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Physical Infinities: a Substitute for God?

It has been argued at various times that our universe may be infinitely old, infinitely large, or one of an infinite set of universes. In such ways the physically infinite has sometimes been seen as a substitute for God or a means to avoid thinking about God. In particular, this may refer to the causational aspects of the universe, the presence of laws of nature, and to intelligent design arguments. This article presents a survey and a critique of these ideas. That they do provide a plausible replacement for God is highly questionable: either the ideas themselves lack a firm basis, or else faith is able to accommodate them.

Keywords: infinite, infinity, universe, God, design

Introduction

Writing many years after the event,[1] the astrophysicist C. F. von Weizsäcker described a thought-provoking experience which took place in the year 1938 in Berlin. He had been giving a university colloquium on nuclear processes in the sun, proudly remarking that his ideas fitted in well with current thinking on the finite age of the universe. But this aroused violent opposition from Walther Nernst, a celebrated elderly physical chemist who was present. The age of the universe, Nernst expostulated, was not science; science demanded the 'infinite duration of time'. The age of the universe should not even be put forward as a hypothesis – this 'contradicted the very foundations of science'. The older scientist held these views in an evidently very emotional way.

Reflecting on the incident, von Weizsäcker concluded that the problems Nernst had with a universe of finite duration were not of a scientific nature. Why was he so angry? The answer seemed to be that in Nernst's outlook, 'the everlasting universe had taken the place both of the eternal God and the immortal soul'. A deeply irrational trait was revealed in what purported to be a scientific opinion. The world had taken the place of God, and it was blasphemy to deny it God's attributes.

The aim of the present article is to examine the place of ideas of the infinite in the physical universe and their impact, or otherwise, on Christian belief in God.[2] Two problems must be kept in mind. The first is that if the connection

1 von Weizäcker, C. F. *The Relevance of Science*, 1959-60 Gifford Lectures: London: Collins (1964), pp.151ff.
2 Which in this debate, of course, affiliates with Jewish and other beliefs in God.

between scientific beliefs and religious beliefs (or their absence) turns out to be 'irrational', there will no doubt be limitations to exploring them rationally; be this as it may, it is useful to demonstrate even an irrational connection if it is present. The other difficulty is that scientists and others may not openly come forward with an admission that their scientific views derive from theological scepticism; indeed, as is likely in Nernst's case, the thought might not even consciously cross their minds.

Still, there are those who are quite explicit about such matters. As an example, the theoretical physicist Leonard Susskind has recently published a book *The Cosmic Landscape: String Theory and the Illusion of Intelligent Design*.[3] His purpose is to advance the view that a quasi-infinite number of physical universes, of which ours is just one, have occurred or will occur. In this case a universe with the appearance of design will be bound to be found sooner or later, and we need not bring God into the argument. Here the intentions are clear and the agenda is in no way hidden.

In the following sections, we will first consider a historical perspective on thoughts of infinity and the infinite, starting with the mainly theistic context of medieval Europe. We then survey some specific ways in which the infinite has been introduced into human attempts to understand the physical universe. These will include whether the universe is infinitely old, infinite in spatial extent, or whether there is an infinite number of universes. We will try to draw some conclusions about the implications, if any, that all this may have for religious belief.

A brief historical overview

The world of the medieval philosophers may seem a surprising starting point for a discussion of modern physics.[4] However the thinkers of this period exposed and discussed many basic questions in the area of natural philosophy.[5] Here we are concerned with the idea of infinity in mathematics and in nature, including both space and time. The academic debate of the medieval period may be regarded largely as reactions to the teachings of Aristotle and the later Arabic philosophers, with the writings of St Augustine providing an important input. Scientific knowledge was limited, but some of the philosophical arguments were relatively sophisticated. In mathematics, a number of the questions discussed were dealt with properly only after the development of differential calculus by Newton and Leibnitz in the seventeenth century, and of infi-

3 Susskind, L. *The Cosmic Landscape: String Theory and the Illusion of Intelligent Design*, Adult Books (2005).
4 Information from this section has been largely obtained from Pierre Duhem, *Medieval Cosmology*, Ariew, R. (ed. and trans.), Chicago: Univ. of Chicago Press (1985).
5 Grant, E. *The Foundations of Modern Science in the Middle Ages*, Cambridge: Cambridge Univ. Press (1996).

nite set theory by Cantor in the nineteenth century.

In discussing the infinite, a particularly important distinction must be made between saying that no upper limit may apply to a quantity, and saying that it can be actually infinite in magnitude. The former sense is obviously weaker than the latter. Thus, we might say that a line can be indefinitely long meaning that although it is always finite in length, it can be as long as we wish it to be. But it is quite another matter to claim that a particular line is actually infinitely long. With regard to the physical universe the issue is therefore not whether a universe can be as large as God may choose to make it, but whether our own universe is actually infinite.

Aristotle had held a negative opinion on the existence of any kind of infinite quantity. Thus his universe was finite in extent, comprising a set of concentric spheres centred on the earth, and time was also finite; here the philosopher believed in a series of cyclic recurrences of the history of the universe. His medieval followers were forced to adjust his views on the latter topic, since the teaching of the Christian Church was clearly that time had a beginning.

The central new task for the medieval philosophers was to incorporate Christian teaching on the nature of God into their critique of Aristotle's ideas. It is God's infiniteness that is especially relevant in our present context, because it may allow him to create infinite things, provided they are of a lesser kind of infinity than his own. Thomas Aquinas therefore taught that God could create any kind of infinite thing that did not imply an inner or logical contradiction. However he himself believed that an infinite object always entailed some kind of philosophical contradiction, and so was not creatable. It was generally accepted that to talk about potentially infinite things was permissible. Thus a line was potentially infinite if it could be extended as far as one wished, and numbers were potentially infinite likewise. However an actually infinite number presented problems, as did the idea of an actually infinite line. The philosophers fell into two camps according to whether or not they felt that these difficulties were surmountable.

The French mathematician John Buridan[6] put forward what turned into a classic problem. It was accepted that a finite number could be the sum of an infinite number of subdivisions: thus, one equals one-half plus one-quarter plus one-eighth, and so on. So, proposed Buridan, let us imagine a cylinder of unit height that is subdivided in this way into sections of height one-half, one-quarter, and so on. Further, let us imagine that a line is drawn obliquely around the circumference of the cylinder once within each of these sections, starting at the lower boundary and ending at the upper. These lines can be joined at their ends so as to make one overall spiral line, and since the number of height sections is infinite, the overall line will be infinitely long. Buridan himself did not believe that such a line could exist, because he did not believe in actual infini-

6 Duhem *op. cit.*, [4].

ties. Others disagreed, and so opinions were divided.[7]

Concerning infinite space, views also differed. There were two issues here, one of which was whether more than one universe (or 'world') could exist. In 1277, Bishop Tempier of Paris issued a list of prohibitions of opinions that he considered erroneous, included in which he declared that to deny the possibility of multiple universes was to deny God's creative power. Thereafter, the philosophers of the University of Paris were obliged to consider other universes as possible, at least in principle; however they spent much effort expounding the difficulties presented by this idea. Nobody in the medieval period, it seemed, positively believed in other universes, but merely – following Bishop Tempier – in their possibility.[8] A notable later exception was the Scottish born Parisian scholar John Major, who taught around 1500. His view was that there exists an infinite number of worlds simply because 'one cannot give a convincing reason for the opposite of this opinion'.[9]

Even with only one universe, the question needed to be raised as to what lay outside it. Possibly this might be an infinite void, if a void could exist, which was another hotly debated topic. Thomas Bradwardine of Oxford, in the fourteenth century, held that since God was infinite and was intimately related to the universe, an infinite outer space should exist simply as a manifestation of God's own immensity.[10]

A universe that is infinite in too many ways is problematic. It risks contravening an objection raised by the fourteenth-century John of Bassols[11] that while God can create a universe that is infinite in a few ways, one that is infinite in every way would trespass on God's own infinitude and make it appear that God had created something resembling another God. This of course is disallowed from a Christian perspective. If the universe is 'acceptably' infinite, we may be inclined to associate God with it in a strongly immanent sense. This can easily develop into a form of pantheism, something which Bradwardine strove to avoid by using language that was sufficiently vague.

The belief that the universe was finite generally prevailed until after the work of Copernicus and Galileo placed the sun, rather than the earth, at the centre of the cosmic stage. Galileo, however, was at heart a practical astronomer who interpreted his findings along Copernican lines but was not primarily interested in speculating on the nature of the Cosmos as a whole – no doubt feeling that he had enough controversy on his plate already. His approach was above all to seek to justify his views by means of experimental

7 There are also modern thinkers who are sceptical about actual infinities, such as W. L. Craig and G. Ellis. I thank one of this journal's referees for pointing this out.
8 Grant *op. cit.,* [5].
9 Duhem *op. cit*., [4], p. 503.
10 Grant *op. cit.*, [5], p. 123.
11 Duhem *op. cit*., [4], p. 97.

observations. It was Newton who presented a broader picture, his theory of gravity providing a set of new ideas that were sufficiently powerful to give a framework for cosmology.

In Newton's view the universe was infinite, and his reasons for believing this were very much connected with his view of God as filling all space and time. 'By existing always and everywhere, he constitutes duration and space… each and every particle of space is *always*, and each and every indivisible moment of duration is *everywhere*…' Bradwardine had not identified God quite so closely with the physical universe, but these were similar ideas, reflecting a deity whose immanence in the universe meant that the universe has to share physically in his infinite nature.[12] In attempting to model the universe, Newton had his own law of gravity very much in mind. He believed that if the universe consisted of matter that occupied a finite volume of space, the matter would eventually all fall in on itself through mutual gravitational attraction. However if the matter were 'evenly disposed throughout an infinite space' it could condense in local clumps to form the sun and the stars, scattered over great distances as observed.

Later physicists were not convinced by Newton's arguments, and in the nineteenth century the most commonly held view was of a universe that comprised infinite space except for one major congregation of matter, namely our own galaxy. This was allowed to rotate so that it did not fall in upon itself. A highly important development was the transition from seeing the universe as a few thousand years old (following the traditional interpretation of Genesis) to many millions of years old, as argued by geologists. A few people posited an infinitely old universe. The twentieth century saw the acceptance that just as the stars were bodies like our own sun, so the 'nebulae' were in many cases galaxies like our own. What had formerly been an infinite outer void was now occupied by these galaxies – in this way producing a vision of the universe that was perhaps not so very unlike Newton's after all.

Some mathematical background

The thirteenth-century Duns Scotus may have been the first to warn that magnitudes of infinite quantities cannot easily be compared so as to say that one is more or less than another; usually, infinite is infinite and one must leave it at that. His statements did not amount to a clear mathematical treatment of the subject but did at least help his followers to avoid simplistic errors, and many of the infinitist school owed allegiance to his teachings.

It was left to Georg Cantor, six hundred years later, to put the mathemati-

12 Newton, I. *The Principia, General Scholium* (1687), Cohen, I.B. and Whitman, A. (trans.), Berkeley: University of California Press (1999), p. 94.

cal understanding of the infinite on a better footing.[13] Mathematically speaking, the set of whole numbers is infinite, but the set of possible lengths of a line is 'more infinite'. The set of whole numbers is infinite in a 'countable' sense: we can count them as 1, 2, 3, and so on indefinitely, and we will reach any particular member of the set eventually in this way. Although there is no upper limit to this, techniques of mathematical logic have been devised to provide satisfactory ways to deal with the 'entire infinite set' of whole numbers. On the other hand, the set of possible lengths of a line, or equivalently the set of 'all decimal numbers between zero and one', is 'continuously infinite'. No counting procedure can be devised such that any given length of line will be counted sooner or later, and it was the achievement of Cantor and his followers to make these ideas mathematically rigorous. Further classes of 'more infinite infinities' can be defined, but these examples will do for us here.

What Cantor's work made clear is that infinity is in no way a simple concept, and the further development of his ideas has been a major area of mathematical research since then. Cantor himself became firmly convinced that God, as 'absolute', was the 'true infinity' beyond the series of infinities uncovered in the mathematical realm. At least by analogy, God can therefore be 'more infinite' than an infinite universe if the latter exists – a theme which had its place in the medieval discussion of infinities.

An infinitely old universe?

Bishop Tempier included in his prohibitions the advocacy of an infinitely old universe. The earlier medieval scholars had occasionally mentioned the subject, but only as a philosophical possibility with many qualifications.[14] Thomas Aquinas had avoided taking strong sides on the matter saying that nothing could be demonstrated. After Tempier, most opinions settled on the orthodox teaching that the history of the universe is finite. It was later realised that having a universe of finite size or finite age could avoid Olbers' paradox.[15] However the issue was a matter of debate during the following centuries.

The most important cosmological development during the twentieth century was the observationally-based discovery that our universe is expanding. This provided a different way of avoiding Olbers' paradox and enabled debates concerning the finite or infinite size of the universe to be reopened on a more scientific basis. The reason why the night sky appears black is that the light from stars and galaxies is visible to us only out to a finite distance, beyond which the

13 Barrow, J. *The Infinite Book*, Jonathan Cape (2005) contains a fuller and very readable account of Cantor and his work, together with a more detailed explanation of many of the physics topics discussed here.
14 Grant *op. cit*., p. 75.
15 Olbers' paradox (originally stated by Kepler) points out that in a truly infinite universe the sky will not be black, but we should see a star in every direction.

galaxies are receding from us faster than the speed of light, so that information from them can never reach us. Thus astronomers today emphasise that our measurements refer to the *observable universe*. A finite age to the universe also puts a limit on its observable size.

A common objection to an infinitely old universe had been that as a consequence of the second law of thermodynamics, any universe will 'run down' eventually, the so-called 'heat death' of the universe. This has not yet happened, implying that our universe must be of a finite age. Occasional thinkers such as Nietzsche (and Aristotle) had postulated an infinitely recurring universe, which is also a feature of Indian thought, but the thermodynamic argument remains very difficult to overcome. There was considerable interest, therefore, when in the late 1940s three physicists in Britain proposed a new theory in which the universe was both infinite in extent and also infinitely old – the so-called 'steady-state' theory of the universe by Hermann Bondi, Thomas Gold and Fred Hoyle.[16]

At the centre of the steady-state theory was the idea that the universe should possess the property of having the same appearance at all places and at all times, the so-called Perfect Cosmological Principle. All three physicists concurred in stating that their motivations were 'philosophical'. There were initially two variations on the theory, that of Bondi and Gold being more explicitly based on the Perfect Cosmological Principle, while Hoyle sought more to avoid the Big Bang. A universal expansion of space was postulated in which matter continually appeared spontaneously thoughout the universe, its mean density always staying the same. There were two more specific motivations for the steady-state theory. One was that the measured value of the Hubble constant gave an age of the universe that was too young, a discrepancy that was eventually rectified by better experimental data but which was a problem at the time. This gave a certain amount of a priori credence to alternatives to the standard Big Bang model.

The other motivation, stated openly by Hoyle, was to avoid having a finite starting-point to time. He wrote: '… it seemed absurd to have all the matter created as if by magic… I therefore began to see if the creation of matter could be put into a rational mathematical scheme.'[17] Whether such a motivation is 'philosophical' or based on antipathy to religion is clearly a question of some delicacy. None of the originators of the steady-state theory wished to assert the latter as a scientific reason in scientific circles, but all three had attitudes to religion ranging from sceptical to hostile. In a series of BBC radio broadcasts written up in a widely-selling book,[18] Hoyle took the opportunity to make a naive attack on Christian beliefs, and he retained a strong anti-clericalism

16 Nernst had earlier put forward a less developed theory of this type.
17 Hoyle, F. *Steady-State Cosmology Re-Visited*, Cardiff: Univ. College Cardiff Press (1980), p.7.
18 Hoyle, F. *The Nature of the Universe*, Oxford: Blackwell (2nd edition, 1960), pp.100ff.

throughout later years.[19] Bondi likewise remained extremely antagonistic towards belief-systems. Bondi and Gold were later to accept the standard Big Bang theory when the experimental evidence became stronger, but Hoyle (with colleague Narlikar) went on to develop a more elaborate theory which allowed a quasi-steady-state viewpoint to be formulated on a broader temporal scale. He was later to refer to God more impersonally as 'the system of laws that govern the Universe, what are often called the laws of physics'.[20]

Hoyle was the most prominent and persistent advocate of the steady-state theory. Whatever his deepest motivations may have been, the infinity of the age of the universe certainly allowed him to avoid the question of whether a finite universe requires a First Cause, and what this First Cause might be.

In general, there seem to be a number of options on this question. The traditional one is to suppose that there was indeed a First Cause to the universe, arising from outside physical time and to be identified with God. This type of argument is ancient but was formulated in a famous way by St Augustine. It obliges us to think very carefully about the nature of causation, however, since it implies that causation is more than just a *physical* process. Stephen Hawking has suggested that time might change its nature at the earliest stages of the universe's development; this begs the question, though, because if at some stage time is no longer capable of sustaining causal processes, then one must here again seek a First Cause from outside time. Another attempt at an answer has been to suppose that the universe can somehow just happen. The Chicago theorist Rocky Kolb has stated: 'The laws of the universe tell you if you start out with truly nothing, this is unstable and will decay into something. Yes, the universe is inevitable. Nothing cannot exist forever… I usually wear my Zen robes when I talk that way.'[21]

Of course there are many objections to this latter kind of pronouncement. Terms such as 'unstable', 'decay' and 'forever' imply at least an existence of time. Time in present-day physics is also intimately bound with space. Indeed, 'nothing' surely cannot possess any qualities at all, not even Zen-like ones! The laws of what universe, might one also ask? The only way to pursue this type of argument would be to suppose that the laws are like Platonic Ideas which exist timelessly but which also have the ability to materialise temporal universes out of nothing: that is to say, nothing physical. Philosophically speaking, however, there is an enormous difficulty in giving Ideas material creative power. Possessed of such remarkable ability, a set of Platonic Ideas is clearly a quasi-divinity: definitely a substitute for God. Though where, we might wonder, did the Ideas themselves come from?

19 Kragh, H. *Cosmology and Controversy*, Princeton Univ. Press (1996). For a further discussion of many of the topics covered here, see Kragh, H. *Matter and Spirit in the Universe*, Imperial College Press (2004).
20 Hoyle, F. *Man in the Universe*, New York: Columbia Univ.Press (1966), pp.16f.
21 Quoted in *Vanity Fair*, June 2004, p.142.

An infinite past time scale for the universe can itself clearly play the role of a God-substitute. It is there, always in the past, its contents always providing the Efficient Cause of any given situation. It is hard to be certain whether anti-religious sentiment formed a conscious part of the motivation for the steady-state theory, but there is a fine line in this kind of area between philosophy and religious avoidance.

In fact, Christian believers were able to accommodate themselves to the steady-state theory. God could still be attributed as the Efficient Cause of the infinitude of creative processes that generated the matter that was always spontaneously appearing in space.[22] This was not such a powerful argument as the traditional First Cause argument, however, because the spontaneous appearance of atoms might be asserted as a 'property of space' (although unexplained) while the truly spontaneous appearance of a universe strains one's credulity to its limit, especially if claimed as a property of 'nothing'.

An infinitely large universe

As we have noted, the medieval universe was believed to be spatially finite. The system of concentric celestial spheres allowed the intuitively satisfying picture of having God's heavenly realm located physically in the region surrounding the universe. In contrast, Newton's universe was of infinite size. However, the basic existence of God, as an item of primary faith, did not seem much affected by whichever choice was made. Neither did it seem to matter whether the universe was infinite and full of stars, as with Newton, or whether an infinite void lay outside our galaxy, as with much of later opinion. Such a void was of course both conceptually simple and sufficiently close to non-existence so as to present no encroachment on God's own infinite nature.

Space curvature

In the twentieth century the idea of an infinite outer void was abandoned, and the choice lay between a finite or infinite universe of matter. Both cases were consistent with Einstein's General theory of Relativity. For a finite universe, the simplest analogy was to the surface of an expanding balloon. As a balloon is blown up, points on its two-dimensional surface become more and more separated; in the same manner, as time elapses, this also happens to points in the three-dimensional space of an expanding universe. Now, the two-dimensional balloon surface exists within ordinary three-dimensional space. Even without the existence of a third space dimension, however, two-dimensional surfaces can be mathematically defined that have the property of closing upon them-

22 Kragh *op. cit.*, [18], pp. 254f., relates how the radio astronomer Bernard Lovell and the cosmologist William McCrea were both Christian believers who accepted the steady-state theory – McCrea even helped to develop it.

selves like that of the balloon (they are 'topologically compact'). Likewise, it is not necessary for a three-dimensional space to be contained in a fourth space dimension in order to close around on itself in this kind of way. Three dimensions, suitably mathematically defined, will do.

Let us imagine a planet whose surface is permanently hazy, so that neither the skies nor the horizon are seen. Without being aware of their planet's spherical form, the inhabitants of such a world might still develop a knowledge that if they travelled far enough in a straight line, they would return to their starting point. Such a situation would be attributable purely to a strange inbuilt geometric property of their planet's surface. The same mathematical property – curvature – can be attributed to three-dimensional space, such as that of our universe; it too could have the feature that a straight line projected from a planet (say) will end up returning to its starting-point from the opposite direction, like a line drawn on the surface of the earth. The universe can in this way be both finite and unbounded in the sense of having no edges.

Curvature as an inbuilt geometrical property of space is a key part of the theory of General Relativity, at the heart of which lies a relationship between energy density and space-time curvature. The universe is finite if its mean energy density is sufficient to make space close round on itself, which happens above a certain critical value. Otherwise the universe is open and infinite in extent. These statements apply to the simplest, spherical, spatial topology; in more complex cases a less dense universe can also be finite. But in all cases the universe is expanding with time, starting at a finite point in the past when for an infinitesimal instant it was infinitely dense. This initial explosive start to the universe was the Big Bang. There has been much debate among cosmologists about whether a mathematically singular starting condition is acceptable in a theory of the universe. As we shall see, however, some much more remarkable ideas are in circulation.

Does either a finite or an infinite universe, as such, make it easier or harder for a person to believe in God? A finite universe is conceptually simpler, according to taste perhaps more aesthetic, and possibly easier to place in relation to God since we can consider it as a whole. An infinite universe can still be accommodated, however, as with Thomas Bradwardine and the prevailing opinion of most seventeenth to nineteenth century physicists who were believers. Indeed for pantheists who want an infinite God, it may be essential to make the universe also infinite.[23]

Observational considerations

Recent measurements of the energy density of the universe – which seems to

23 On the other hand Bertrand Russell, who was far from being a believer, seemed prepared to accept the possibility of a universe finite in space and time, see *Human Knowledge* (1948), p. 28, reissued Routledge, 1994).

contain matter of different kinds and a mysterious unidentified component known as 'dark energy' – appear to be very close to the critical value, possibly slightly higher. Suggestions have been made[24] that the measurements may imply a universe that is finite, but very large, and with a more complex topology than that of a sphere. There are significant experimental uncertainties on these results, however, and it is very possible that our measurements will never be able to distinguish between a finite and an infinite universe.[25] If the universe actually has the critical energy density, then no measurement with a finite uncertainty could ever establish this precisely.

Another point is that our direct experimental knowledge is confined to the portion of the universe that is observable to us – though that might encompass the whole universe. A major limit occurs at the early period when the cosmic microwave background was formed (originally as very hot radiation). Prior to this, however, the light chemical elements had already formed with certain abundances which give us some information about earlier times. It is from properties of the cosmic microwave background that the possible topology of the universe is tentatively argued. The limited observations may be able to disprove certain models of the universe, but to prove that the universe is infinite seems to be an impossibility. Even if we could show that its mean density is lower than the critical density, it might still be possible to embed the observed universe into a larger but still finite structure. Conversely, an apparently finite observable universe might be part of a larger infinite structure – unless we can demonstrate that the observable universe includes all of it.

The laws of physics as 'infinites'

Every electron in the universe has a physical nature that is, as far as we can tell, the same. Likewise so has every proton, and every other type of elementary particle. They do not have a spread of properties, as exists for example with individuals of a given biological species. What rational reason can be given for these cosmic coincidences? The normal statement is that all physical things in the universe are subject to the same laws, and these are responsible for the identical nature of every electron, every proton, and so on. What then is the nature of the laws of physics? This is a big question, but their universality and their seemingly infinite scope and determining power may allow them to pose as another kind of substitute for God, one in which a number of modern cosmologists appear to believe. The aim of many theorists is a complete unified theory of the laws of the universe, something of interest to both believers and unbelievers, of course. However, for unbelievers, this goal has finality. It appeared to be Fred Hoyle's viewpoint that laws of physics were all there is of God to know.

24 See articles by G. D. Starkman and D. J. Schwarz, *Scientific American*, August 2005 and J-P Luminet, *Physics World*, September 2005.
25 Barrow *op. cit.,* [12], and interview in *Physics World*, Feb. 2005, p.12.

There are two modes to the laws of physics that are important here. The first might be termed their immanent presence within the universe, determining physical processes. Another much more controversial possibility is that the laws might exist *transcendently* as quasi-Platonic entities, a suggestion already mentioned. But it is always possible to ask further underlying questions, and God, to the believer, is the Creator and Initiator of the laws of physics.

To Einstein, whose God was not of a personal kind, the laws of physics were nevertheless direct manifestations of a divine Mind. If, for some, too much emphasis on the laws of physics therefore seems uncomfortable, two avenues may be available. For the first, it may be noted that the laws are not quite infinitely precise in their effect: there is quantum randomness in nature (according to most interpretations of quantum theory) and so not everything is completely determined. Einstein strongly objected to this notion and made the famous protestation that 'God does not play dice'. The mathematical laws of quantum theory nevertheless do specify the relevant probabilities for quantum events to happen. The next step, and an extremely bold one, is to talk about the quantum 'wave-function of the universe' and to propose that there is randomness of a radical kind in the initial processes out of which the Big Bang itself emerged. It just 'happened', by chance, as a kind of secular miracle. There are still laws, but the stress is here on the randomness. However to propose that the initial appearance of the universe lacked a proper cause seems to undermine in a big way the scientific search for rational understanding of nature. Rather than having the universe happen for no real reason, even in the presence of Platonic Ideas, it may be more reasonable to attribute everything (including the Ideas) to the Mind of God after all.

But the main problem with treating Platonic entities as a substitute for God, even by implication, is that it is hard to see how they can have physical creative power. They are not the right kind of things for that.

Moreover, it is one thing to believe in small-scale randomness in nature, connected with quantum measurements and similar processes when an atomic-scale object interacts with a large-scale measuring apparatus. It is another thing to say that these two entities constitute a single 'self-measuring physical system', and another again if the latter is the whole universe. Even the nature of normal quantum processes is something for which we have no good understanding yet, within current theory. So it is probably necessary to solve this problem first before we can have any confidence as to whether one can talk sense about the wave-function of the universe.

Another possibility is to make the laws of physics into less universal objects, as we discuss in our next section.

Infinitely large or multiple universes and questions of design

Anthropic arguments and design

An interesting recent development in the theo-cosmological debate – as readers of this journal will be well aware – is whether the universe shows evidence of design. This could be manifested in a number of ways. At the biological level, it might be that living organisms have sets of characteristics that require multiple finite changes to have taken place in the organism's genetic material in a highly coordinated manner. This might possibly be difficult to accommodate within Darwinian theory, but could provide evidence for the activity of a Designer if we decided that the probability of the set of changes occurring by random chance is unacceptably low.

More broadly, a strong case can be made[26] that with given physical conditions the initial development of life was unlikely, and the evolutionary emergence of our own species highly unlikely. This lies at the crux of whether Darwinian theory is a good explanation for our existence, and it is not easy to see how the necessary mathematical information can be made precise. The so-called 'anthropic principle' states that we must by definition live on a planet capable of supporting our development and existence. P. Ward and D. Brownlee[27] have argued that primitive life may be frequent in the universe, but that advanced life may be quite uncommon.

Life also requires a number of physical constants to be right. For example, carbon and other chemical elements must be available. These are produced inside stars, and when the latter finally explode as supernovae at the end of their lives, their material is dispersed in space to form subsequent stars and planets, including our own. But the formation of large quantities of carbon requires a particularly delicate adjustment of the nuclear physics, and if certain constants of nature were substantially different from their actual values, the chemical constituents of life would not be present usefully in the universe.

So there is a sequence of questions which can be summarised as follows:

1. Given that Darwinian processes occur, how much time might be required for a species such as ourselves to evolve from simple organisms?
2. How likely is it that an absence of planetary catastrophes (such as collisions with extra-terrestrial bodies or instabilities of the sun) will allow advanced life to develop without being snuffed out?
3. How likely is primitive life to form if a planet is able to support it?

26 Barrow, J. and Tipler, F. *The Anthropic Cosmological Principle*, Oxford: Oxford Univ. Press (1988).
27 Ward, P. and Brownlee, D. *Rare Earth*, New York: Copernicus (2004).

4. How many such planets exist in the universe? They must lie at suitable distances from suitable stars. Life is demanding in its requirements.
5. The laws of nature appear to be fine-tuned so as to make life processes possible. Why should this be?

It is beyond our scope here to give detailed study to these questions, especially those of a biological nature, but there seems to be sufficient evidence that our presence in the universe is remarkable to worry a number of theological unbelievers. If we require a reasonable explanation for our existence, and science is unable to provide it, then design arguments will have force. Now it is dangerous to rely too strongly on arguments based on a lack of scientific explanation, because future developments in science might be able to supply this. On the other hand, science makes predictions, and if these fail to give a good account of observations then the science will need amendment. Either better science or a different kind of explanation will be required. To suppose that science will *always* provide answers could be an example of the wishful thinking of which religious believers are often accused.

Infinities as the claimed 'solution'

Leonard Susskind is perhaps a little unusual for a religious sceptic in admitting so frankly in his book that the universe really does look as if design has been at work.[28] There is no obvious new scientific theory at hand to give a direct explanation. However, given enough chances, even very improbable things can be expected to occur occasionally. One way to assist the situation from the unbeliever's point of view is to suppose that the universe we inhabit is spatially infinite. With an infinity of galaxies providing an infinity of opportunities, even processes with minute probability are sure to take place. So, if the immense age of our universe still provides insufficient plausible time for advanced life to develop on a given planet (something most evolutionists would not accept regarding the Earth), with enough planets on enough stars in enough galaxies the situation should be rectified.

However this might not be good enough. A planet's advanced life might turn out to have appeared abnormally quickly, which would seem strange. Or the universe might in fact be finite and not really big or old enough to make the development of advanced life in it plausibly probable. To deal with such cases, it is possible to produce speculative models in which our universe is one of a vast or infinite number of universes. This could be a useful alternative to just one infinite universe. By universe we mean a cosmic object that has come into existence through a big-bang-like process out of a prior state of affairs that can

28 For a more extensive summary of Susskind's book see the review by M. Duff in *Physics World*, Dec. 2005, p. 42. This issue also contains a variety of interesting comments on Intelligent Design in its Letters page.

permit this. So-called 'chaotic inflation', proposed by cosmologist Andre Linde, provides the best known example of this kind of theory. Within an infinite space and time, there is a kind of 'cosmic foam' which can occasionally and unpredictably produce universes that suddenly emerge as expanding bubbles, so to speak, within it. All this takes place on a mind-blowingly colossal scale, but this is not seen to be of any great importance.[29]

But the argument that the laws of physics are specially 'suitable' for life to occur may still be bothersome. In that case, it has been postulated by a number of physicists (including Linde) that the laws of physics themselves can vary from universe to universe. It seems that the desired safe haven has now been reached. Given an infinity, or effectively so, of sets of laws of physics, everything however unlikely will take place somewhere sometime somehow,[30] and the Intelligent Designer can be relegated to the sidelines. Theories of this kind can be devised, moreover, so that although each expanding universe has a beginning there is no absolute overall beginning to time.

Some comments

A first comment to be made is that not all cosmologists are necessarily trying to eliminate God. There are those who are willing to express 'humility in the face of the persistent great unknowns'.[31] Linde is on record as saying, 'It doesn't mean that there is no place for God, just that there are some new possibilities. I am not a religious person or an antireligious person; I am just trying to figure out what I can say without emotion.'[32] In the end, like Hawking[33] he acknowledges that there is a deep mystery about why the universe (or universes) should exist at all, and that this is something beyond the scope of science to answer. Clearly, these are metaphysical questions.

Science relies on observational evidence to make its points with authority, however. It is legitimate to extrapolate well-tested laws into regions where they are not yet tested and perhaps never can be – for example into the interi-

29 For an accessible account of these cosmologies, written by an enthusiastic believer in them, see M. Tegmark in *Scientific American*, May 2003. Astonishingly, the journal editors presented the article as if its claims were all completely established fact.

30 This conclusion has been contested by R. D. Holder in *God, the Multiverse and Everything*, Ashgate (2004). Holder argues that the finite range of physical parameters well-matched for life represent a zero fraction of the infinite range of possible values. Therefore a multiverse, as such, provides no guarantee of including a set of parameters within the life-giving range, since zero times infinity is an indeterminate quantity. For firmer conclusions one would have to consider the specifics of a given theory.

31 Rees, M. *Before the Beginning*, Simon and Schuster (1997) p.6, quoting this in agreement with his colleague J. Silk.

32 Quoted in Powell, C. S. *God in the Equation*, New York: Free Press (2002), p249. In the latest web version of his quoted essay, Linde omits this personal statement while retaining a generally agnostic theological position; see http://www.stanford.edu/$\sim$alinde/SpirQuest.doc.

33 Hawking, S. *A Briefer History of Time*, London: Bantam (2005), p.142.

ors of Black Holes. But from the point of view of good scientific procedure, it is not legitimate to invent new laws that apply exclusively to the untestable.

There are currently unknown aspects to our universe, such as the nature of the mysterious 'dark energy', which indicate that we certainly do not know all there is about the observable universe, let alone the unobservable. Concerning the very earliest instants of the Big Bang we have no direct observational evidence and do not at present know what physics may have been acting. (I have heard these instants described as a 'theorists' playground'.) Our universe might possibly be provable to be finite, but not provable to be infinite. With regard to other universes, there is no experimental evidence and very likely never will be. Since the relevant theories can then never be proved or disproved, science would seem to be making a full circle since the Middle Ages, reminding us of discussions of the infinite then. In the earlier period a set of philosophical assumptions provided the framework for what was believed, and today we seem to be heading back towards philosophy again.[34]

'Is it possible?'

This leads us to a point of language. When new theories and ideas are put forward, they invite the question as to 'could it be', or 'is it possible', that the theory is true? 'Is it possible' that these extra universes with different laws of physics might exist? Now words such as 'could' and 'possible' have several meanings which need to be distinguished. If we say that a new theory is 'possible' we might mean one or more of the following:

a) established laws of physics encompass the theory, i.e. it is in a confirmed sense physically possible;

b) while it may go beyond the known laws of physics, its predictions still agree with known observational facts; i.e. it is empirically possible;

c) it can be proposed without self-contradiction, i.e. it is logically and conceptually possible.

Here we have been looking at proposed theories which are definitely beyond the scope of (a). It may be that some of them make observable predictions about the nature of the cosmic microwave background, and so come under category (b). However (b) is unhelpful if there are no predictions that might conflict with observation. If all theories on the table are in agreement with the observational facts, or if the theory in question can always be adjusted so as to achieve this, then a statement of its possibility under (b) is weak. In principle, (c) ought always to hold. Historically, however, theories have sometimes been proposed

34 Stenmark, M. *Faith and Philosophy* 21 (2004), p.334 has argued that scientific theories with extra-scientific motivations will still be dealt with properly when good scientific methodology is applied. But here the good methodology (i.e. experimental verification) does not seem to be available.

which appear to transgress (c), in order to be in agreement with (b). Thus, quantum mechanics was set up to give an account of observational data, but its concepts were seen as self-contradictory at the time, and in fact still appear so to many today. This serves as a warning that full consistency under (c) is dangerous to insist on in a new area, and may very well be irrelevant.

The question 'Could this new theory be true?' might therefore in the end be futile! This could especially be the case if untestable proposals are being made using radical extensions to present knowledge. The example of quantum mechanics cautions us that a theory that has inconsistencies on the basis of our present understandings might actually (though we would not know it) be truer than one that seems to be more coherent. In other words, even the *questions* may not be well-defined once we go beyond a certain point.

In the case of our universe being infinite, statement (a) might apply, but (b) would be dependent on experimental evidence which might always remain inconclusive. We would also need to have confidence in the extrapolation of the known physical laws into infinite realms beyond our observation. With 'extra universes', unless we can communicate with them, the applicable laws of nature are hypothetical only, and (a) is of little help. In the case of new universes *designed* to have variant laws of nature, (a) carries no information at all. Then we must hope for contact with observational reality via (b), which is probably not possible, or else attempt a problematic recourse to (c).

The issues end up being philosophical. We may well note a statement made by the quantum theorist Max Born: 'Intellect distinguishes between the possible and the impossible, but reason distinguishes between the sensible and the senseless. Even the possible can be senseless.'[35] In the end, therefore, the choice between different theories may have to be made on the basis of what is 'sensible'. Our universe has an appearance of intelligent design. If we are unwilling to accept this, we may instead need to believe in an extravaganza of multiple universes, infinite or effectively so, and intelligently designed to be a substitute for God.

Conclusions

The relationship between a finite or infinite universe and belief or unbelief in God might at first be regarded as a purely subjective matter. Even though not all unbelievers require an infinite universe as an emotional substitute for a Deity, it probably helps. Conversely, an infinite universe, whether in space or in time, can be accommodated to belief in God by emphasising God's own infinitude. One problem seems to be that an infinite universe may make it harder to accept that God can have personal interests in human beings on a small planet.

35 Quoted in CERN Courier, December 2002, p.21. I have been unable to trace the original.

The immediate Christian response here might be to quote the statement of Jesus that not a sparrow falls to the ground without our heavenly Father knowing about it. We have pointed out that every electron in the universe is identical, as is every proton, and so on. God is a God of details, and of the small as well as the large. It seems quite common for cosmologists to assert unbelief in a 'personal' Deity. Maybe they are looking for that in the wrong place. The personal is to be found in connection with the personal, and so it is in our own personhood and relationship to God that his personal nature is to be found. This is not even primarily something intellectual.

Much of modern theoretical physics and cosmology seems to be becoming increasingly Platonic. That is to say, there is an increasing emphasis on mathematical structures and philosophical motivations to construct abstract theories, theories of theories, and speculative cosmological models. This should be recognised as what it is, meta-science rather than science. Many proponents of these ideas emphasise the beauty of the mathematics, saying that it is the aesthetic arguments which are the most convincing – although beyond the abilities of most people to appreciate. A Platonic priesthood? But if this argument has any validity it raises the hugely significant question of why the human mind should be attuned to these arcane aesthetica. What is so special about us? A personal relationship to something cosmic and all-determining, whether or not it is impersonal, is being implied after all.

Some types of hypothetical physical infinities are clearly a way of avoiding God. But scientific theories should not depend on theological or anti-theological motivations, and attempts to design theories with this kind of goal should be acknowledged as possessing an extra-scientific agenda. It is my hope here to have aired some of the basic choices to be made. These must depend on sense and reasonableness, something difficult to quantify. There will be in any case mystery at the bottom level, and the final choice will be for each of us to decide what kind of mystery we prefer.

A further point should be made. If *physical* infinities were to exist, why stop there? Why should we not also allow infinities to exist of a mental and of a spiritual nature? These of course are associated with the mode of existence of God. It makes no particular sense to confine infinity to the physical.

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