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The BBC, the Victoria Institute, and the Theological Context for the Big Bang – Steady State Debate

In the late 1940s, Fred Hoyle, Hermann Bondi and Tom Gold introduced a steady state model for the universe. Theirs was a universe without beginning or end, a model that neatly avoided the ex nihilo problem and bore little resemblance to Christian origin stories. Despite Hoyle's early efforts to cast the big bang – steady state debate as a debate between a Christian cosmology and a more sober and scientific cosmology, the discussion of these models in many quarters quickly embraced both as potentially deistic visions of the universe.

Key Words: Cosmology, big bang, steady state, Victoria Institute, BBC, American Scientific Affiliation, Fred Hoyle, George Gamow

In the late 1940s and early 1950s, a debate about the origins of the universe erupted in the periphery of the British and American astronomical communities. Early in the history of the debate, proponents of an evolving universe recognised similarities between the cataclysmic creation of the universe and the Genesis account of creation. Similarly, proponents of a steady state universe – endlessly expanding while new matter emerges – recognised that their vision of the cosmos was not as obviously connected to theistic interpretations of nature. By most accounts, the debate over these competing theories of the universe was one in which religion played a static role, albeit of varying intensity, with a faint theistic stamp of approval on evolutionary models and a stronger materialistic and atheistic undertone surrounding steady state models. The relationship that emerged between science and religion in the debate over the origin of the universe turns out to be much more complicated than this easy generalisation allows. Though steady state cosmologists appear to have been influenced by the materialist implications of their theories, commentators in Britain and America quickly baptised the steady state theory, some of them expressing greater admiration for a constantly balanced cosmos than for a dramatically created one. The relationship between science and religion in this regard played out very differently in Britain from in America, making the theological context of the big bang – steady state debate remarkably resistant to generalisation.

The most visible steady state advocate of the 1940s and 1950s had deeply seated anti-religious sentiments that informed his approach to cosmology generally. At an early age, Fred Hoyle took note of the hypocrisy of the religious climate in his town:

> The notion that things are frequently not the way they are supposed to be entered my head at an early age, a favorable situation for a prospective scientist… the Protestant youth would occasionally converge, with evil intent, on the Catholic school, stoning the Catholic pupils in true biblical fashion as they emerged into a veritable hellbrew, scattering them shrieking in all directions like birds under a hawk.

Hoyle apparently associated his anti-clerical feelings with the origins of his scientific outlook. As a child, Hoyle resented his compulsory education, which he referred to as 'incarceration in a mental prison house'. He much preferred roaming the countryside and observing nature. Aside from an early interest in mathematics that was fostered more by his mother than his local school system, Hoyle's education was unremarkable until he started attending Cambridge University in 1933, on a Yorkshire scholarship.[1]

At Cambridge, he majored in applied mathematics (physics) and was the First Wrangler in the prestigious Tripos examination in 1936. He stayed on at Cambridge for graduate studies under Rudolf Peierls, a German theoretician who had studied under Wolfgang Pauli. Peierls left Cambridge the following year, and Hoyle worked independently for a while until Paul Dirac took him on as a student. Hoyle worked on quantum theory, publishing a paper on the details of beta decay with Peierls and Hans Bethe in 1938.[2] Though a career in quantum physics seemed to be off to a good start, a number of events led him to make a radical change in fields in 1939, from quantum theory to astronomy. Dirac warned him that theoretical physics was 'running out of steam'. Worse, Hoyle had an intellectual crisis of faith in the foundations of quantum theory:

> This caused me a year later to quit theoretical physics for astronomy. My brain patterns were seriously disturbed, and I could not see how to reshuffle them in a satisfactory way… this was the question I failed to resolve, the question which led me in 1939 to leave theoretical physics for astronomy, thinking with youthful idealism to be entering a more rational subject.

The move was fortuitous, as Hoyle pointed out in his 1985 autobiography:

1 Hoyle has published four book-length autobiographies: Hoyle, F. *Encounter with the Future*, New York: Trident Press (1965); Hoyle, F. *The Small World of Fred Hoyle: An Autobiography*, London: M. Joseph (1986); Hoyle, F. *Ten Faces of the Universe*, San Francisco: W. H. Freeman (1977); Hoyle, F. *Home is Where the Wind Blows: Chapters from a Cosmologist's Life*, Mill Valley, California: University Science Books (1994). Quoted material is from *Home is Where the Wind Blows*, p. 37 and p. 43. The role of science popularisation in the big bang steady state debate is considered in McConnell, C. *The Big Bang_Steady State Controversy: Cosmology in Public and Scientific Forums*, Ph.D. Dissertation, University of Wisconsin-Madison (2000). The role of science popularisation in Fred Hoyle's career has been explored in two recent scientific biographies – Gregory, J. *Fred Hoyle's Universe*, Oxford: Oxford University Press (2005) and Mitton, S. *Conflict in the Cosmos:Fred Hoyle's Life in Science*, Washington, D.C., Joseph Henry Press (2005).

2 Bethe, H., Hoyle, F., & Peierls, R. 'Interpretation of Beta-Disintegration Data', *Nature* (1939) 143, 200-201. See also Hoyle, F. 'ß-transitions in a Coulomb field', *Proceedings of the Royal Society* (1938) 166, 249-269.

'My generation was the unluckiest of the past half century. We were too late to receive anything but crumbs from the rich table of the years around 1926, we were too early for quantum electrodynamics, and very much too early for quarks. Additionally from 1939 to 1945 we lost six wartime years.'[3]

Hoyle worked under Raymond Lyttleton on the problem of how the accumulation of interstellar gas affects the evolution of stars. He published a number of articles in the war years, despite his participation in war projects from 1940 to 1945 (the war evidently interfered with astronomy much less than it did with particle physics). He worked on a new radar system for detecting ships at sea for the Admiralty Radar Group near Portsmouth from 1940 to 1942; he was then transferred to Witley, between Portsmouth and London, where he was made the head of the theoretical section of the Admiralty Signal Establishment. It was in this capacity that he met his collaborators Bondi and Gold.

Bondi and Gold came from similar backgrounds that were strikingly different from Hoyle's. Hermann Bondi was born in Vienna in 1919. Ethnically Jewish, his father was nonreligious, and Bondi's own encounters with Orthodox Jews engendered an attitude toward religion that he would later admit was 'direct hostile'.[4] Like Hoyle, Bondi associated religiosity with intolerance. Throughout his life, Bondi promoted rationalistic and humanistic alternatives to religion, eventually serving as the President of the British Humanist Association. Bondi met Arthur Eddington in 1936, when Eddington was speaking in Vienna. The encounter made an enormous impression on Bondi, who later recalled that he was 'enormously impressed by this man, splendid scientist and writer, but silent to a fault'.[5] This prompted him to apply to study mathematics at Cambridge. He entered Trinity College, Cambridge, in the autumn of 1937, ahead of the *Anschluss* of 1938: 'It was not push that brought me, but pull. It was because I wanted to be here [in England], and I never had any doubt that this is where I wanted to live for the rest of my days.'[6] Bondi liked everything about England, from the weather and the gardens to the meat in the butcher cases.[7]

As an Austrian citizen living in the United Kingdom, he was interned as a hostile alien from May 1940 to August 1941, in Quebec, Canada. His parents, who had also moved to England, were interned with him, and upon their arrival in Canada they immigrated to New York and became US citizens, a route not available to Hermann because he had been transported by a military

3 Dirac quoted in Hoyle, F. 'Personal Comments on the History of Nuclear Astrophysics,' *Quarterly Journal of the Royal Astronomical Society* (1986) 27, 449. Reflections on his generation are in Hoyle, *Small World*, p. 145.
4 Bondi, H. Interview by DeVorkin, D., (20 March 1978), Transcript held at American Institute of Physics, Niels Bohr Library, OH52.
5 Bondi, H. *Science, Churchill & Me*, New York: Pergamon Press (1990), p. 13.
6 *ibid*., p. 18.
7 *ibid*., p. 13, p. 18.

vessel. Hermann was determined to return to England, and did so in 1942. In April that year, he joined the Admiralty's naval radar programme. Bondi claims that shortly after arriving at Portsmouth, 'I was told there was a very brilliant but rather crazy young mathematician by the name of Fred Hoyle. It was some time before I met him.' Bondi was soon put to work on top secret projects, and has commented that 'there was a very short time from my being behind barbed wire because I was so "dangerous", to my being behind barbed wire because the work I did was so secret!'[8]

Just before being interned, Bondi had finished his BA in mathematics; upon his return to England, he completed a Ph.D. in mathematics at Cambridge in 1942. Throughout his career, he sought out problems which had not been previously addressed – it was his aim to provide the first analysis, and then move on to another problem, while others worked out the details: 'I want to see the structure of the thing and how it works out – and then, as much accuracy as you can get with a minimum amount of work.' This philosophy made him a versatile addition to Hoyle's radar team, and a natural collaborator on astrophysical and cosmological problems as well.[9]

A year younger than Bondi, Thomas Gold was born in Austria in 1920. He was raised without a religious education, moved to Berlin in 1930, and attended a Swiss boarding school. He followed his parents to England, and, like Bondi, entered Cambridge University in 1937. Though he wanted to study mathematics, his father pressured him to study the more practical field of engineering. Like Bondi, Gold was interned in Quebec (they realised afterwards that their parents had known each other in Vienna). Bondi made the best of the situation by teaching his fellow internees mathematics and physics. Gold recalls:

> Little of my scientific education comes from my Cambridge undergraduate career. Being interned in rather miserable circumstances as a supposed enemy alien for one year of the war with Hermann Bondi was probably more important in getting me started on a scientific career. As there wasn't much else to do, he taught a number of us about subjects that he, at that stage, was extremely expert in, like dynamics.

After his internment, Gold returned to Cambridge to finish his BA in 1942 and eventually took an MA in engineering in 1945. Edwin Salpeter, who was a graduate student in Cambridge at the time, later characterised Gold's working style as a combination of three ingredients: 'A willingness to question any basic principle… an engineer's ability to analyse complexity concretely' and 'an interest in detailed evidence even if it were not quantitative'. Upon Gold's graduation, Bondi helped him join Hoyle's radar group. Already, Gold's brash

8 *op.cit*., Bondi, Interview by DeVorkin [4].
9 Bondi, H. *op. cit*., [5] pp. 35-36. Quotation is from Bondi, Interview by DeVorkin, D [4].

reputation preceded him – Hoyle recalled in 1965 that Gold 'came to me with a reputation of being difficult'. Hoyle, who also had a reputation for being difficult, found in Gold a kindred spirit and hired him.[10]

The steady state universe that these three men created appealed to each of them for a variety of shared reasons. Foremost among these must have been its novelty. On aesthetic grounds, an infinite universe in a constant state of balanced motion was appealing. It also avoided much of the uncomfortable psychological implications of a universe created all at once, which implies a finite universe with a finite past and *ex nihilo* creation. It did not slip their notice that the steady state universe also avoided the synergy between physical cosmology and the Genesis account of the creation of the world. Bondi and Gold were particularly taken with the idea that their cosmology was homogenous not just in space, but in time as well – an idea they formally referred to as the 'perfect cosmological principle' (an extension of the 'cosmological principle', the notion that the universe is homogenous in space and that we occupy no special place in the universe). Most satisfying, the steady state universe neatly avoided the so-called time-scale problem: astronomers knew of objects in the universe that were older than the calculated age of the universe itself. In their steady state model, Edwin Hubble's observation that distant galaxies are moving away from us did not necessarily imply that all matter had once been concentrated in the distant past; it merely implied that there was a limit to how far into space an observer could peer before the expansion of the universe prevented light from a distant source from reaching an observer. The Hubble data implied a horizon, not an age, for the universe, and the time-scale problem did not exist. The biggest problem they faced in 1947 was figuring out a way to publish a paper about their model.[11]

Popular science outlets served a sustaining role in the early years of the debate, providing Hoyle and his collaborators with a platform for advancing their theory when editors of technical journals were hesitant to carry their work. The most formative action took place in England, where Hoyle in particular entered the popular arena with a variety of motivations. American cosmological discourse was comparatively subdued during this period. Cosmological discussions in the United States were less energetic and were less often framed in terms of a debate between competing theories. For many in Britain, the opening salvos in the debate between steady state cosmologists and evolutionary cosmologists were fired across the air waves of the British Broadcasting Corporation (BBC) in 1949. Less than a year later, Hoyle was known as a prominent populariser of science generally, as well as an atheistic religion-

10 Gold, T. 'Steady State Origins: Comments II', in Terzian, Y. and Bilson, E., (eds.) *Cosmology and Astrophysics: Essays in Honor of Thomas Gold*, Ithaca: Cornell University Press (1982), p. 62; Salpeter, E. 'Foreword', *ibid*., pp. 5-6; Hoyle, *Encounter with the Future*, p. 92.

11 Bondi, Gold, and Hoyle have all complained about the difficulties they had publishing their ideas. Anonymous referee reports at the Royal Astronomical Society support their claims.

basher. It was in these broadcasts that Hoyle coined and popularised the phrase 'big bang' to describe evolutionary cosmologies.

At the end of his first series of radio broadcasts Hoyle addressed his audience directly, claiming, 'I'm sure you'd hardly wish me to end without saying something about how the New Cosmology affects me personally.' These comments ran the gamut of his ideas from those about Marxism to ideas about consciousness and the progress of science. On turning to theology, he warned his listeners, 'Perhaps I should say that, as I shall not be dealing any more kindly with religion than I have just done with materialism, I'd advise you, if you're a deeply religious person, to switch off at this stage.' Not surprisingly, BBC audience research indicates that most of the deeply religious audience members paid closer attention to these comments than any other part of the programme. Hoyle ridiculed biblical cosmology, and attacked Christians directly, asserting that 'in their anxiety to avoid the notion that death is the complete end of our existence, they suggest what is to me an equally horrible alternative'. For Hoyle, the idea of an eternal afterlife was abhorrent.[12]

Hoyle's concluding remarks on philosophy and religion raised considerable concern among the panelists polled by the BBC's Listener Research Department, who felt that such comments were inappropriate, either because he apparently lacked expertise in philosophy or religion, or because they feared that he was needlessly taunting potential opponents. One listener pointed out: 'I was one of the "religious persons" who did not switch off, but I heard nothing to undermine my convictions.' There were a number of listeners who were pleased with Hoyle's outspoken style, and many of them admired Hoyle for being forthright. A hostel-keeper said, 'I agreed with his criticisms of religion, especially Christianity, and think they were fairly and humbly put. I am delighted the BBC has come off its pulpit for once.'[13]

Despite the rave reviews reported by the Listener Research Department, there was a heated religious backlash against Hoyle's outspoken comments concerning religion in his last lecture. In speaking so openly against religion, Hoyle broke radically from the programming norms of the day. Arthur Eddington's 1928 *The Nature of the Physical World* and James Jeans's 1930 *The Mysterious Universe* were both conciliatory towards religious interpretation of science. Until Hoyle's lecture, cosmology had been a 'safe' subject for people concerned with possible friction between science and religion. Some letters written to the BBC and to the editor of *The Listener*, the BBC's companion publication, demanded that Hoyle be censured, while others applauded him for his candidness. Most expressed either shock or surprise that such comments found

12 British Broadcasting Corporation (BBC) Listener Research Department (LRD) Hoyle, 'The Nature of the Universe,' BBC Third Programme, BBC Written Archives Centre, R9/68/17. The transcripts of these broadcasts are very nearly the same as the published form, which is much more accessible: Hoyle, F. *The Nature of the Universe*, Oxford: Blackwell (1950).
13 *ibid*.

their way on the air.[14]

Hoyle's remarks presented something of a problem for the producers at the BBC, which had long carried a number of religious programmes that served both to attract religious listeners and to project an implied image of the BBC and the Anglican Church's working in concert. Insofar as Hoyle intended to upset religious sensibilities in the UK, he was remarkably effective. Ironically, however, his discussion of his religious views soon eclipsed his primary agenda – to facilitate a public discussion of his steady state theory. Soon after the last broadcast, the well-known liberal Protestant Leslie Weatherhead published a pamphlet entitled 'Really, Mr. Hoyle!', in which he took Hoyle to task for his attempts to transfer his authority in astronomy (which Weatherhead considered to be very secure) to authority in religion (which Weatherhead considered to be far beyond Hoyle's reach). Weatherhead attacked Hoyle's scriptural interpretations and reviewed the literature of the previous two or three decades that posited synergy between science and religion. Weatherhead complimented Hoyle's astronomical claims while challenging Hoyle's authority to speak on religious matters.[15]

Less than six months after Hoyle's first BBC broadcast, however, R.E.D. Clark, the editor of a science and religion review journal, redeemed Hoyle's steady state theory, noting,

> the repeated sudden and inexplicable creation of brand new hydrogen atoms, of new and slightly more complicated forms of life, or whatever else it may be, only serves to replace one great miracle by a multitude of small ones. And the sum total of the small ones amounts to the total of the large one – the small ones provide no magic formula for banishing God from His universe.

This theistic reinterpretation of the steady state theory is strikingly similar to theistic interpretations of evolution and became a common motif in most of the subsequent literature on the steady state theory.[16]

14 Eddington, A. *The Nature of the Physical World*, Cambridge: Cambridge University Press (1928); Jeans, J. *The Mysterious Universe*, Cambridge: Cambridge University Press (1930); Dingle, H. 'Does the 'New Cosmology' Exist?' *The Listener*, (2 November 1950), 456-457; Dingle, H. 'The New Cosmology (Letter to the Editor)', *The Listener*, (21 December 1950), 798; Sayers, D. 'The Theologian and the Scientist.' *The Listener*, (9 November 1950), 496-497, 500.

15 Weatherhead, L. *'Really, Mr. Hoyle!' A Reply to the Broadcast Talks on 'The Nature of the Universe' by Fred Hoyle*, London: Epworth Press (1949). This pamphlet is held in the collection of the British Library.

16 Clark, R. 'Continuous Creation,' *Science and Religion: A Review of Current Literature and Thought* (1949) 2, 105. Laplace's nebular hypothesis underwent a similar transition in the nineteenth century. See Numbers, R. *Creation by Natural Law: Laplace's Nebular Hypothesis in American Thought*, Seattle: University of Washington Press (1977). For a survey of the variety of interactions between science and religion, see Brooke, J. *Science and Religion*, Cambridge: Cambridge University Press (1991). Brooke identifies three recurrent modes of interaction between science and religion – warfare, synergy and 'separate spheres'. It is often the case that a single scientific theory can evoke several of these interactions in different individuals. As Brooke says, 'there is no such thing as *the* relationship between science and religion. It is what different individuals and communities have made of it in a plethora of different contexts.' (p. 321).

Most of the preparation for the rebroadcast of the series on the BBC's more prominent Home Service revolved around softening the anti-religious sentiments in the original programmes. Instead of five 40-minute lectures, the program had to be rearranged into eight 25-minute ones. Producer Peter Laslett recognised that this would necessitate considerable revision, and the BBC hoped that this would afford Hoyle the opportunity to remove or at least modify his anti-religious barbs. S.Spicer, acting as assistant controller for the BBC, met with Hoyle in March 1950. In a memo to other BBC controllers, Spicer laid out a ten-point memo in which the details of their agreement were enumerated, including routine contractual details, and the following two items:

> (3) Dr Hoyle said he would play down the religious part of the last talk, but he did wish to say something about the relations between the Almighty and the creation of matter because he had so many letters on the subject. He feels that he must say something about the religious part to draw the conclusions from his ideas.
> (4) Laslett believes that he can handle Hoyle so that the talks will not give offence.

In a follow-up memo, Spicer appealed to Laslett, 'Please do your best about this also so as not to cause offence, remembering that these talks are going out in the Home Service. Perhaps he could put up the Christian case rather more fairly before he proceeds to knock it down?'[17]

The tension escalated in May, when the Chairman of the BBC was present at a commencement speech delivered by Geoffrey Francis Fisher, the Archbishop of Canterbury, who had been outraged at what he had read, presumably in *The Listener*, of Hoyle's anti-religious comments. In a memo complaining about Hoyle's lack of professionalism, the Chairman of the BBC said of the Archbishop, 'He had been reading Hoyle in the train coming up, and spent ten minutes out of a fifteen-minute speech abusing the young man for his views, given in the last few sentences, on Religion!' The Chairman added his own assessment in closing, 'Hoyle has not the humility of a good scientist.'[18]

Despite this pressure, Hoyle stood fast with his assessment of religion. A comparison of the original Third Programme scripts with the Home Service scripts reveals that Hoyle made only the most superficial of changes, often cutting and pasting sections from *The Listener* or galleys from his forthcoming book based on the Third Programme lectures into his Home Service script.[19]

17 Spicer, S. to Controller of Home Service, (4 April 1950), BBC Written Archives Centre, Hoyle Talks I: 1947-1962; Spicer, S. to Peter Laslett, (5 April 1950), BBC Written Archives Centre, Hoyle Talks I: 1947-1962.
18 Chairman of the BBC to D.S.W., (23 May 1950), BBC Written Archives Centre, Hoyle Talks I: 1947-1962.
19 Because audio recording was expensive and unreliable in the 1950s, the BBC maintained an archive of scripts, which were edited after broadcast so that they constituted a verbatim transcription of what had been said on the air.

Science programming and religious programming were compartmentalised into separate spheres at the BBC, leaving the producers in religious programming powerless to censor Hoyle. Instead, they had to rely on their autonomy to schedule rebuttals under the auspices of religious programming. Sir Edmund Whittaker, a professor of mathematics at Edinburgh who converted to Roman Catholicism in his fifties, gave one such talk in May 1950, focused on 'the wider implications of the new cosmology', in which he summarised Hoyle's theory of continuous creation in a paragraph and then moved on, noting that 'Mr. Hoyle explained both these processes admirably, and it isn't necessary for me to repeat what he said.' The remainder of the talk focused on philosophy and religion, with very little reference to astronomy or cosmology, thus countering Hoyle with an oblique parry.[20]

Hoyle's Home Service programmes were broadcast from the end of July to the middle of September 1950, with his original lecture on 'Man's Place in an Expanding Universe' broken into two pieces, a lecture on continuous creation, and a final lecture giving 'A Personal View'. By August, however, the controllers of religious programming had scrapped their original plan for a discussion between Hoyle and Herbert Dingle, a professor of history and philosophy of science at University College London, and instead proposed allowing Dingle and religious broadcaster Dorothy Sayers jointly to present a rejoinder to Hoyle. The BBC wrote to Hoyle, explaining, 'This decision was reached as a result of the not inconsiderable pressure on us to allow a Christian to challenge the views you expressed in the final talk about Man's place in a Universe such as you described.'[21]

Following the last lecture, Herbert Dingle and Dorothy Sayers were invited to provide commentary. Dingle had been suggested by a number of astronomers who had been irritated by Hoyle's presentation, no doubt in part because he had been one of the most vocal opponents of the paper Hoyle had published in the *Monthly Notices of the Royal Astronomical Society* in 1949. Sayers was an established BBC broadcaster with a wide range of expertise, including theatre, literature, philosophy and theology. The BBC made it clear that Dingle was to discuss the scientific merits of the talks and to provide some perspective on the universality of his claims in the scientific community, while Sayers was to focus on Hoyle's religious position. This structure reflected and reinforced the BBC stance on separate spheres for science programming and religious programming, and allowed Sayers, who spoke after Dingle, the luxury of ignoring all astronomical content. Through clever parables and analogies, she ridiculed Hoyle for the naïveté of his religious thought and for his apparent lack of

20 Whittaker, E. 'The New Cosmology', broadcast 26 May 1950 on BBC Third Programme, BBC Written Archives Centre, Third Programme Scripts, Microfilm.
21 Mary Somerville to Fred Hoyle, (30 August 1950), BBC Written Archives Centre, Hoyle Talks I: 1947-1962.

understanding of even the simplest theological principles.[22]

In his review, Dingle congratulated Hoyle on his eloquence and charm, but quickly moved to a comprehensive dismissal of his comments on cosmology, taking great care to point out that he was not refuting the steady state hypothesis, merely attempting to correct the impression created by Hoyle that the steady state theory enjoyed the support of significant astronomical evidence or of the astronomical community. Dingle's comments ranged from historical observations, to insider reports about the British astronomical community, to a review of the astronomical evidence. All of these arguments were marshaled into a powerful denunciation of Hoyle's confidence in his 'New Cosmology'. (Dingle pointed out that Hoyle 'begins both noun and adjective with a capital letter'.) Drawing on examples from the Middle Ages to the twentieth century, Dingle told his listeners that the history of astronomy could be characterised by periods when ideas are firmly grounded in observation and periods when 'the whole of astronomy seems in a ferment, and only the unforeseeable can be expected to happen… [and] the present time is emphatically of the second type', though Hoyle had characterised it otherwise in presenting the steady state cosmology as definitive.[23]

The publication of the text of these broadcasts in *The Listener* created a new platform for cosmological argument in the British popular science forum: Hoyle's indignant response to Dingle appeared as a letter to the editor on 16 November, and a weekly volley, joined by Ray Lyttleton writing in support of Hoyle, continued until 21 December. Technical details and citations to articles in the technical literature alternated with *ad hominem* attacks, petty correction of trivial errors, and complaints of various sorts, until Dingle finally capitulated, claiming that his lecture and the ensuing correspondence had surely ameliorated the impression that Hoyle's views were widely accepted, and even admitting that the steady state theory, 'though very far from conforming to its sponsor's view of it, is by no means wholly beneath notice'.[24] Two enduring legacies came out of this exchange. First, the use of the popular forum to discuss technical details, standards of observational evidence, and the likely future of the steady state theory was established at a time when the technical literature had closed off such discussions on the grounds that they were too speculative. Second, the hostile nature of the exchange undoubtedly served to discourage other astronomers from contradicting Hoyle, and at the same time cemented Dingle's stance of opposition, if not immediately to the steady state theory, then certainly to Hoyle and his colleagues. In a letter pitched at presenting Hoyle's lectures abroad, the BBC Controller of Talks noted that,

22 Sayers, D. 'The Theologian and the Scientist', *The Listener*, (9 November 1950), 496-497, 500.
23 Dingle, H. 'Does the 'New Cosmology' Exist?', *The Listener*, (2 November 1950), 456-457.
24 Hoyle, F. 'The New Cosmology (Letter to the Editor)', *The Listener*, (16 November 1950), 547; Dingle, H. 'The New Cosmology (Letter to the Editor)', *The Listener*, (21 December 1950), 798; cf. pp. 594-595, 647, 693, and 743.

'though we sought far and near we could get no other astronomer to come and controvert him at the microphone. A number of scientists… had slaps at him in the Press or on the air, but always at *him*, not his hypothesis.'[25]

While Hoyle fanned the flames, William McCrea, former secretary of the Royal Astronomical Society who had helped Bondi, Gold, and Hoyle publish early versions of their work in the *Monthly Notices of the Royal Astronomical Society*, worked to cool things down. McCrea was also a member of the 'Victoria Institute or Philosophical Society of Great Britain'. Founded in 1865 as an 'avowedly Christian society', comprised mostly of men of science, the Society saw precipitous declines in membership early in the twentieth century. The Victoria Institute's character shifted from a conservative creationist institution at the turn of the century to a more liberal institution where many members were comfortable with theistic evolutionism by the 1920s. By the 1930s, many of the addresses at the Victoria Institute were aimed at demonstrating synergy between science and religion. Nevertheless, in the public discussion that followed a 1937 address at the Victoria Institute, there was much relief expressed that the evolution of the universe carried none of the objectionable connotations that the evolution of life did. In the early 1950s, McCrea delivered a number of crucial addresses at the Victoria Institute that gave a balanced account of possible religious interpretations of the evolutionary and steady state cosmologies.[26]

In 1951, McCrea delivered a talk that was later published as an extensive review of the steady state theory in the *Journal of the Transactions of the Victoria Institute*. The published review is remarkable in this context for its total avoidance of the question of religious implications. McCrea instead focused on the current state of relevant astronomical data and on the status of the theory in scientific terms. He characterised the steady state theory as a defensible and falsifiable theory – in other words, as good science. In the discussion that followed this address, most of the participants followed McCrea's lead and addressed issues of astronomy and the standards of scientific theories. Even Dingle, who chaired the session, commented that the steady state theory, whether or not it would ultimately prevail, was 'quite a normal scientific hypothesis'.[27]

The baptism of the steady state theory was made complete in the discussion,

25 Mary Somerville to O.L.O., (29 October 1951), BBC Written Archives Centre, Hoyle Talks I: 1947-1962. Emphasis in the original.

26 Phillips, T. 'Some Recent Views of the Physical Universe and their Reaction on Present-Day Thought', *Journal of the Victoria Institute* (1937) 69, 183-200. On the Victoria Institute, see Bruce, F. 'Foreword,' *Faith and Thought: Journal of the Victoria Institute* (1958) 90, 1-2 and Numbers, R. *The Creationists: The Evolution of Scientific Creationism*, Berkeley: University of California Press (1992), pp. 140-142.

27 McCrea, W. 'Continuous Creation', *Journal of the Transactions of the Victoria Institute or Philosophical Society of Great Britain* (1951) 83, 105-135. McCrea's text is on pp. 105-122; discussion by Dingle and correspondence from members of the Institute is on pp. 122-135.

with Charles Coulson, a noted Oxford University applied mathematician and evangelical Christian, restating the creation rate as 'one atom of hydrogen in a volume the size of St Paul's Cathedral during one year', and recapitulating the argument that the creation of hydrogen in the steady state theory might be evidence of the hand of God in the daily balance of the universe. Coulson concluded with the remark that 'one might, indeed, say that in so far as this theory provides more colour to our picture of the physical world, it helps the worship of the Christian'. This separation of Hoyle's religious outlook from his cosmological theory had a lasting impact – in 1954, after an anti-steady state lecture by W. Filmer, who claimed that Hoyle had attempted to 'reduce the Creator to the status of an automatic machine for the production of hydrogen atoms', the chairman of the Victoria Institute said, 'This may be true of Mr Hoyle but it certainly is not true of his theory.' McCrea, who was asked to provide written commentary on Filmer's paper, nearly declined, claiming that 'public controversy over such matters is in general quite fruitless'. McCrea felt compelled to respond, however, in order to insist on treating the scientific evidence separately from the considerable philosophical and theological implications. Most of McCrea's communication reads like an errata sheet. He noted that 'many scientists would say that it is too soon to expect solutions to these problems and… we ought not to try to attack them directly'. He countered this sentiment with the idea that 'it is probably valuable that from time to time a survey should be made of the possibilities of progress based upon the existing state of knowledge. But it is valuable only if it reveals the difficulties still to be overcome.' In the end, McCrea reported that Filmer had failed to identify these difficulties.[28]

The scene across the Atlantic was decidedly different in a number of important regards. Though often painted as a counterpart to Fred Hoyle, the Russian emigre George Gamow approached his public in a distinctly different manner. Playful and irreverent, Gamow enjoyed exchanging banter with Hoyle about their respective theories, but nothing like a public controversy is recognisable in the United States in the early 1950s. Late in 1951, as Gamow was completing the manuscript for *The Creation of the Universe*, his seventh popular science book, he found his platform for addressing Hoyle directly. In the preface, Gamow said of this book, it 'is the third of my cosmological trilogy, being a sequel to *The Birth and Death of the Sun* and *Biography of the Earth*… it discusses fundamental questions, such as whether or not our universe had a beginning in time, and whether or not it has an end in space'. Though the first two books in this series were organised around a variety of topics, presenting an overview of their respective fields, *The Creation of the Universe* was organised into topics of pertinence to the emerging debate between evolutionary and

28 Filmer, W. 'Recent Theories of the Origin and Nature of the Universe', *Journal of the Transactions of the Victoria Institute or Philosophical Society of Great Britain* (1954) 86, p. 31, p. 94, pp. 95-96.

steady state cosmologies. *The Creation of the Universe* was Gamow's extended response to Hoyle's *The Nature of the Universe*. Just as Hoyle had dismissed big bang theories on methodological and observational principles before advancing claims about the plausibility of the steady state theory, Gamow dismissed the steady state theory on a variety of observational points, and then summoned a catalogue of support for evolutionary cosmologies. More so than his previous popular books, *The Creation of the Universe* was aimed at a hybrid audience, with Gamow hoping that it would serve scientists and laymen alike.[29]

Gamow was candid about the lack of consensus in cosmological thought, and on first mention of evolutionary and steady state cosmologies presented a balanced view, warning that 'it is probably too early to say which of the two points of view will ultimately prove to be correct'. Gamow's detailed presentation of the steady state theory in the second chapter amounted to one of the clearest descriptions on record. Gamow presented it in his characteristically clear prose:

> [The steady state theory] is based on the assumption that the thinning of matter in the universe caused by continuous expansion is compensated for by continuous creation of new matter, taking place uniformly throughout intergalactic space. To compensate fully for expansion no more is required than the production of one new hydrogen atom per gallon of expanding space once every 250 million years, so the creative genie would not overstrain himself doing the job. According to these views, the older galaxies are gradually receding farther and farther, but all the time new galaxies are being formed by condensation of newly created matter in the widening spaces between them. Thus the show goes on without a beginning and without an end. If we were to make a motion picture representing the views of Bondi, Gold, and Hoyle, and run it backward, it would seem at first that all the galaxies on the screen were going to pile up as soon as we reached the date of 1.7 billion years ago. But as the film continued to run backward, we would notice that the nearby galaxies, which were approaching our Milky Way system from all sides, threatening to squeeze it into a pulp, would fade out into thin space long before they became a real danger. And before the second-nearest neighbors could converge on us (at about 3.4 billion years back in time), our own galaxy would fade out too. While this point of view provides for the origin and evolution of individual galaxies, it considers the universe itself as being eternal, though with a constantly changing galactic population.

Immediately following this charitable account, Gamow thoroughly undermined the whole notion, saying that though it 'may look very attractive to those who find it difficult philosophically to imagine a beginning in time, [it] experi-

29 Gamow, G. *The Creation of the Universe*, New York: Viking Press (1952), p. vii, p. 5.

ences serious difficulties on theoretical as well as on observational grounds'. In particular, he pointed out that the steady state cosmologists could not account for the relative abundances of elements, and he ridiculed Hoyle's theory of element production in stellar interiors as 'artificial and unreal'.[30]

Of course, Gamow was much less critical of his evolving universe model. Evolutionary cosmologies still suffered from the 'age problem' that had inspired Bondi, Gold and Hoyle. Gamow resurrected Einstein's cosmological constant, noting that even a very small nonzero value for this constant would have an appreciable impact on the Hubble estimate for the age of the universe. In his discussion of nucleosynthesis, Gamow made light of the difficulties he was having with building elements, employing a cartoon of his colleague Eugene Wigner leaping spryly over the mass 5 crevasse, a proposal that Gamow admitted would not produce the desired results, and leaving evolutionary cosmologists to search for 'some other similar reaction… to take its place'. These manoeuvres led H.S.W. Massey, in a review for *Nature*, to note that 'it has become quite clear that, unless there are continuous and manifold checks applied to theoretical speculation, its relation to experience becomes extremely slender', a sentiment undoubtedly shared by many of Gamow's colleagues.[31]

The Creation of the Universe, as the title itself indicates, was a pitch for an instantaneous creation of the universe and a discussion of the evolutionary processes in astronomy and nuclear physics that have occurred since the creation. Though Gamow had no intention of attracting religious commentary, many reviewers took notice of the word 'creation' in the title. Hugh Taylor, writing in the Catholic *Commonweal*, opened as follows:

> The Holy Father in an address to the Pontifical Academy of Science in November 1951 pointed out that modern science has 'followed the course and direction of cosmic developments… (and) pointed to their beginning of time some five thousand million years ago.' This little book of one hundred and fifty pages records that course and direction from the beginning.

Taylor later pointed out that 'the use of the word "Creation" in the title is not supported by anything in the text', provoking Gamow to add a note to the second printing:

> In view of the objections raised by some reviewers concerning the use of the word 'creation', it should be explained that the author understands this term, not in the sense of 'making something out of nothing', but rather as 'making something shapely out of shapelessness', as, for example, in the

30 *ibid*., pp. 5, 32-33, 52.
31 *ibid*., pp. 31, 71. Gamow's use of the cosmological constant was quite orthodox. Many cosmologists retained the constant either for mathematical completeness or as a means to fine-tune their models.

phrase, 'the latest creation of Parisian fashion'.

Though Gamow pointed to a plural group of reviewers, Taylor's seems to be the only review that quibbled with the word 'creation'. Gamow was sufficiently irritated by this review to paste it into the front of his desk copy and draw a heavy red line through Taylor's byline, a reaction that seems very much out of character with Gamow's otherwise easy-going manner. In the aftermath of Pius XII's remarks to the Pontifical Academy of Science, Gamow mailed complimentary reprints of two of his technical articles and a copy of *The Creation of the Universe* to the Pope, and lovingly pasted the letters of acknowledgment in his desk copy alongside the positive reviews he clipped.[32]

The tone of religious reactions to the steady state theory in the United States was dramatically calmer than the religious reactions in the United Kingdom. In both the US and the UK, attempts were made to consider the religious impact of modern cosmological theories, but in the US the steady state theory was viewed as more of an oddity than a threat. Synergy between the evolutionary cosmology of Gamow and the Genesis account of creation played a more prominent role in American reactions to cosmological developments. Beyond doubt, the largest difference between the British and American situations was the almost total lack of engagement between elite American scientists and their religiously sympathetic colleagues. Whereas the British Broadcasting Corporation and the Victoria Institute played considerable roles in the framing of the British cosmological scene and the big bang-steady state debate, there were no analogous roles in the American scene.

The American Scientific Affiliation, founded in 1941 to foster synergy between faith and science, had outward similarities to the Victoria Institute. Full membership in the ASA was contingent upon holding a science degree and being engaged in scientific work. In the September 1950 *Journal of the ASA*, Delbert Eggenberger of the Illinois Institute of Technology published an extensive review of the technical literature on nucleosynthesis that surveyed a broad swath of articles in American, British, and German physics and astronomy journals. Only the last paragraph made reference to the religious implications of evolutionary cosmology. Eggenberger noted that, 'To the Genesiac exegete, present theories are refreshing in the implication of the sudden appearance of mass a finite length of time back. This could well be the creation of Genesis 1:1.' A few years later, Eggenberger reviewed Hoyle's *The Nature of the Universe*, noting that the steady state theory led to the paradoxical conclusion that 'bodies an infinite distance away are moving away at an infinite relative velocity,'

32 Taylor, H. 'A Few Billion Years Ago (Review of *Creation of the Universe*)', *Commonweal*, (6 June 1952). Gamow pasted a copy of the review into his shelf copy, and drew a red line through Taylor's name. Gamow's desk copy has been preserved by the Library of Congress. The two technical pieces sent to Pius XII were Gamow, G. 'The Role of Turbulence in the Evolution of the Universe', *Physical Review* (1952) 86, 251; and Gamow, G. 'The Origin and Evolution of the Universe', *American Scientist* (1951) 39, 393-407. In the former, Gamow quoted from the papal address.

and ultimately dismissing Hoyle's position in terms of religion *and* science, concluding that 'it seems impossible to find a correspondence between the continuous creation theory and Genesis 1:1. Also, from a perusal of the literature, it appears that few, if any, other cosmologists are following this theory.'[33]

In 1953, the *Journal of the ASA* initiated a series of columns providing updates in each of several scientific disciplines. The first instalment on astronomy was a letter from Owen Gingerich, an alumnus of Goshen College, a Mennonite school, who was at the time a graduate student in astronomy at Harvard. Gingerich provided a straightforward review of the problem of calculating the age of the universe, with no religious commentary. A year later, Gingerich contributed another letter on continuous creation, which he said 'belongs to the highly speculative realm of cosmology… its mere mention can produce a controversial argument between astronomers'. Like Gamow, Gingerich appeared either unfamiliar with or totally unimpressed by Hoyle's consideration of conservation principles, noting both that continuous creation amounted to *ex nihilo* creation and that it violated the law of conservation of energy.[34] Despite the technical tone of these contributions, they were either unknown by Gamow and other American cosmologists or were totally disregarded by them. There is no evidence that these notes made any impact in the specialists' forum or the general science forum in the United States. The editors of the evangelical magazine *Christian Life* commissioned an article on the latest state of affairs in the science of creation, resulting in a collaborative venture published in 1955 by several prominent members of the American Scientific Affiliation. They noted that 'several lines of evidence point to a unique creation of the universe', and made no mention of the steady state theory. Indeed, the only reference to a contemporary text was to Lincoln Barnett's article on 'The Starry Universe', which appeared as the conclusion of a 13-part series on 'The World We Live In' in the pages of *Life* magazine. Barnett gave a paragraph to the evolutionary cosmologies of Lemaître and Gamow and another to 'a British school of cosmology', but aside from noting that the big bang enjoyed greater credibility than the steady state theory, Barnett made no mention of controversy or debate. The religious issues raised by physical cosmology in the American evangelical press made no mention of cosmological debate and instead focused on synergy between Gamow's work and the Genesis account of creation. These articles in *Life* and *Christian Life* indicate that by the middle of the decade, no debate between big bang and steady state cosmologists had been framed in the popular forum in the United States.[35]

33 Eggenberger, D. 'Gamow's Theory of Element Building', *Journal of the American Scientific Affiliation* (1950) 2, 23-26; Eggenberger, D. 'Book Review, *The Nature of the Universe*', *Journal of the American Scientific Affiliation* (1952) 4, 3-4.

34 Gingerich, O. 'New Distance and Time Scale', *Journal of the American Scientific Affiliation* (1953) 5, 12-13; Gingerich, O. 'Continuous Creation', *Journal of the American Scientific Affiliation* (1954) 6, 30-31.

35 Kulp, J. et.al. 'Origin of the Universe,' *Christian Life* (March 1955), 15-17, 54; Barnett, L. 'The Starry Universe', *Life*, (20 December 1954), 44-70.

One of the remarkable features of the big bang-steady state debate is its near absence from the scientific specialists' forum in these early years. Scientists and science writers frequently noted this explicitly. In 1950, McCrea wrote in the pages of *Endeavor*, 'in its present state, cosmological theory probably impresses the general theoretical physicist as a highly unsatisfactory subject', and Clark wrote in *Science and Religion*, 'most scientists feel that, today, cosmological speculations are becoming altogether too free and unrelated to known facts'. Many of the cosmologists interviewed by Alan Lightman in the 1980s recall similar sentiments.[36] At roughly the same time, astronomers working with the 200-inch telescope on Mount Palomar came to realise that the world's largest telescope did not have sufficient light-gathering power to see objects sufficiently distant to distinguish between cosmological models. The Palomar telescope quickly proved to be a most valuable tool for investigating galaxies, assuring its importance to the astronomical community, but it was soon seen to be of little use in settling the big bang-steady state debate. Gamow conceded that stars might make up part of the nucleosynthesis in the universe, removing yet another distinguishing test between models, and even Gold admitted at the British Association for the Advancement of Science meeting, 'I am not sure that on a day like this it is not better to enjoy the cosmos than to investigate it.'[37] In an article on stellar evolution and nuclear synthesis, Fowler, Burbidge, and Burbidge explicitly pointed out that 'it is not possible at our present stage of knowledge to choose between a primeval and a continuous synthesis'.[38]

A thriving big bang-steady state debate existed only in the public forum in England during these years. Relaxed standards for observational evidence and an appreciation for originality of argument allowed cosmologists to interact in this form, which proved to be an ideal venue for the discussion of cosmological ideas. In scientific circles, we can recognise a growing research programme in the United States and a struggle for credibility in the United Kingdom, but almost no communication at all between these two groups. In the technical literature, evolutionary cosmologies were dismissed at first because of the age problem and later because they were not philosophically satisfying. Steady state cosmologies were dismissed as ad hoc or outside the realm of a relativistic paradigm, despite Hoyle's relativistic formulation. It was the debate in the public forum in Britain in the early 1950s, sustained largely by the theological

36 McCrea, W. 'The Steady-State Theory of the Expanding Universe', *Endeavour* (1950) 9, 3-10; Clark, R. 'In the News', *Science and Religion: A Review of Current Literature and Thought* (1950) 3, 9; Lightman, L. & Brawer, R., (eds.), *Origins: The Lives and Worlds of Modern Cosmologists*, Cambridge: Harvard University Press (1990). In *Origins*, see in particular the comments by Steven Weinberg (pp. 452-454) and Dennis Sciama (p. 145).

37 Gold, T. Lecture Notes for BAAS, Oxford, Gold Papers, Folder: Lecture, British Association (1954).

38 Fowler, W., Burbidge, G., & Burbidge, E. 'Stellar Evolution and the Synthesis of the Elements', *Astrophysical Journal* (1955) 122, 271-285.

richness of the dispute, that established the basic features of the controversy per se – the contentiousness, the hope for observational adjudication, and the sense of stage play that shaped the norms of behaviour and expectations for resolution in the 1960s and beyond.

Historian Helge Kragh says that the religion issue, while perhaps 'interesting in its own right', is 'in the end… by and large, much ado about nothing'. Taking the long view, Kragh is perhaps correct in his claim that these religiously motivated discussions had no impact on the ultimate technical framing of big bang cosmology in most quarters after the 1970s, but in dismissing the long-range impact of these discussions, he has glossed over them too quickly. Particularly in Britain, the dynamic that played out between science and religion in cosmological discourse played a constitutive role in the terms of debate and in the very existence of the debate between steady state and evolutionary cosmologies. For most participants in the controversy in the first half of the 1950s, their reason for participating in the dialogue and their guiding questions are a direct result of the anti-religious baiting that Hoyle incorporated into his BBC lectures. The theological context of the big bang – steady state debate is thus an important part of the early history of modern physical cosmology, and a case study that shows that the interactions between science and religion are neither predictable nor controllable.[39]

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39 Kragh, H. *Cosmology and Controversy:The Historical Development of Two Theories of the Universe*, Princeton, New Jersey: Princeton University Press (1996), p. 251.