Georges Lemaître and Fred Hoyle: Contrasting Characters in Science and Religion

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Abstract Georges Lemaître was a jocular Roman Catholic priest and Fred Hoyle a bluff Yorkshireman who despised organized religion. Both were giants of twentieth century cosmology but espoused diametrically opposed cosmological models. This paper explores the extent to which ideology, and particularly religion, played a part in the controversies over the big bang and steady-state theories. A particular problem for many cosmologists, including Hoyle, was posed by the idea that the universe had a temporal beginning: an eternal, unchanging universe seemed metaphysically preferable. And Hoyle was highly polemical about religion in his popular writings. In contrast, Lemaître saw no theological import from the big bang, and never entered a debate about its theological implications until, perhaps unexpectedly, he took issue with an address given by the Pope. Hoyle's seminal work on stellar nucleosynthesis led him to speak of a 'superintellect monkeying with physics' though this was never identified with the God of classical theism. The work of both Lemaître and Hoyle resonates with more recent debates concerning cosmology.

Introduction

In Georges Lemaître and Fred Hoyle we have two characters who are so utterly different in many ways, yet shared one very significant attribute: they were giants in twentieth century cosmology and astrophysics.

In short, here we have a Belgian Roman Catholic priest who can rightly be described as the Father of the big bang, and in Hoyle an atheist Yorkshireman who pioneered the alternative of a steady-state universe with neither beginning nor end. What I particularly want to explore is the extent to which ideology influenced the

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science in these two great figures, though personal characteristics will also be important in the study.

Georges Lemaître

Lemaître's 'primeval atom', unlike the model in his 1927 paper, provided the first ostensibly physical big bang model, comprising as it did the two components of expansion *and* a beginning in time. Adumbrated in a brief but remarkable letter to *Nature* (Lemaître 1931a), it was described in an address he gave to the British Association (Lemaître 1931b), and developed in one of the more substantial papers of the *annus mirabilis* of 1931 (Lemaître 1931c).

There was a great deal of ideological suspicion of the idea that the universe had a beginning, from the time such theories were first mooted until the big bang was finally established beyond reasonable doubt by observation of the predicted background radiation in 1965. Lurking in cosmologists' minds was no doubt the suspicion that, if the universe had a beginning, did it not therefore require a creator? It seems to me that atheists have often perceived that difficulty as a problem, whereas theologians can happily see God creating a universe with either a finite or an infinite past.

Among those who disliked the idea that the universe had a beginning were Einstein, who had assigned a particular value to the cosmological constant so as to yield a static universe, and Eddington, who wrote in 1931 that 'philosophically, the notion of a beginning of the present order of Nature is repugnant to me' (Eddington 1931, quoted in Kragh 1996, p. 46). Interestingly enough these two were quite different with regard to religious faith, and that is reflected in the many others who took sides in the steady-state versus big bang controversy. Einstein believed in Spinoza's pantheistic God whereas Eddington was a Quaker. Helge Kragh writes that astronomers in general preferred to speak of the 'cosmic time scale' rather than to date the present epoch from an absolute beginning of time (Kragh 1996, p. 76). Indeed, says Kragh, 'most astronomers preferred to neglect what may seem to be a natural consequence of the evolutionary, relativistic worldview' (Kragh 1996, p. 142).

Another who did so was of course Fred Hoyle. Indeed it was Hoyle who coined the term 'big bang', applied as term of abuse because he hated the idea. Nevertheless the terminology stuck and Lemaître's term 'primeval atom' faded. Hoyle first used the term 'big bang' in a radio broadcast he gave in 1949. He repeated it in another broadcast in 1950, following which it appeared in print when Hoyle's talk was published in full in the BBC's magazine *The Listener* (Mitton, pp. 127–129).

Clearly Lemaître did not share these concerns, but interestingly enough he also did not want to identify the beginning of the universe in time with the theological doctrine of creation. We shall examine this, and Lemaître's view of science and theology as two different realms, in this chapter, in comparison with the views of Hoyle.

Fred Hoyle

Hoyle was a bluff Yorkshireman, from the beginning something of an outsider to the Cambridge world he came to inhabit from his time as an undergraduate. And though he became part of the Establishment—elected FRS, Professor at Cambridge, knighted—he continued to advance controversial theories and engage in hot polemical disputes throughout his career.

One of Hoyle's aphorisms was 'it is better to be interesting and wrong than boring and right' (Foreword by Paul Davies in Mitton 2011, p. x). And this is something the great man lived up to.

Hoyle was a controversialist from the earliest point of his scientific career. He did important work on accretion by stars with Raymond Lyttleton, and later Hermann Bondi. However, Hoyle and Lyttleton failed to get their work published by the Royal Astronomical Society because they refused to accept criticism and modify their paper accordingly, eventually publishing it in *Proceedings of the Cambridge Philosophical Society* (the story is told in Mitton 2011, pp. 62–80). There were in fact severe problems with these papers in the context for which they were conceived, though they became important many years later when accretion was seen to be operative in binary star systems. In these systems one member of the pair, a compact object such as a neutron star, accretes material from the other. The papers by Hoyle and Lyttleton, and Bondi, are even cited in the doctoral thesis of the present author, who in his youth studied accretion in the very different context of intergalactic gas by the galaxy.

Accretion was an idea ahead of its time and rightful context but the controversy characterised Hoyle's relationships with many in the scientific establishment. By way of example, among Hoyle's more outlandishly controversial ideas was that of panspermia, particularly because Hoyle was here stepping outside the area of his own expertise. Panspermia is the idea that life on earth was seeded from space (publicised in Hoyle and Wickramasinghe 1978). Along with this came the idea that disease-causing viruses were introduced from space. Hoyle and his colleague Chandra Wickramasinghe thought that Darwinian evolution alone was inadequate to account for the explosion of speciation over the last 600 million years unless further genetic information were seeded from space (Hoyle and Wickramasinghe 1978, p. 32). Mitton's rather blunter statement that they simply did not accept Darwinian evolution (Mitton 2011, p. 309) is borne out in Hoyle's 1983 book *The Intelligent Universe*. Here we get the statement that 'the Darwinian theory is wrong because random variations tend to worsen performance' (Hoyle 1983, p. 48). Inevitably this view did not endear Hoyle and Wickramasinghe to the biologists who were the experts in such matters.

Hoyle and Wickramasinghe even claimed in 1985 that the intermediate fossil archaeopteryx was a fraud, only publishing this outlandish idea in *The British Journal of Photography*, and this was another claim that got them into deep water with the experts.

Despite these aberrations, it remains true that Hoyle was a very great scientist and his greatest and enduring contribution to astrophysics was his work on stellar

nucleosynthesis in collaboration with Geoffrey and Margaret Burbidge and William Fowler. The magisterial paper produced by these four, invariably shortened to B^2FH, showed how virtually the whole periodic table of the chemical elements could be built up through nuclear reactions in stars (Burbidge et al. 1957). This earned Fowler a share of the Nobel Prize in 1983, though Fowler forever after regretted that his friend Hoyle was undeservedly excluded from the award.

Interestingly, helium could not be produced in sufficient quantity this way and in the 1960s Hoyle and colleagues Roger Tayler and Bob Wagoner showed how the very lightest elements could be created in the conditions of a hot big bang (Hoyle and Tayler 1964; Wagoner et al. 1967). Performing calculations more accurate than those of George Gamow's team in the 1940s, Hoyle and his colleagues thus helped provide evidence favouring the theory he despised!

Clearly, however, it was the steady state theory which both made Hoyle well-known, not least among the general public, and which also was the source of his most serious disputes within the astrophysical community.

The Steady State Theory

By the 1940s, the evidence of the redshifts, interpreted as due to the expansion of the universe, had seemed to indicate that some version of the big bang theory was correct. The Einstein static, eternal universe did not seem to reflect reality. However, a major challenge was that the estimated age of the universe, a couple of billion years or even less as deduced from the Hubble law, was smaller than the estimated age of stars and galaxies, and indeed of the earth itself! More accurate observations came much later, in the late 1940s and early 1950s. Today the age is believed to be about 13.7 billion years, comfortably older than the objects within it, and the three significant figures indicating how far cosmology has advanced as a science of measurement.

In 1948, however, the view that there was any kind of evolution at all was challenged by a new theory which ran clean contrary to the big bang idea. As formulated by Hermann Bondi and Thomas Gold in that year, it was based on a metaphysical principle called the 'perfect cosmological principle' (Bondi 1961, p. 12). This principle amounted to the assumption that not only does the universe on the largest scale present a uniform aspect at every place within it, as assumed by the big bang theory too and indeed necessary to obtain the Friedmann-Lemaître solutions, but also at every time in its history. Put simply, the universe looks the same at any place and any time, always excluding local irregularities. It should be stressed that this is indeed a metaphysical principle, not an empirical scientific principle derived from observation or experiment.

In order to account for the observed expansion it was necessary in the steady-state theory that new matter be created in the space created between the receding galaxies, and at just the right rate. In fact, other steady-state continuous creation models had

arisen in the pre-war period, quite often associated with a metaphysical preference for God to be continuously creating rather than, as it were, winding up the universe at the beginning and letting it run down. Physicists such as Robert Millikan and many others put forward such highly speculative steady-state type theories, and in 1933 such ideas were endorsed from the theological perspective by W.R. Inge, the well-known Dean of St Paul's Cathedral (Kragh 1996, p. 150). However, there seems to have been an atheist agenda attached to the steady-state theory proper put forward by Bondi, Gold and, significantly, Hoyle who simultaneously came up with a rather different version of the theory. Nevertheless the steady-state still attracted Christian support, notably from the cosmologist W.H. McCrea. Moreover, the Anglican theologian E.L. Mascall noted how it was entirely in keeping with Aquinas' notion of God both bringing things into existence and preserving them in existence so that 'if he withdrew his action from them, all things would be reduced to nothing' (Mascall 1956, pp. 158–159, quoting *Summa Theologiae*, Ia.9.2).

Kragh notes that it was particularly Hoyle who objected to a singular creation event that was beyond the realm of scientific understanding (Kragh 1996, p. 174). In his 1948 paper Hoyle wrote: 'For it is against the spirit of scientific enquiry to regard observable effects as arising from "causes unknown to science", and this is in principle what creation-in-the-past implies.' (quoted in Kragh 1996, p. 179). As noted above, and as explained in more detail in William Carroll's chapter in this present book, the Christian doctrine of creation can in fact happily account for either type of universe. But another reason the trio rejected standard cosmology was the time-scale problem. This could be solved in the Eddington-Lemaître, Lemaître models but at the seemingly unacceptable cost of fine-tuning the cosmological constant. This was deemed a fudge that ought to be unnecessary in a true theory.

Interestingly enough, Hoyle initially objected to matter creation, as suggested by Gold, and this delayed progress on the steady-state theory (Kragh 1996, p. 177). After all, matter creation would constitute a violation of the law of conservation of energy. In the event this would mean that two versions of the steady-state theory would emerge, both in 1948, the one authored by Hoyle and the other by Bondi and Gold. Another very significant difference within the trio is that, unlike Hoyle, Bondi and Gold regarded general relativity as suspect when extrapolated so as to apply to the universe as a whole.

In his version of the theory, Hoyle modified Einstein's equations of general relativity by replacing the cosmological term with a 'creation tensor' that did, after all, violate energy conservation! The rate of matter creation governed by the creation tensor just matches the rate at which matter disappears across the horizon of the visible universe. But Hoyle preferred his approach rather than that of Bondi and Gold who started instead from the abstract 'perfect cosmological principle'. For Hoyle that principle was a consequence of his theory rather than an axiom. In contrast Bondi and Gold judged it necessary to ensure that the laws of physics did not change over time, and they claimed that without such a principle cosmology could not be counted a science (Kragh 1996, p. 182).

At this stage I could suggest that perhaps a theological principle would have done what Bondi and Gold wanted! They are right that some metaphysical principle is required to undergird the constancy of physical laws. Theologians would say that this principle is the faithfulness of God. The constancy of physical laws is a sign of God's reliability in maintaining those laws, and the God of the Christian religion is not capricious but faithful. It is this kind of view which informed the natural philosophers of the scientific revolution, those such as Johannes Kepler who saw himself 'thinking God's thoughts after him' when uncovering the laws of planetary motion. No science at all is possible without some sort of presupposition about there being order and law-like behaviour out there to be discovered. Why that should be the case is not explained by science, but is explained by theology. But it is not an explanation that would have appealed to the proponents of the steady-state theory.

The perfect cosmological principle implies that the Hubble expansion rate we observe today is the same as that at all times, past, present and future. This enabled Bondi and Gold to calculate, very straightforwardly and without any appeal to general relativity, the rate of creation of matter required to balance the expansion. In Bondi's book, which utilises an up-to-date figure for the Hubble constant, he gives a rate of something like the equivalent of one hydrogen atom per litre coming into existence every 500 billion years (Bondi 1961, p. 143). Hoyle put his comparable figure more graphically in his 1950 radio broadcasts as one atom per year in a volume equal to that encompassed by St Paul's Cathedral. Clearly that is many orders of magnitude below any detectable threshold. (Hoyle 1950, p. 106).

One of the most bitter disputes in all cosmology was occasioned by Hoyle's defence of the steady-state theory. It involved the future Nobel prize winning Cambridge radio astronomer Martin Ryle and was mainly concerned with counts of radio sources, once these were established to be extragalactic (which Ryle originally denied but Hoyle rightly asserted), relative to their brightness. If the steady state theory is correct then sources of a given brightness should be uniformly distributed throughout space. There is then a simple and easily derivable formula for the number N of sources of brightness greater than S, i.e. $N \propto S^{-3/2}$. A plot of $\log N$ against $\log S$ should then yield a straight line of slope $-3/2$.

From about 1954 onwards Ryle sought to catalogue radio sources and to disprove the steady state theory. Indeed he apparently achieved results that did so, getting a slope different from $-3/2$. The trouble was that the survey results Ryle presented in 1954 (the 2 C, second Cambridge survey) were unreliable. Observers in Australia contradicted them, and the survey results of 1958 (3 C, third Cambridge survey) were still disputed. However, by 1961 further results were much more accurate, were confirmed by other observers, and did indeed seem to refute the steady state theory. These latter results were further confirmed by the complete Cambridge 4 C survey carried out between 1958 and 1964, though the steady state advocates stuck to their guns despite the mounting evidence. It was of course the observation of the microwave background in 1965 which provided the clinching evidence in favour of the big bang.

The Rôle of Ideology

Hoyle

We have begun to see already that ideological factors were at work when both the big bang theory and steady-state theories were being developed, and we need to look at this a little more closely.

One feature that is common to many of the scientists on all sides of the big bang versus steady-state divide is the search for simplicity. Lemaître, influenced by Einstein, wrote in 1922 that 'Scientific progress is the discovery of a more and more comprehensive simplicity.' (Kragh 1996, p. 28). Einstein himself in 1931 rejected his earlier espousal of a positive cosmological constant because of its ugliness and lack of simplicity. Bondi and Gold appealed to the principle of simplicity to justify giving priority to the perfect cosmological principle over the principle of conservation of matter/energy which, given the non-detectability of new matter, could be regarded as only approximate.

The idea that the simplest of competing hypotheses is most likely to be true has been a useful guiding principle in science. However, one could regard the Bondi-Gold theory as too little driven by empirical data, indeed as rather Platonic and rational in being deductive rather than inductive, and that conservation of energy and the validity of physical laws across space and time are as simple assumptions to make as is compatible with observation and experiment. It is surely preferable to seek solutions in terms of current well-established physical theories before amending those theories or abandoning them altogether and applying over-arching metaphysical principles. Eddington would be a scientist who, in his search for a 'fundamental theory', which occupied most of his life from the 1930s, was also adopting a more rational and Platonic approach.

Hoyle, on the other hand, would I think be in the majority among scientists in downplaying grand metaphysical principles and hardly discussed the philosophy of science. However, he did not simply embrace the alternative empiricist approach either, but (rightly I think) noted that no empirical facts were bare or uninterpreted facts. Thus for Hoyle, theory and observation go hand in hand (Kragh 1996, p. 195). While Bondi shared this view, as Kragh notes, he was more emphatic and provocative in claiming that errors in observation are likely to be more frequent than errors in theory (Kragh 1996, p. 238). While observation was of course still deemed important, these views gave the steady state cosmologists grounds for resisting apparently falsifying data, as well as for having postulated a completely undetectable rate of creation of new matter.

It is in the area of religion where there is the greatest divide. There are two major questions where modern cosmology and theology potentially interact. The first relates to whether the universe had a temporal origin or not. As noted above this is not really a problem for theology, if the doctrine of creation is properly understood (as explained in detail by William Carroll in this volume); nevertheless it is the case that a temporal origin is perceived to be a problem by atheists, up to

and including Stephen Hawking in the present day. If we can get rid of the temporal origin it is claimed, falsely of course, that we then get rid of God. The second question relates to the special way in which the big bang and the laws of physics need to be set up in order for the universe to give rise to life—the so-called fine-tuning—and we return to this shortly.

We have seen that Hoyle disliked the notion of an initial cause beyond the realms of science, which is what seems to be implied by the big bang, and he certainly associated the steady-state theory with atheism (Kragh 1996, p. 253). Indeed he freely expressed an emotional preference for the steady state even though he saw that this in itself was irrelevant to its acceptance (Hoyle 1955/1970, pp. 353–355).

In the last chapter of his book *The Nature of the Universe*—'Man's Place in the Expanding Universe'—he explains why he believes the steady-state theory to be superior to the big bang. There are reasons of physics such as the time-scale problem and difficulties to do with galaxy formation, and with either theory one is face with the problem of creation. However, Hoyle is clear about his preference: 'In the older theories all the material in the Universe is supposed to have appeared at one instant of time, the whole creation process taking the form of one big bang. For myself I find this idea very much queerer than continuous creation.' (Hoyle 1950, p. 105). Incidentally this book transcribes Hoyle's further radio broadcasts of 1950 and we have in it the reoccurrence of the pejorative term 'big bang'.

At the end of this chapter Hoyle adds a personal reflection, in which he writes this about religion:

> it seems to me that religion is but a blind attempt to find an escape from the truly dreadful situation in which we find ourselves. Here we are in this wholly fantastic Universe with scarcely a clue as to whether our existence has any real significance. No wonder then that many people feel the need for some belief that gives them a sense of security, and no wonder that they become very angry with people like me who say that this security is illusory (Hoyle 1950, pp. 115–116).

It is no surprise that Hoyle's broadcasts gave rise to considerable controversy, and indeed the long-running dispute with Ryle began at about the same time (Mitton 2011, p. 172). There were a number of scientists who criticised Hoyle for his too unqualified presentation of his own speculative theory. In July 1950 the philosopher of science Herbert Dingle was allowed to say as much in a responding broadcast. The novelist Dorothy L. Sayers was also allowed to do something similar with respect to Hoyle's views on religion, which had occasioned the ire of Geoffrey Fisher, Archbishop of Canterbury, among others (Mitton 2011, pp. 135–137).

Further association of the steady-state theory with atheism occurs in Hoyle's book *Frontiers of Astronomy*. The theory contrasts with the big bang which requires the acceptance of starting conditions 'which we are obliged to accept as conditions arbitrarily imposed for no reasons that we understand'. He writes:

> This procedure is quite characteristic of the outlook of primitive peoples, who in attempting to explain the local behaviour of the physical world are obliged in their ignorance of the laws of physics to have recourse to arbitrary starting conditions. These are given credence by postulating the existence of gods, gods of the sea . . ., gods of the mountains, gods of the forests, . . ., and so forth (Hoyle (1955/1970), p. 351).

It seems to me, in contrast to Hoyle, that physics normally proceeds precisely by applying the laws to a set of starting conditions to see how a system evolves. It is in cosmology now, as in Hoyle's day, where the avoidance of starting conditions is uniquely being sought.

Elsewhere Hoyle expresses what he sees as the gulf between the way science and religion work. In a lecture given in 1957 at Great St Mary's, the University Church, in Cambridge he said this:

> Religious thought is not controlled by the requirement that it must make correct predictions concerning the events that take place in the external world. It is controlled by doctrines usually laid down many centuries ago in canonical forms, in the Bible for the Christian, in the Koran for the Muslim. The existence of these written doctrines would seem to make any rooted change of outlook difficult to achieve (Hoyle 1959, pp. 57–58).

In similar vein Catholicism, like Communism, argues by dogma:

> An argument is judged "right" by these people because they judge it to be based on "right" premises, not because it leads to results that accord with the facts. Indeed if the facts of the case should disagree with the dogma then so much worse for the facts (Hoyle 1957, p. 139).

Hoyle shares with the religious person a sense of awe before the universe and the sense that there must be some 'deep laid purpose' there. It is the particularities of religion that he rejects, such as miracles, which he sees as God constantly correcting his own poor handiwork when things go wrong, (Hoyle 1957, p. 157) and, in the case of Christianity, such specific doctrines as the divinity of Christ and the Virgin Birth. Indeed Hoyle is utterly scathing about such beliefs, which amount to a 'denial of rational thought' and 'contradict the very fabric of the world' (Hoyle 1957, p. 152), thus negating the faculty which separates man from the beasts. He states: 'Religion, if it is not to be pernicious nonsense, must be based on rational thinking.' (Hoyle 1957, p. 152). If religion *were* to change its dogmas, in the way science does, such changes would have to be on the scale of seeing Jesus as just an exceptional man rather than God incarnate (Hoyle 1959, p. 58).

I would argue that Hoyle's view of religion is naïve in a number of ways. Religion may not be predictive—and there are other areas of human enquiry which are not predictive, such as ethics and history—but it *is* explanatory. Scientific laws codify the regularities normally observed in nature. They have nothing to say about singular instances, which miracles are. And Christian doctrines can be regarded as rationally formulated responses to historical evidence and the experience of the Church.

As an example of the explanatory role of religion, the doctrine of the *imago dei* explains why the inherent logic of the human brain parallels the structure of the universe as a whole. Hoyle recognises and alludes to this fact but circumvents it by identifying God with the universe (Hoyle 1959, p. 56; Hoyle 1957, p. 157). How the universe manages to create a pattern of itself inside our heads, as Hoyle believes it does, remains unclear, but for him 'The Universe constitutes everything that there is.' (Hoyle 1957, p 158).

The first chapter of *The Ten Faces of the Universe* (Hoyle 1977) is called 'God's Universe' and in it Hoyle launches another tirade against Christian belief.

He remarks that 'the attributes of God so frequently and confidently announced from the pulpit were quite indefensible' and lists some of them: 'God the father—i.e. the family man; God the maker of all things—i.e. a craftsman or artisan; God almighty—a war leader; God in heaven, wherever that may be'. (Hoyle 1977, p. 4). Rather than engaging with what theologians say about these matters, Hoyle contents himself with remarking that they are 'plainly man-made' and 'without meaning'. (Hoyle 1977, pp. 4, 6–7). Again, only equating God with the universe makes any sense to him. His solution to the Northern Ireland problem would have been to 'arrest every priest and clergyman in Ireland and to commit every man jack of them to long jail sentences on the charge of causing civil war'. (Hoyle 1977, p. 7). After all, the violence is simply due to priests and clergymen instilling 'nonsense words and concepts' into children, and different nonsense words at that into Roman Catholic and Protestant children.

Despite this negativity towards religion Hoyle does, however, recognise as significant the second area in which cosmology and religion interact, namely that concerning the 'fine-tuning'. Thus he notes that there are very surprising connections between the origin of life, the building up of chemical elements in stars, and the laws of nuclear physics. These connections are either 'random quirks' (Hoyle 1959, p. 64) or signs of a superintellect behind the universe (Hoyle 1981, p. 12).

Hoyle famously predicted a resonance, an enhanced effect, in the carbon atom at just the right level to ensure that carbon could be manufactured efficiently by nucleosynthesis in stellar interiors despite the intermediate product, beryllium, being unstable. At the same time it turned out that there was an energy level in oxygen just below that which would make the production of oxygen resonant and thereby turn *all* the carbon into oxygen. Indeed it is worth quoting Hoyle more extensively on this point. In the Great St Mary's lecture he said this:

> If this were a purely scientific question and not one that touched on the religious problem, I do not believe that any scientist who examined the evidence would fail to draw the inference that the laws of nuclear physics have been deliberately designed with regard to the consequences they produce inside the stars. If this is so, then my apparently random quirks have become part of a deep laid scheme. If not, then we are back again to a monstrous sequence of accidents (Hoyle 1959, p. 64).

In an article of 1981 he wrote:

> From 1953 onward, Fowler and I have been intrigued by the remarkable relation of the 7.65 MeV energy level in the nucleus of ^{12}C to the 7.12 MeV level in ^{16}O. If you wanted to produce carbon and oxygen in roughly equal quantities by stellar nucleosynthesis, these are just the two levels you would have to fix, and your fixing would have to be just about where these levels are actually found to be. Is that another put-up, artificial job? Following the above argument, I am inclined to think so. A commonsense interpretation of the facts suggests that a superintellect has monkeyed with physics, as well as with chemistry and biology, and that there are no blind forces worth speaking about in nature. The numbers one calculates from the facts seem to me so overwhelming as to put this conclusion almost beyond question (Hoyle 1981, p. 12).

To me it seems difficult to reconcile these remarks with the minimalist religious view expressed by Hoyle earlier whereby God is identified with the universe. Persons

are intelligent, not the universe per se, and the Christian God at any rate is conceived as personal. Hoyle's alternative to this, in *The Intelligent Universe*, is a considerable degree of speculation to do with backwards and forwards causation in time:

1. Information comes from the future to control quantum events in a manner similar to that which John Wheeler has argued for ('observer created reality');
2. Life-bearing information is transferred into new forms from past to future along lines popularized by Frank Tipler and resulting in 'collective immortality'; and
3. These two time flows of information are interrelated thus: 'We are the intelligence that preceded us in its new material representation—or rather, we are the re-emergence of that intelligence, the latest embodiment of its struggle for survival'. (Hoyle 1983, p. 239).

This paradoxical-sounding scheme appears to resemble the closed quantum causal loops invoked by Wheeler and more recently Paul Davies. Hoyle recognises the similarity of the quantum controller in (1) both to the Christian God outside the Universe and to Greek deities who manage an existing cosmos. The advantage of his scheme is that God's existence is also dependent on the Universe.

Hoyle also blames attacks on the steady state theory in the 1950s as arising 'because we were touching on issues that threatened the theological culture on which western civilization was founded' whereas the 'big bang theory requires a recent origin of the Universe that openly invites the concept of creation'. (Hoyle 1983, p. 237).

Lemaître

Clearly Lemaître was in the opposite camp to Bondi, Gold and Hoyle in the matter of religion. But how did it affect his approach to cosmology? Incidentally, Bondi later became President of the British Humanist Association and of the Rationalist Press Association—a really serious atheist!

Odon Godart and Michal Heller discovered an unpublished manuscript from about 1922 in which Lemaître states that the universe began with light just as Genesis had suggested. However, Godart further notes that 'Lemaître was too careful a scientist to build his theory on what was no more than an intuitive opinion; a scientific basis was necessary'. (Godart 1984, p. 395).

According to Kragh, Lemaître's theology may have influenced his preference for a spatially finite universe (positive curvature) over an infinite universe. The finitude of the universe was asserted by Aquinas and goes back to Aristotle, though at times an infinite universe had also been postulated, for example by Cardinal Nicholas of Cusa in the fifteenth century. This is interesting, since it is again a matter which is in dispute in recent philosophical discussion of cosmology. Indeed some, including George Ellis and the philosopher William Lane Craig, have questioned whether an infinitude of physical things, as opposed to infinities treated in pure mathematics, can actually exist. In any case an infinity can always be added to and is never

'complete'. Again according to Kragh, Lemaître could not take the steady-state theory seriously, mainly because it differed so radically from his own view, but possibly also because he thought it incompatible with his theology. (Kragh 1996, p. 198). However, none of this implies that he had advanced his own theory from theological motives, and indeed the weight of evidence is that he did not consider his theory to have any intrinsic theological significance. In this regard the following quotation (Kragh 1996, p. 60) is particularly apposite:

> As far as I can see, such a theory [of the primeval atom] remains entirely outside any metaphysical or religious question. It leaves the materialist free to deny any transcendental Being. He may keep, for the bottom of space-time, the same attitude of mind he has been able to adopt for events occurring in non-singular places in space-time.

As explained in this volume in Dominique Lambert's chapter and expounded in more detail in George Coyne's chapter, in 1952 there arose a notable disagreement between Lemaître and Pope Pius XII when the latter ventured to suggest that the big bang theory supported the doctrine of creation. The pope had addressed the Pontifical Academy of Sciences on 22 November 1951 in the following terms:

> Clearly and critically, as when it [the enlightened mind] examines facts and passes judgment on them, it perceives the work of creative omnipotence and recognizes that its power, set in motion by the mighty *Fiat* of the Creating Spirit billions of years ago, called into existence with a gesture of generous love and spread over the universe matter bursting with energy. 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 primordial *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. . . .
>
> What, then, is the importance of modern science in the argument for the existence of God based on change in the universe? By means of exact and detailed research into the large-scale and small-scale worlds it has considerably broadened and deepened the empirical foundation on which the argument rests, and from which it concludes to the existence of an *Ens a se*, immutable by His very nature. . . . Thus, with that concreteness which is characteristic of physical proofs, it has confirmed the contingency of the universe and also the well-founded deduction as to the epoch when the world came forth from the hands of the Creator. Hence, creation took place. We say: therefore, there is a Creator. Therefore, God exists! (Kragh 1996, p. 257).

Lemaître, usually irrepressibly cheerful, was deeply unhappy about this. Scientifically it portrayed science as unequivocal about the big bang, which was certainly not the case. The big bang was still a hypothesis and had a strong rival in the steady-state theory. Ernan McMullin recalls Lemaître saying that the universe could easily have gone through a previous phase of contraction. (McMullin 1981, p. 53, quoted in Kragh 1996, p. 431, n. 186). Indeed George Gamow, who did so much important work on the big bang in the late 1940s thought the same, as related in his book *The Creation of the Universe*. (Gamow 1952, p. 29, cited in Mascall 1956, pp. 153–154). In addition, Lemaître thought it confirmed the suspicions of Hoyle and others of a theological agenda behind the big bang. Lemaître had himself steered clear of such arguments. Thus he neither commented on Hoyle's atheistic assertions in his BBC broadcasts, which resulted in *The Nature of the Universe*, nor on the opposite argument from the big bang to God advanced in

the 1940s by the great mathematician E. T. Whittaker, whom, incidentally, the Pope quoted in his controversial address. (Deprit 1984, p. 387).

Theologically the Pope's statement confused creation, which is inaccessible to science, with origination in the sense that science could investigate—essentially the same mistake as Hoyle! Lemaître intervened with the Pope's science adviser and succeeded in dissuading the Pope from further ventures into scientific territory, which he deemed unhelpful.

To Lemaître theology and science were two different realms, two different paths to truth—indeed as he once said, two paths both of which he had decided to follow. He was, naturally, very far from being a fundamentalist. To believe that the Bible teaches science is like 'assuming that there must be authentic religious dogma in the binomial theorem'. If the Bible is right about immortality and salvation, it is simply fallacious to believe it is right about everything else—that is completely to miss the point of why we were given the Bible in the first place. (Kragh 1996, p. 59).

When Dirac said to Lemaître that he thought cosmology was the branch of science closest to religion, Lemaître disagreed, saying he thought psychology was the closest. (Farrell 2005, p. 191).

Anticipations of Modern Debates

Lemaître's ideas are still very much with us, notably in the discovery a decade ago that the cosmological constant takes a small positive value. Perhaps as a thinker very much 'outside the box' it is no surprise that Hoyle too in a sense anticipated much that is going on in the present day both in the popular media, and in cosmology and the philosophy thereof. Let me give three rather different examples, one a salutary lesson, the second highlighting a consequence of the steady state theory shared with more modern theories, and the third a fascinating reflection on cosmology at the time of his 60th birthday.

We have seen how Hoyle's forays into the popular media, both broadcast and written, provoked hostility from many of his colleagues and that is a present danger too. One example in Hoyle's case comes from a review of his book *Frontiers of Astronomy* in the *Manchester Guardian*:

> Mr Hoyle has done it again. . . . Here is the universe from A to Z, all cleverly parcelled up. It is indeed clever, too clever. . . . Perhaps the most serious deficiency of this book is that it conveys no impression of the great many uncertainties that exercise astronomers just now and which give their subject such high interest. And, because the book might have been a valuable one, it is a pity that Mr Hoyle has been so dogmatic. For in spite of his lucid prose and his fine illustrations, much of the dogma is unacceptable (*Manchester Guardian* 15 July 1955, p. 6, quoted in Mitton 2011, p. 182).

Cosmology is clearly a subject that captures the popular attention, but it seems to me that these criticisms could apply a fortiori to much of today's popular cosmology writing.

In a radio broadcast in 1949 Hoyle postulated that, in an infinite universe, as in his continuous creation model, anything that can happen does happen somewhere sometime. Thus there would be multiple copies of Hoyle doing a similar broadcast elsewhere in the infinite universe. (Mitton 2011, p. 131). Although Hoyle did not see this, it seems to me that this is a good reason to be sceptical of the theory and modern multiverse theories which say the same thing. It is at least paradoxical and raises questions of human identity and free will, since I or some copy of me makes all the choices I could possible make infinitely many times, and a theory which avoids such paradoxes is surely simpler and metaphysically preferable, provided of course it accounts for the observations.

More positively, and yet more humbly, in a BBC interview with John Maddox, editor of *Nature*, to celebrate his 60th birthday, Hoyle made these prescient remarks:

> Many of the past generation believed they were very close to the ultimate structure for the universe, and that it was only a question of time before extra work would fix the final details. I don't believe this at all myself. I think what we see is a tiny fragment of a much bigger structure. The big advances in astronomy come when there are big advances in physics. We shall find it difficult to arrive at a unique answer for the universe because we see only a part of it (Mitton 2011, pp. 306–307).

Postscript: How Did Hoyle and Lemaître Relate at a Personal Level?

All the evidence would indicate that Hoyle and Lemaître got on very well at the personal level despite the fundamental disagreements over cosmology, and indeed over religion—and we have noted Hoyle's view of priests! I will end with a nice anecdote given by John Farrell concerning a 2-week drive Hoyle, his wife Barbara, and Lemaître did together through Italy and the Alps in 1957. They were dining one night, which happened to be a Friday. Hoyle ordered a steak and Lemaître fish. When the food came, Hoyle's steak was of moderate size, whereas Lemaître's fish was enormous. Hoyle commented, 'Now at last, Georges, I see why you are a Catholic!', at which Lemaître became 'red-faced and peevish'. Hoyle was puzzled, thinking he had committed some terrible 'religio-diplomatic indiscretion' as he put it. That was until he remembered that Lemaître hated fish! (Farrell 2005, pp. 156–157).

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