic attitudes were derived metaphysically from the worldviews of their respective religions. These worldviews predisposed each scientist to take a certain stand on how much we can know and ought to know of the world: Lemaître by an epistemic optimism and Eddington by an epistemic reserve. The disparity in epistemic attitudes, I will show, made the world of difference on how each approached the idea of a beginning of the universe.

That I have chosen to examine two physicists working on questions

dealing with cosmology is not accidental. Biologist Ernst Mayr once said, "No greater revolution has occurred in the history of human thought than the radical shift from a fixed stable cosmology to a dynamic evolving ever-changing cosmogenesis" (Francoeur, 1970, p.x). Science historians Helge Kragh and Dominique Lambert (2007) aver that the big bang universe cosmology is generally considered to be one of the most important events in the history of cosmology ever, comparable with the Copernican revolution. Indeed, this revolution has had an impact on the collective worldview of society, and today the big bang universe cosmology serves as the foundational perspective of many academics, social and environmental ethicists, and activists, as they develop new understandings of what our role as humans might be in a world marred by tremendous social and environmental upheaval. In short, as my paper will show, the big bang universe cosmology matters and with science being arguably the most powerful vehicle to understand that universe, what scientists convey about it and how they represent it ought to matter as well.

Methodology

In order to address my questions and substantiate my claim, I have relied on a variety of sources, primary – where accessible – as well as secondary. The historical research carried out by Helge Kragh and Dominique Lambert is quite comprehensive and is helpful in understanding Lemaître's epistemic attitude while some of Eddington's own writings and the historical research on Eddington's Quaker roots carried out by Geoffrey Cantor and Matthew Stanley have proven most beneficial. I have gained much insight by incorporating papers written by scientists of the same period of time, as they provide unique perspectives and insights. My aim has been to connect the dots on a history that is not always clear. I shall begin with a brief explanation of Lemaître's hypothesis, as well as by providing the context in which he created it, as knowing the controversial nature surrounding this scientific revolution contributes to understanding the passion with which each scientist held his view. By necessity, then, we begin at the most crucial point in cosmological history: when Einstein was developing his theory of relativity.[3]

Investigating Einstein's calculations

For centuries the universe was believed to be a static construction. No one doubted this. Thus, it should not be surprising to learn that in 1914, when Einstein was working on his theory of relativity and found his equations were

portraying a universe that was anything but static, he purposefully – and was later to regret having done so – modified his equations to come up with a different calculation. To do this, Einstein inserted what he termed a 'cosmological constant', whose function was to account for the forces of gravity on time and space and, as Farrell appropriately puts it, "to keep the universe he grew up with" (2005, p. 31).[4]

Enter George Lemaître (1894-1966), a Belgian Catholic priest, physicist and astronomer, who, while studying for his doctorate in mathematics at the University of Louvain in the 1920s, became fascinated with Einstein's work (he was later to obtain his second doctorate in Physics at the Massachusetts Institute of Technology in 1929) (Lambert, 1999). It was also during this time, in 1923, that Lemaître became acquainted with the renowned astrophysicist Sir Arthur Eddington (1882 -1944) having spent a year in Cambridge under his tutelage. Investigating Einstein's calculations, Lemaître realized that something was not right about the insertion of the cosmological constant. He reasoned that if the universe were static then, given the force of gravity, all objects would congregate at the bottom of the largest dent in space and time, which was not the case. Why were these objects not pulled together into one conglomerate mass? Lemaître concluded that the universe had to be anything but static, and reasoned it must be expanding; what is more, all matter would stay separated as the expansion force was slightly exceeding the gravitational force. In 1927, Lemaître published his now famous paper, "Un Univers homogène de masse constante et de rayon croissant rendant compte de la vitesse radiale des nébuleuses extragalactiques," in an obscure Belgian Journal (Farrell, 2005 ; Kragh and Lambert, 2007; McCrea, 1984).[5]

That same year, at the Solvay Conference in Brussels, which Einstein also attended, Lemaître approached Einstein and communicated his conclusion that the universe was not static but expanding from a state of equilibrium as represented in Einstein's own model. Einstein dismissed his conclusion, purportedly saying, "Your calculations are correct, but your physics is abominable" (Lambert, 1999, p.104). It was not until 1930 that Lemaître's hypothesis became known to the broader scientific community (Godart and Heller,1985).[6] In the next year, Einstein, based on visual proof of an expanding universe from Edwin Hubble's findings through the telescope, relented and agreed with Lemaître that his calculations were indeed the right ones and, by

extension, his physics first-rate.[7] By this time, however, Lemaître was already working on his other, far more contentious hypothesis: the primeval atom, an undivided fragment which exploded, marking the beginning of the universe and, by extension, the beginning of time and space.

Lemaître arrived at this conclusion by adapting Eddington's model of the second law of thermodynamics. Eddington described entropy as "the measure of disorganization of a system," and this disorganization, which deals with the transfer of heat energy within a system, increases from past to future (Eddington, 1931; Kragh, 2004).[8] Lemaître read entropy to refer to increasing fragmentation, which means that the universe must be relentlessly and irreversibly dividing itself into smaller and smaller pieces. By simply going backwards in time, Lemaître reasoned, the universe would have had to start from a single entity, which he labeled the Primeval Atom (Deprit, 1984; Lambert, 1999; Peeble, 1984). Lemaître also reasoned that if the universe did expand from such a single and dense state, then we ought to be able to find some evidence of it, some debris from "fireworks" (Godart and Heller, 1985, p. 143; Lambert, 1999).[9] Lemaître made his hypothesis known in a letter to Nature in 1931. It was not until later that the term "big bang," was coined by physicist Fred Hoyle (Lambert, 2007, p.17; Kragh, 2004, p. 235).[10]

Eddington's reaction to the big bang hypothesis

The idea of a beginning of a universe was generally not well-received by the scientific community. Einstein himself did not like to speak about a beginning because of its metaphysical implications, saying it, "suggests too much the creation" (Kragh, 2004, p. 83). Fred Hoyle and William Bonnor, both cosmologists, suspecting the atom theory was inspired by Lemaître's religious faith, dismissed the hypothesis outright as a mere attempt to find concordance between his faith and his science (Kragh, 2004, p. 241-242). In short, until 1966, when Lemaître's hypothesis was finally empirically confirmed by the discovery of so-called microwave background radiation (the debris from the fireworks), Godart and Heller tell us that Lemaître had to bear the brunt of derisive joking behind his back, labeling him the 'big bang' man (1985, p. 142).

Although never derisive, Eddington nonetheless was firm in his aversion to the big bang hypothesis, despite Lemaître's insistence. By this time, Eddington, having obtained the post of Plumian Professor at Cambridge, had

already long-established his credentials as an experienced physicist. Of note was his work to confirm Einstein's general theory of relativity (Stanley, 2007). Eddington claimed, "As a scientist, I simply do not believe the universe began with a bang" (Eddington, 1958, p. 85). More importantly, in his 1931 address to the British Mathematical Association, he said, "Philosophically, the notion of a beginning of the present order of nature is repugnant for me" (Kragh, 2004, p. 105; Eddington, 1931).[11] The choice of wording is significant. Eddington could have meant to imply that the idea was merely inconsistent. But he also could have used the word to denote the idea as being so objectionable as to arouse disgust within him or to deserve condemnation, as both meanings are encompassed by this word.

In a supplement to *Nature*, Eddington (1931) addressed this question. Here, he seemed to imply that the idea is inconsistent, or certainly unpredictable. He reasoned that given the incredible improbability of there being a "fortuitous concourse of atoms" we are left with two conclusions, neither of which is acceptable to science: one is design, the other is blind chance. The first (which he preferred to call "anti-chance") is not the competency of science to know and the second, mathematically, could only come to be through infinite time, "during which the most improbable coincidence might occur," and hence, was equally unacceptable. In other words, neither way allows us to know.[12]

One might question why Eddington would find discussion of a beginning of the world repugnant while being open to discuss its end, evidence by his Supplement in *Nature* mentioned above. If we examine his argument of what the end of the world (universe) might look like, we notice that it is carried out from the standpoint of mathematical physics, and even then refers to probabilities and not certainties. His argument rests heavily on the second law of thermodynamics where entropy, as a measure of disorganization of the universe, stands as a "signpost" for time which is unidirectional (from greater to less organization). He reasons that ultimately the whole universe will reach a state of complete disorganization, "a uniform featureless mass in thermodynamic equilibrium." He concludes, "This is the end of the world. Time will *extend* on and on, presumably to infinity. But there will be no definable sense in which it can be said to *go* on." Eddington, therefore, recognizes an end of a direction in time by which point consciousness will have long-disappeared and, accordingly, stops his analysis there. Applying the same logic in the opposite direction – toward the

past, as Lemaître had done – he concludes that we do indeed find more and more organization in the universe and even find a time when all matter and energy had maximum possible organization. Once again, though, at this point Eddington stops short of making claims that cannot be supported by observation, underlining, "To go back further is impossible." In other words, while his former student, Lemaître, was prepared to aver that "the beginning of the world happened a little before the beginning of space and time" (Lambert, 1999, p. 112), Eddington can make no further claim on this, as we have come to "an abrupt end of space-time." Consequently, Eddington finds limits to what we can know with regard not only to the beginning but the end of the universe as well.

Dominique Lambert, a scientist himself, helps clarify why Eddington believed this. Lambert believes the reason why Eddington finds the notion of a beginning repugnant is because such a beginning of the world is far removed from our ordinary experience; as a result, we lack the wherewithal to perceive it. He states,

> Car ce qui est probablement 'répugnant' au [sic] yeux d'Eddington, c'est de tenter d'appliquer à un phénomène extrêmement éloigné de notre expérience usuelle, des catégories relevant de celle-ci (1999, p. 111).

There is indeed logic to this line of reasoning. In his book written in *The Philosophy of Physical Science*, Eddington (1939, p.10) underlines this argument: "For, knowledge which has not been or could not be obtained by observation is not admitted into physical science."[13] Lambert concludes from this that Eddington was guarding against the mixing of the epistemologies of science and religion: the former which describes nature, and the latter which expresses an interior (metaphysical) revelation (2007, p. 54). In his same work above (1938, p. 3), Eddington avers, "By defining the physical universe and the physical objects which constitute it as the theme of a specified body of knowledge, and not as things possessing a property of existence elusive of definition, we free the foundations of physics from suspicion of metaphysical contamination." In the same vein, in *Science and the Unseen World*, Eddington underlines that any reconciliation between science and religion, "must be carefully distinguished from any proposal to base religion on scientific discovery" (1929, p.72). He goes on to say, "The mystic accepts premises the scientists does not." By premises he means, "The vista of the world outside space and time that it reveals" (1929,

p.75).

There are grounds, therefore, for Lambert to claim, “Or, Eddington est un Quaker convaincu et à ce titre il ne peut en aucune manière mélanger ce qui relève de la description de la nature avec ce qui est manifesté par une révélation religieuse tour intérieure” (2007, p. 54). However, there appears more to Eddington's stance than the concern, albeit valid, over the difficulty of observing and explaining scientifically phenomenon far removed from our physical experience. After all, although Einstein did not like to speak about a beginning because of its metaphysical implications, as we noted earlier, he was nevertheless, according to Farrell, “willing to *entertain* [my emphasis] the possibility that the universe had a temporal beginning” (2005, p. 102).[14] Even philosopher and mathematician (and proclaimed atheist) Bertrand Russell, writing at the same time of Eddington, found the entropic reasoning behind there being a beginning to be logically sound, according to Helge Kragh. Russell states, “I think we ought provisionally to accept the hypothesis that the world had a beginning at some definite, though unknown, date” (Kragh, 2004, p. 112).[15] Moreover, as stated and as we shall see in more detail later, Lemaître adopted a restrictionist position that was similar to that of Eddington (Kragh, 2004, p. 143; Kragh and Lambert, 2007, p. 466). In an unpublished manuscript intended for a Japanese Catholic publication, Lemaître addressed the notion of creation in regards to his primeval atom hypothesis. He notes, “The question if it was really a beginning or rather a creation, something starting from nothing, is a philosophical question which cannot be settled by physical or astronomical considerations” (Kragh and Lambert, 2007, p. 467). It would seem that Lemaître too was keen to guard against the mixing of epistemologies. Yet, despite their apparent similarities in this regard, Lemaître and Eddington stood at two ends with regard to the big bang hypothesis.

Eddington's epistemic attitude

So what is it, then, that forced Eddington to find the notion of a beginning of the present order of nature repugnant? There is reason to suspect that there was something underpinning to Eddington's stance. It was something he said to Lemaître in their last conversation together on the ferryboat from Malmo to Copenhagen in 1938. Lemaître tried once more to overcome Eddington's hesitation toward the big bang hypothesis. He expected his mentor to comment that no scientific hypothesis is admissible unless it is confirmed by experiments

or observations; however, his actual response was rather curious. According to Lemaître, “Eddington in a somewhat confidential tone, declared that, to the contrary, 'he could not trust an experimental result unless it was confirmed by theory'” (Deprit, 1984, p. 380). It is not clear what Eddington meant by this and the source (physicist and contemporary of Lemaître, A. Deprit and, presumably, a reputable source), does not entertain any thoughts on what he thought this might mean. To what 'theory' might Eddington have been referring?

To answer this, I think we have to look beyond Eddington's philosophy of science. While not discounting some influence from his particular Christian belief, we have also to look at the epistemic attitude that undergirds it. As mentioned, Eddington was a Quaker, and although Quakers are Christians, they reject any ready-made religious creeds or dogma[16], emphasizing instead the presence of the Inner Light within each individual, a divine spark, which might best be understood as God's presence within (Kragh, 2004, p. 109; Cantor, 2005).[17] Antipathy to religious dogma, however, would only partially explain why Eddington found the big bang idea repugnant, since Lemaître did not present his hypothesis with religious undertones.[18]

What is more significant about Eddington's Quakerism is what it said about the limits to knowledge. In his Swarthmore Lecture, Eddington (1929),[19] insisted that Quakers should be seekers, not systematizers. While accepting that hypotheses are useful in science, he considered that they are merely temporary experiments on which the scientist should not rely too heavily. “Truth shines ahead as a beacon,” Eddington says, “We do not ask to attain it; it is better far that we be permitted to seek” (1929, p. 23).[20] One could conclude that Eddington even seems antagonistic toward any hermeneutic of certainty, as he states, “There is a big difference between 'sureness' in religion and 'cocksureness'” (1929, p. 91). The true spirit of getting to the truth, it would seem, lies in the constant pursuit of something forever elusive: “You will understand the true spirit neither of science nor of religion unless seeking is placed in the forefront” (1929, p. 88). Clearly, for Eddington, creeds and dogmas are anathema, as they are impediments to seeking truth: “Religious creeds are a great obstacle to any full sympathy between the outlook of the scientist and the outlook which religion is so often supposed to require” (1929, p. 88). He continues, “I would not go so far as to urge that no kind of defence of creeds is possible, but I think it may be said that Quakerism in dispensing with creeds holds out a hand to the scientist…the spirit

of seeking which animates us refuses to regard any kind of creed as its goal" (1929, p. 89). With the preceding in mind, we can safely conclude, as does Geoffrey Cantor, that for Eddington, "Empiricism was the scientific method of the humble Quaker who looked unflinchingly at God's creation; commitment to a speculative system of hypotheses implied dogmatism, arrogance, and an undue restriction on scientific activity" (2005, p. 238).

Cantor (2005) believes Eddington's gloss on Seekers reflected the prevalent Quaker attitude to knowledge acquisition at that time. If this is the case, then, science for Eddington, far from putting an end to mystery, merely reveals new depths which might fill the scientists with awe but not answers. Quakers like Eddington, Cantor concludes, "considered that no matter how far science advanced, God's creation remains ultimately mysterious and wonderful" (2005, p. 241).[21] While Eddington seeks truth as a scientist, like Lemaître (as we will see), as a Quaker, the pursuit of truth (in all aspects of life whether scientific or religious) will always remain just that, a pursuit, not a realization.

Matthew Stanley's (2007) own research on Eddington's Quaker roots seems to support this view. Stanley, however, focuses far more on Eddington's methodology and how it was based on a metaphysical "valence of values" that he carried with him from his Quaker faith.[22] Stanley examines Eddington's rather innovative scientific approach, which took on a "pragmatic, exploratory method that valued opening avenues of scientific investigation over any dogmatic reliance on mathematics and certain knowledge" (2007, p. 11), and concludes that – methodologically – Eddington thought of science much in the same way he thought of his religion: science was a continuing search for truth. Eddington believed scientists should not obsess over the absolute certainty of their physics but "instead work with a spirit of exploration that relied on physical intuition and observation" (2007, p. 11). Hence, much like Cantor concludes above, theoretical advances were the beginnings – never culminations – of scientific advances. In short, truth for Eddington was not something ultimate; instead it was a process. (2007, p. 73). Good science, to Eddington, was not looking for a final answer.[23]

With the above in mind, we can come to a clearer understanding why Eddington ultimately found the notion of a beginning of the universe as repugnant and what ultimately he meant by the term. The term is meant to be employed with both its meanings: as a Quaker, he found the idea that we could know the beginning of the universe and thus 'put an end to mystery' not only

inconsistent with scientific reasoning but also objectionable, lying somewhere on an epistemological continuum between 'sureness' and 'cocksureness.' This is redolent of dogma, which is anathema and, thus, arouses disgust within a Quaker. It is this spirit of continuous seeking, the 'theory' Eddington spoke of on the ferryboat, which accounts for Eddington's epistemic attitude of reserve, a stance of constraint toward any judgment that might entertain the belief that truth has been realized.

Lemaître's epistemic attitude

To fully understand Eddington's epistemic attitude, though, it will be helpful to contrast it with Lemaître's. Undoubtedly, as in the case of Eddington, other factors account for Lemaître generating his hypothesis (after all Lemaître was, in the end, correct). We should not discount his brilliance and ability to think 'outside the box'. We might cite Lemaître's comparative youth as playing a role in shaping his hypothesis. Lemaître, it is interesting to note, was the first cosmologist to learn his science within Einstein's world, while Eddington was of the Newtonian world.[24] But this idea does not entirely add up given Eddington's prodigious work on, and popularization of Einstein's theory of relativity (Stanley, 2007, pp. 153-193).

Both Kragh and Lambert examine the possibility that Lemaitre's primeval-atom hypothesis was theologically motivated. It is indeed plausible that Lemaitre, a Catholic priest and a member of the Pontifical Academy of Sciences, found resonance between creation accounts in the Bible and his hypothesis. But Kragh and Lambert correctly find the claim unfounded (2007, p. 466).[25] Much earlier in 1926, for instance, Lemaître gave a talk to a Catholic congress in Malines where he emphasized that “The activity of divine omnipresence is everywhere essentially hidden. It can never be a question of reducing the supreme Being to the rank of a scientific hypotheses” (Kragh, 2004, p. 145). While religious considerations were not completely outside Lemaître's thinking, Kragh and Lambert conclude, correctly, I think, “they did not motivate his cosmological ideas in any direct way” (2007, p. 466).

Perhaps it might be more helpful to point to Lemaître's penchant for quantum research as playing a role, as do Godart and Heller (1985).[26] Indeed, Lemaître's primeval atom was from the very beginning, “tightly bound up with quantum considerations” (1985, p. 105). Thus, “Lemaître was one of the first scientists who noticed that quantum principles could drastically change the

scenario of the very evolution of the universe" (1985, p. 106). The indeterminacy principle within quantum mechanics opened new vistas for cosmology: it allowed one to conjecture that from the big bang, widely different universes can evolve. In a letter May 9, 1931 to *Nature*, he addresses this quantum reality and uses it to explain why his hypothesis is not repugnant at all. It is worth repeating in part here:

> Sir Arthur Eddington states that, philosophically, the notion of a beginning of the present order of Nature is repugnant to him. I would rather be inclined to think that the present state of quantum theory suggests a beginning of the world very different from the present Nature.
>
> Thermodynamical principles from the point of view of quantum theory may be stated as follows: (1) Energy of constant total amount is distributed in discrete quanta. (2) The number of discrete quanta is ever increasing. If we go back in the course of time we must find fewer and fewer quanta, until we find all the energy of the universe packed in a few or even a unique quantum […] If the world has begun with a single quantum, the notions of space and time would altogether fail to have any meaning at the beginning; they would only begin to have a sensible meaning when the original quantum had been divided into a sufficient number of quanta. If this suggestion is correct, the beginning of the world happened a little before the beginning of space and time. I think that such a beginning of the world is far enough from the present order of Nature to be not repugnant at all (Lemaître, 1931).

The notion of quantum indeterminacy certainly allowed Lemaître to posit the existence of the initial quantum, or dense singularity, without having to conclude that within it was a programmed, ready-made universe, only the potential for one. In the same letter above, Lemaître puts it another way: "[T]he whole story of the world need not have been written down in the first quantum like a song on a disc of a phonograph. The whole matter of the world must have been present at the beginning, but the story it has to tell may be written step by

step." Notwithstanding the above, we must remember that Eddington also followed the same principle of quantum indeterminacy. Moreover, as we learned earlier, it was he who steered Lemaître's thinking towards the use of quantum physics. Why then was Lemaître more inclined to see that a beginning of the world could be very different from the 'present order of nature', using the principle of indeterminacy recognized by his mentor?

In what amounts to a process of elimination, we arrive at Lemaître's epistemic attitude, one quite opposite to that of Eddington, in order to account for his finding the notion of a beginning compelling. Alfonso Pérez de Laborda of the Catholic University of Louvain writes about this. Pérez de Laborda (1996) argues that it was Lemaître's Catholic belief of the human being, made in the image and likeness of God, which allowed him to conclude that the universe *must* be comprehensible to the human mind. With this 'likeness', we can comprehend the secrets of the world. This is not a knowledge *a priori*. It has to be worked out and confirmed through proof and verifications. What is *a priori*, however, is the fact that we can know. We find confirmation of this idea in *Lemaître's L'hypothèse de l'atome primitive* written in 1929:

> Il n'est guère possible de terminer la revue rapide que nous avons faite ensemble de l'objet de plus grandiose qui puisse tenter le génie de l'homme, sans nous sentir fiers de Vérité et sans exprimer aussi notre gratitude envers Celui qui a dit 'Je suis la Verité,' qui nous a donné l'intelligence pour Le connaître et pour lire un reflet de Sa gloire dans notre univers qu'il a si merveilleusement adapté aux facultés de connaître dont Il nous a doués (Pérez de Laborda, 1996, p. 125).

Referring to this passage above, Pérez de Laborda believes, "Il n'y a pas doute que cela soit ainsi, car notre faculté de connaître – notre intelligence – a été parfaitement adaptée (par son Créateur) pour lire ce qui est écrit dans ce livre [here, Pérez de Laborda is referring to creation]. La lecture que nous faisons ainsi est ce que l'on appelle Science" (1996, p. 126). Lemaître's cosmology, Pérez de Laborda concludes, comes out of a belief that ostensibly states that there will be a day when there will be no more mysteries. We find this idea reasserted by Lemaître at a conference at the Catholic Institute in Paris. He says:

> […] I hope I have illustrated that the universe is not beyond human possibilities. It is like Eden, the garden which had been placed at the disposal of man so that

> he could cultivate it and explore it. The universe is not too large for man; it exceeds neither the possibilities of man no (sic) the capacity of the human spirit (Godart and Heller, 1985, p. 167).

Lambert affirms Pérez de Laborda's conclusion and helps clarify Lemaître's epistemic attitude as being one of a healthy optimism:

> [un] 'sain optimisme' qui permet de motiver l'effort soutenu qu'implique toute recherche scientifique véritable. Cet 'optimisme' est lié au fait que 'le croyant a peut-être l'avantage de savoir que […] le problème de la nature a été posé être résolu et que sa difficulté est sans doute proportionnée à la capacité présente ou à venir de l'humanité (1996, p. 85).

Lemaître's belief that 'problems are posed to be solved' is supported by Godart and Heller (1985, p. 178), who point to a talk Lemaître gave at the Congrès de Malines (at an unidentified date) where Lemaître spoke about the believer having "an advantage of knowing that the riddle [evolution] possesses a solution."

The view that the universe is not beyond human possibilities or comprehension is why Lemaître, while not dismissing the possibility of the universe being infinite, nonetheless found the idea unconvincing. Both his model of 1927 and his big-bang universe of 1931 were spatially closed, a choice, according to Helge Kragh, which was not observationally, but epistemically based" (2004, p. 139). Simply put, if he affirmed the possibility of an infinite space populated with infinite amount of objects, the universe could no longer be comprehensible to the human mind. Such a concept would run counter to Lemaître's 'sain optimisme'. Kragh refers to a presentation given in the 1950s where Lemaître even spoke of "the nightmare of infinite space."[27]

Conclusion

Lemaître's epistemic attitude that held there will be a day when there will be no more mysteries, contrasts starkly with Eddington's science as a continuing search for truth for which there were no final answers. That both scientists were decidedly influenced by a particular epistemic attitude or worldview that conceived how much we, as humans, can know of the world is

clear: Lemaître by an epistemic optimism and Eddington by an epistemic reserve. This disparity in epistemic attitudes influenced how each approached the idea of a beginning of the universe and caused each to take opposite and passionate positions on the notion of a beginning to the universe. Undoubtedly, other factors played a limited role, such as the youthfulness of Lemaître and his proclivity to quantum physics. And although theological concerns may have played some role in motivating his scientific understandings – notwithstanding Lemaître's protestations of following a restrictionist agenda – it is not the whole story. We can take a lesson from this account: epistemic attitudes in scientific research matter; they affect the way scientists approach the world and their understanding of the universe.

While this conclusion might seem academic, consider a popular belief embraced by many scholars today, here expressed aptly by philosopher and Buddhist scholar David Loy: science is "the most powerful alternative explanation of the world" (Loy, 2003, p. 67). Physicist Nigel Calder underlines that science is "the most powerful engine ever conceived for the advancement of knowledge" (1977, p. 14), and evolution biologist Elizabet Sahtouris maintains that scientists have been given the role of "official priesthood" (2002, p. 72). Indeed, physicist Fritjoff Capra argues that science, and not a new mysticism, will prove to be more effective in helping us change our worldviews. He goes on to say, "In a culture dominated by science, it will be much easier to convince our social institutions that fundamental changes are necessary if we can give our arguments a scientific basis" (1982, p. 48).[28] Notwithstanding potential arguments citing hyperbole, I think we can nonetheless make a case that the statements above adequately reflect a prominent worldview in Western society today.

If science has acquired tremendous authority in explaining our world, then, the narrative history of the universe is increasingly becoming the most powerful mythos for our time, argues Astronomer Emeritus at the Adler Planetarium and Astronomical Museum in Chicago, Eric Carlson. Indeed a growing number of academics (from the physical and social sciences and humanities), social and environmental ethicists, activists, see this "new story of the cosmos" as providing a new sense of purpose and place to the human species. Referring to this new Mythos or Cosmic Story, Carlson believes we are "the fortunate first generation to experience a new kind of cosmic story that

provides an exhilarating new sense of being at home in the Universe – one that is not 'just sitting there'- it is doing something!" (2002, p. 5). That something, he later concludes – referring to our present environmental and social global problems – is a "new and vital perspective that grants dignity and meaning to our struggle – and gives strength to our determination" (p. 20). Indeed, what provides Carlson a sense of exhilaration is the concept of human consciousness as a process of evolution. He states,

> I sometimes like to think of the Cosmic Story as a cosmic history book – a book of 14,000 pages so far; each page carrying a record of one million years. *Homo sapiens* appears only in the last two lines of this book. Our just finished millennium fits in the space of a single letter…Far from dwarfing our significance, these perspectives are uplifting me. I feel enthralled that the human consciousness could arise at all, much less in such an incredibly short cosmic time (p. 20).

Carlson's conclusion demonstrates the importance of cosmology today, as it underlines what many pundits (scientists and non-scientists) are also saying: "From the Big-Bang – this?" (p. 21).

What are we to make of this rising authority of the scientist and the provocative mythos that is surrounding cosmology? Cosmologist Brian Swimme and geologian Thomas Berry have been arguably the most influential people to popularize this new story (Swimme and Berry, 1992).[29] Their writings and talks have instilled awe in countless enthusiasts and instigating countless educational undertakings throughout North America. Both authors believe the new story can unite all humanity. At a gathering of the Parliament of the World's Religions in 1999, for instance, scientists and scholars of religion used the "Universe Story" as one of the main themes of discussion.[30] A documentary film about the nature of the universe produced and co-written by Swimme and Yale Divinity School Senior Lecturer Mary Evelyn Tucker premiered in spring 2011 and has been presented in colleges and universities throughout the United States.[31]

Godart and Heller seemed to have intuited much earlier the impact the big bang theory might have on humans. They write that by its very nature "cosmology induces questions about the limits of physical sciences touching upon epistemology, metaphysics…" (1985, p. 160). Notwithstanding the merits of such an appropriation of the big-bang cosmology as mythic story, the fact

remains: our understanding of the science in cosmology and our attitude toward it are supporting and – at this moment in time at least – maintaining particular ethical visions of the future (Carroll and Warner, 1998). Because of its import, I suggest, the scientists who convey 'the story' to us are especially beholden to be sensitive to their own epistemic attitudes which may or may not influence their scientific conclusions. And it is not just scientists; should not those relying on their work also be cognizant of the challenges and opportunities epistemic attitudes present to us?

Much energy was spent over many years by our two scientists in defending their respective positions on the then big-bang hypothesis. Would the history of science have been different had either scientist had a different epistemic attitude? Had they been more up-front about their respective epistemic attitudes (presuming they themselves were aware of them), would the science of cosmology have advanced sooner? One could make a case and answer yes to both questions, though it would be difficult to say in what way or manner things would be different. More importantly, given the import that the science of the big-bang theory is having, we are prudent to ask, Would there have been less energy wasted and more understanding and hence greater cooperation between Lemaître and Eddington regarding Lemaître's hypothesis, had both entered into a dialogue on each other's epistemic attitude? One could make a case and answer yes to this question too.[32] And I suggest this is the main lesson we can take from their disagreement.

On a final note, are the metaphysical values we unearthed an issue solely for scientists who are religious? I would argue no. Astronomer, astrophysicist and author Carl Sagan (1997), maintains:

> For myself, I like a universe that includes much that is unknown and, at the same time, much that is knowable. A universe in which everything is known would be static and dull, as boring as the heaven of some weak-minded theologians. A universe that is unknowable is no fit place for a thinking being. The ideal universe for us is one very much like the universe we inhabit. And I would guess that this is not really much a coincidence.

Sagan, not a religious man, reveals an epistemic attitude which seems to lie somewhere in between those of Eddington and Lemaître (arguably closer to

the former), and it is based on a worldview that is no less metaphysically attained.

Notes

[1] According to Farrell, "Lemaître is clearly here grappling with the origin of all things – including space and time – from an initial quantum state. He would later refer to this ultimate origin in his 1950 collection of essays, *The Primeval Atom*, as 'the now without a yesterday,' which has been translated as 'the day without yesterday,' a quote often associated with Lemaître's letter to Nature" (p.108).

[2] I note here a sampling of authors of different academic backgrounds specifically to make a point: the assignment of religious influence on scientific research is sometimes presented without deep analysis or only casually suggested. For example, Barry Parker (1986), *Einstein's Universe: The Search for a Unified Theory of the Universe*, New York: Plenum Press, 147, states,

> Eddington preferred to believe that the universe was originally in an Einstein state, i.e.: static, when suddenly something disrupted it and it began to expand. This gets around both the problem of a beginning and a dense primordial state. But Lemaître, perhaps because he was a priest, and the Church preferred a beginning to the universe, was fascinated by the possibility of a dense origin.

Most are more thoughtful, but not as rigorous in their analyses. Two I have already mentioned: Farrell's chapter "Cathedrals in Space," 2005, p.191-213; Godart and Heller, 1985, p. 141, 169, 171; Don O'Leary (2006), *Roman Catholicism and Modern Science: A History*, New York: Continuum Publishing, 165; Peter E. Hodgen (2005), *Theology and Modern Physics*, Aldershot, England: Ashgate Publishing Limited,192, states, "Although some Christians have indeed used the big bang theory as evidence for creation, others have been more cautious, notably the originator of the theory, the Belgian Abbé Lemaître."

[3] I take my cue here from Peeble (1984), who avers that modern cosmology can be traced to Einstein's theory of general relativity.

[4] We must recall that to scientists at the time, the universe was not expanding but static and, as Godart and Heller (1985, p. 49) point out, "the transition to the new cosmological paradigm was not easy."

[5] Farrell brings up the question why he published in such an obscure journal, unable to provide a convincing answer himself. Given it meant that Lemaitre's hypothesis would not be known for 3 more years, it was certainly not a shrewd idea. Also, it should be mentioned – though it is not necessary for my argument here – that Russian mathematician Alexander Friedman had come to a similar conclusion of the universe expanding, based on a reinterpretation of Einstein's calculations and he published his findings in 1922. Friedman had communicated with Einstein about this and Einstein

dismissed his notions as incorrect, really unwilling to open the debate. Friedman died in 1925 and according to many sources, Lemaître was unaware of his work when he came to his own conclusions. Kragh and Lambert (2007) add that Friedman's conclusion was based only on pure mathematical grounds and not on observation of the redshifts of the spiral nebulae, as was Lemaître's, although these must have been known to the former.

[6] Another curious incident is worth mentioning here. When Lemaître sent his paper to the journal in 1927, he also sent a copy to his mentor, Eddington. Lemaître received no response. According to Farrell (2005) and supported by Godart and Heller (1985), George McVittie, a former pupil of Eddington, recalled that Eddington confessed later that he had seen the paper but had completely forgotten about it. Eddington, together with G. C, McVittie, had begun their own work on the problem of stability of Einstein's static world model. According to Godart and Heller, Eddington and McVittie believed the problems they encountered would be overcome with an expanding model. It was in 1930 that Lemaître heard about Eddington's efforts and immediately sent a note to his mentor (along with another copy of his paper) informing him that he had already solved this problem. Any attribution of mal-intent on Eddington's behalf does not match the evidence: once this oversight was made known to Eddington by Lemaître, Eddington went out of his way to let the scientific community know of Lemaître's work and to ensure Lemaitre received the credit. Furthermore, Eddington was always supportive of his former student, even helping him get his teaching position at the l'Université catholique de Louvain.

[7] Here again, we have somewhat of a mystery on how it was that Einstein and Hubble came together, forcing Einstein subsequently, to change his mind. According to one source, albeit not a scholarly one, David Filkin (1997), *Stephen Hawking's Universe: The Cosmos Explained*, London: BBC Books, 86 (also found – and more dramatically portrayed – on a video, "Stephen Hawking's Universe" [online, accessed April 14, 2010, available from World Wide Web: http://www.youtube.com/watch?v=Rc2hNHjC84Q&NR=1]), it was Lemaître who took the concerted effort to bring Einstein and Hubble together, along with himself, in California so that Einstein could see through his own eyes that Lemaitre's calculations were correct. Unfortunately, there is no citation for this assertion, in either Filkin's book or the video, despite the unambiguous claim. Although one might presume this information to be credible, as it ultimately comes from Stephen Hawking, none of the other authors investigated mentioned this interesting and important encounter. In particular, the sources, Lambert, Farrell, Godart and Heller, whose works were particularly detailed as well as the only ones [which I could get a hold of] cited as being credible sources on Lemaître, according to the website [online] of the Département de physique de l'Université catholique de Louvain's [accessed April, 2, 2010, available from World Wide Web: http://www.uclouvain.be/en-204119.html#livres], fail to mention this encounter. Does it matter whether it was Lemaître who prodded Einstein to meet with Hubble or whether Einstein merely came across Hubble's findings without Lemaître's pressing? I think it does, as it would show just how deep Einstein's conviction was to 'stay with the universe he grew up with' as well as demonstrate Lemaître's own resolve to get his unique vision across in an all too skeptical scientific culture. For, in the Filkin-Hawking

interpretation, Lemaître is clearly the main architect of Einstein's change in spirit.

[8] Eddington adds that the increase in entropy is the only trace that we can find of a one-way direction of time; however, he did not make use of the entropic argument to infer a beginning of the universe.

[9] These 'fireworks', of course, subsequently became known to us as cosmic microwave background radiation; in 1965, scientists confirmed the presence of this radiation which, in turn, confirmed Lemaitre's intuition. Lemaître was made aware of this discovery by Godart himself a week before his death in 1966. Lemaître was delighted by the news.

[10] Hoyle employed the term derisively, though. He found the big bang cosmology to be akin to religious fundamentalism. Lambert tells is that this mocking of Lemaître's idea did not prevent the two men from having a friendly relationship.

[11] Helge Kragh tells us Eddington never accepted the idea "and may have continued to find it 'repugnant' until his death. His contempt for such a notion was not entirely new; Eddington announced a similar verdict in 1927 where he criticized any suggestion of there being an initial organization of the world and consequently an organizer (God).

[12] For this reason, he also referred to the idea as "untenable."

[13] Within the book Eddington presents a now famous analogy of an ichthyologist casting a net to demonstrate the limitations of knowledge through observation. After casting a net with two-inch wide holes, the ichthyologist concludes that within the sea there must exist no creature less than two inches long and that all sea creatures have gills: "the catch stands for the body of knowledge which constitutes physical science, and the net for the sensory and intellectual equipment which we use in obtaining it. The casting of the net corresponds to observation; for knowledge which has not been or could not be obtained by observation is not admitted into physical science" (p. 16).

[14] See also Godart and Heller (1985, p. 95), which supports Farrell's claim. Farrell goes on to say Einstein had enough philosophical grounding to realize that "an origin of space-time was not the same thing as creation of the world out of nothing, a concept he appreciated was intrinsically outside scientific bounds" (p. 102).

[15] To be sure, Russell did not infer from this that the world therefore was made by a creator.

[16] Dogma here is understood pejoratively by Quakers as any once-and-for-all truth claim.

[17] Kragh believes these stances might explain why a disproportionate number of eminent scientists have been Quakers in the past. According to Geoffrey Cantor, specialist in the history of science and religion, this stance explains why some Quakers have expressed antipathy towards everyday authority, especially the authority wielded by established churches and exercised through its clergy like the Catholic church: "Quakers repeatedly sought to undermine these religious authorities, which they portrayed as corrupt (p. 239).

[18] Godart and Heller (1985) are emphatic about this; they cite Lemaître's crossing out a passage in his own hand at the end of the transcript announcing his hypothesis to Nature, as evidence of his restrictionist attitude. The passage read: "I think that everyone who believes in a supreme being supporting every being and every acting, believes also that

God is essentially hidden and may be glad to see how present physics provides a veil hiding the creation" (p. 73). Godart and Heller conclude, "Lemaître's handling of this paragraph reflected his conviction that religious beliefs ought not interfere with scientific work. For the method of science, God is 'essentially hidden'" (p. 73).

[19] Subsequently published in book form.

[20] Quaker and physician Thomas Hancock, whose writings influenced Eddington, wrote in 1824 in his now famous *Essay in Instinct* about such limits to knowledge. Hancock asserted that we should "follow the plain and simple path of observation, which may lead to profitable results…[but we should] avoid the giddy heights of speculation, where the mind is too much disposed to look down upon the laborious inquirer, and indulge in vain conceits of superior intelligence" (Cantor, 2005, p. 238).

[21] Recall, as Lambert argued earlier, science and religion for Eddington belong to two different realms. According to Eddington, it is wrong to compare the two ways of knowing. The knowledge of the unseen world is "unable to follow the lines of deduction laid down by science as appropriate to the seen world" (Eddington, 1929, p. 75).

[22] Stanley, as historian of science, having an MA in astronomy from Harvard University, places much emphasis on Eddington's methodology. He cites a case where Eddington began his work on stellar structure but deviated from the norm in mathematical practices of defending his assumptions and only then proceeding: "Instead, he skillfully and rapidly moved beyond what he could prove and simply attempted to advance the theory. The uncertainty of his foundations was justified at the end of his work…" (p. 53). He concludes, Eddington's methodology allowed him "to provide greater understanding and enable further investigation..."; it did not serve to demonstrate its deductive relationship to established facts. Stanley underlines that, at least in regard to his work on stellar structures, his method worked (p. 59).

[23] The reader at this point might consider such a claim surprising given Eddington's *Fundamental Theory* which, according to Philosopher Stanley Jaki, was "possibly the most ambitious ever offered in the history of science"(Jaki, 1967). Indeed, that he created such a theory would appear to contradict his claims to continuous seeking. Matthew Stanley recognizes this problematic. He suggests that while Quaker values of continuous seeking for truth interact with his values in science, evidently, at times this was not the case. As Stanley admits, Eddington's *Fundamental Theory*, unlike the seeking approach – which characterized his methodology in his stellar models – was relentlessly deductive, requiring "completeness from it in a way he never did from his astrophysical theories" (p. 238). Stanley explains that in his own terminology, Eddington was acting like an inflexible mathematician, not an exploratory physicist. Stanley stops short of providing any definitive answer to why this apparent change in approach is so, however. According to Noel B. Slater (1957) who worked on compiling, collating and arranging supplementary material on the *Fundamental Theory*, Eddington did not set out to formulate new general equations, but to synthesize (albeit with grand intentions) already existing theories. Further, in the introduction to Slater's book, it is mentioned that it was Sir Edmund Whittaker who supervised the book's publishing and it was he who gave it the discernibly grand title it now has. Moreover, Eddington's *Fundamental Theory* was

published posthumously (Cambridge: Cambridge University Press, 1948) and it is not clear whether he ever considered the book to be finished, according to Stanley. While Stanley avoids drawing any final conclusions on this problematic, his own findings on Eddington's valence of values do offer a possible clue for Eddington's ambitious endeavor, though Stanley himself does not make this connection. Stanley avers that the spirit of seeking found in Quakerism meant that the scientist too could "take unprecedented and sometimes unwarranted leaps so long as they moved his science forward" (2007, p. 49). If such were the case, could not this pragmatic element also found within Eddington's valance of values, have made him take the 'unprecedented and sometimes unwarranted leap' into formulating a fundamental theory, if he believed it would 'move his science forward'? To argue definitively Eddington's intensions here, however, will at best just amount to conjecture. I maintain that Eddington's *Fundamental Theory* does not negate the overwhelming value he placed on continuous seeking found in so many of his other publications. Unfortunately, definitive answers to this problematic might remain difficult to obtain, according to Stanley, as the material Eddington left behind is fragmentary and sometimes confusing. Moreover, there was a mysterious destruction of his personal papers in 1944 and circumstances surrounding the destruction are not clear. In short, documents surrounding Eddington's personal life are now virtually inaccessible (2007, p. 289).

[24] For instance, Farrell (2005, p. 188), conjectures that, "Lemaître was free to play with relativistic field equations in a way that alerted him to possibilities that were not obvious to his mentors."

[25] Another interesting account can be mentioned here: in 1951, Pope Pius XII created a stir and made Lemaître's restrictionist protestations seem rather insincere to the scientific community when the pope delivered a speech entitled, *Un'ora di serena* to cardinals, representatives of foreign nations and members of the Pontifical Academy of Sciences (to which Lemaître belonged), expressing his view that the scientific evidence of an expanding universe from a singularity offered "virtual proof" substantiating the creation story in the Book of Genesis, stating: "Indeed, it would seem that present day science, with one sweep back across the centuries, has succeeded in bearing witness to the august instant of the Fiat Lux, when, along with matter, there burst forth from nothing a sea of light and radiation, and the elements split and churned and formed into millions of galaxies" (Farrell, 2005, p. 196). Lemaître would never have announced this and was horrified at the pope's indiscretion.

[26] Farrell also underlines this idea, noting, "His primeval atom hypothesis marks the first time that a physicist directly tied the notion of the origin of the cosmos or quantum processes" (2005, p. 106).

[27] One might even venture to say that for Lemaître, it was the idea of an infinite universe that was truly repugnant. By way of support to my claim, the reader can consult the work of physicist, philosopher and Catholic priest, Stanley Jaki (2002, p. 169), where he presents a Thomist take on why "an actually existing universe has to be finite," a epistemic attitude not unlike that of Lemaître, also a Catholic.

[28] The point here is not to convince the reader that this is a right or wrong view, but only to

underline its prevalence amongst many scientists, social scientists and scholars in the humanities. And because of its power to determine our perceptions of reality, perceived or real, many, especially those dealing with issues in ecology, are concerned with how we view and receive science (Carroll and Warner, 1998).

[29] Thomas Berry is perhaps the most important person to articulate this new story as a mythos. A simple Google search with the words, "Thomas Berry new story" will show 4,350,000 results in many categories: religious, spiritual, scientific, academic course listings, eco-initiatives and countless papers.

[30] Clifford N. Matthews, Mary Evelyn Tucker and Philip Hefner eds. (2002), *When Worlds Converge: What Science and Religion Tell Us about the Story of the Universe and Our Place in It*, Chicago: Open Court Publishing Company. Many authors writing on the subject in the last two decades have focused on the evolutionary aspects of science and have made a connection with religion: for instance, John F. Haught (2008), *God after Darwin: A Theology of Evolution*, Philadelphia: Westview Press. How each envisions the relationship of religion and science ought to unfold, however, differs. Such a variety of perspectives can be found in the important volume Dieter T. Hessel and Rosemary Radford Ruether eds. (2000), *Christianity and Ecology: Seeking the Well-Being of Earth and Humans*, Cambridge, Massachusetts: Harvard University Center for the Study of World Religions.

[31] The reader can consult Brian Swimme's webpage [accessed 21 April 2011, available from World Wide Web: http://www.brianswimme.org/index.asp].

[32] To be sure, I have no knowledge whether such a conversation occurred; but doubt that it did.

References

Calder, Nigel (1977), *The Key to the Universe: A Report on the New Physics*, London: British Broadcasting Corp.

Cantor, Geoffrey (2005), *Quakers, Jews, and Science: Religious Responses to Modernity and the Sciences in Britain, 1650-1900*, Oxford: Oxford University Press

Carlson, Eric (2002), "The New Story of the Cosmos," *When Worlds Converge: What Science and Religion Tell Us about the Story of the Universe and Our Place in it*, Clifford N. Matthews, Mary Evelyn Tucker and Philip Hefner eds., Chicago Il: Open Court 2002, 3-21

Carroll, John E. and Keith Warner, OFM, eds. (1998), *Ecology and Religion: Scientists Speak*, Quincy, Il: Franciscan Press

Deprit, Andre (1984), "Monsignor Georges Lemaître," *The Big Bang and George Lemaître*, A. Berger ed., Boston: D. Reidel Publishing Company, 363-392

Eddington, Sir Arthur (1929), *Science and the Unseen World*, New York: The MacMillan Company

____ (1931), "The End of the World: From the Standpoint of Mathematical Physics," *Nature* 127: 3203, 447-453

____ (1938), *The Philosophy of Physical Science*, London: Cambridge University Press

Farrell, John (2005), *The Day Without Yesterday: Lemaître, Einstein, and the Birth of Modern Cosmology*, New York: Thunder's Mouth Press

Francoeur, Robert (1970), *Evolving World, Converging Man*. New York: Holt, Rinehart and Winston

Godart O. and M. Heller (1985), *Cosmology of Lemaître*, Tucson, AZ: Pachart Publishing House

Jaki, Stanley L. (1967), "The Role of Faith in Physics," *Zygon* 2:2, 187-202. [Accessed on 1 April 2011 from ATLA Religion Database with ATLASerials]

Jaki, Stanley L. (2002) *A Mind's Matter: An Intellectual Autobiography*, Grand Rapids, MI: William B. Eerdmans Publishing Company

Kragh Helge S. (2005), *Matter and Spirit in the Universe: Scientific and Religious Preludes to Modern Cosmology*, London: Imperial College Press

Kragh, Helge S. and Dominique Lambert (2007), "The Context of Discovery: Lemaître and the Origin of the Primeval-Atom Universe," *Annals of Science*, 64: 4, 445-470. [Accessed on 1 March 2011], DOI: 10.1080/00033790701317692

Lambert, Dominique (2007), *L'Itinéraire Spirituel de Georges Lemaître*, Bruxelles: Lessius

____(1996), "Pie XII et Georges Lemaître: Deux Visions Distinctes des Rapport Sciences-foi," *Mgr. Georges Lemaitre, Savant et Croyant: Actes de Colloque Commémoratif du Centième Anniversaire de sa Naissance (Louvain-la-Neuve, le 4 novembre 1994)* Jean-François Stoeffel ed., Louvain-la-Neuve : Centre interfacultaire d'étude en histoire des sciences, 81-112

____ (1999), *Un Atome D'Univers: La Vie et l'œuvre de Georges Lemaître*, Bruxelles: Lessius

Lemaître, Georges (1931), *Nature* 127: 3210, 706.

Loy, David R. (2003), "The Religion of the Market," *Worldviews, Religion, and the Environment: A Global Anthology*, Richard C. Foltz, ed., Belmont, California: Thomson/Wadsworth, 66-75

McCrea, W.H. (1984), "Physics and Cosmology: Some Interactions," *The Big Bang and George Lemaître*, A. Berger ed., Boston: D. Reidel Publishing Company, 3-22.

Peeble, P.J.E. (1984), "Impact of Lemaître's Ideas on Modern Cosmology," *The Big Bang and George Lemaître*, A Berger ed., Boston: D. Reidel Publishing Company, 23-30

Pérez de Laborda, Alfonso (1996), "Un Problème d'Interférence et de Représentation," *Mgr. Georges Lemaitre, Savant et Croyant: Actes de Colloque Commémoratif du Centième Anniversaire de sa Naissance (Louvain-la-Neuve, le 4 novembre 1994)*, Jean-François Stoeffel ed., Louvain-la-Neuve: Centre interfacultaire d'étude en histoire des sciences, 119-144

Sagan, Carl (1997), "Can We Know the Universe? Reflections of a Grain of Salt," *Science and its Way of Knowing*, John Hatton and Paul B. Plouffe eds., Upper Saddle River, NJ: Prentice-Hall Inc., 3-7

Sahtouris, Elizabet (2002), "The Conscious Universe," *When Worlds Converge: What Science and Religion Tell Us about the Story of the Universe and Our Place in it*, Clifford N. Matthews, Mary Evelyn Tucker and Philip Hefner eds., Chicago Il: Open Court, 59-72

Slater, Noel B. (1957), *The Development and Meaning of Eddington's 'Fundamental Theory'*, Cambridge: Cambridge University Press

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