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THE HOW AND WHY OF OUR ORIGINS

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The cosmos is about the smallest hole that a man can hide his head in.
(G.K. Chesterton)

What is Man, that Thou art mindful of him?
(Psalm 8, 4)

Human beings need creation stories. Cultures are defined, at least in part, by their common creation myths, stories that answer important questions about how things came to be and how meaning is to be found within the existing order.[1] 'How did we get here?' is a scientific question. 'Why are we here?' is a religious one. Human beings raise both types of question but the relation between the first and the second has not always been obvious. One of the most remarkable insights of the late twentieth century has perhaps made this relation clearer, and I will come to this in a moment. But first a word about the book of *Genesis*.

How the Bible Puts It

When an account of the origins of the universe was first offered in *Genesis* it was intended to provide a religious insight – mind you a genuine insight not a mere emotional response – into the ultimate truth about the world and our place in it. This insight had to be couched in the language

[1] Karl W. Giberson and Donald A. Yerxa, *Species of Origins: America's Search for a Creation Story*. Lanham, Maryland: Rowman and Littlefied, 2002. The present essay owes much to this remarkable book.

and culture of the people to whom it was communicated. So the author of *Genesis* adapted the cosmological science of his day to convey a message that transcended the particular scientific culture of his time but remained deeply imbedded in it. Essential to the story is that God cares for the world he created and that he is responsible for human life.

This story of creation does not fit our current knowledge about the origins of the cosmos and the evolution of life. Yet, the essential (I would venture to say unalterable) truth of creation has to be conveyed to a modern audience. This is not a question of changing the doctrine but of communicating the original insight in a new context.

God did not give us the Bible to satisfy our curiosity about nature. He gave us another book for that, the one described in Psalm 19,1: 'The heavens declare the glory of God; the skies proclaim the work of his hands'. In the sixteenth century, Cardinal Baronio, who was an acquaintance of Galileo, put it this way, 'The Bible teaches us how to go to Heaven, not how the heavens go'.[2] But what if the two books disagree? What strategies can be used to settle their difference? Are certain disciplines in a privileged position to adjudicate between knowledge claims or are all on equal grounds? Other contributors to this meeting have raised some of these issues, I will limit myself to asking: Is a post-modern creation myth possible?

'*We Are Stardust, We Are Golden*'

In their celebration of Woodstock in the 1970s, four young singers, Crosby, Stills, Nash and Young sang, 'We are stardust; We are Golden; We are Billion year old carbon'. Described as the anthem of the baby boomers, and unique among pop songs, the Woodstock lyrics communicate one of the most remarkable scientific insights of the late twentieth century: human beings, and indeed all life forms on planet earth, and even the earth itself, are stardust. It is now well understood that the atoms that compose the earth were once in the interior of a star. This star exploded some 15 billion years ago, strewing its spent fuel – stardust – into an enormous spherical cloud. Our solar system, comprising the sun, planets, and billions of smaller bodies from moons to asteroids, developed from this cloud as gravity slowly reassembled the stardust. Then, one such planetary body happened

[2] Quoted by Galileo in his *Letter to the Grand Duchess Christina* of 1615 (in the national edition of Galileo's *Opere*, edited by A. Favaro, Florence: Barbèra, 1890-1909, vol. 5, p. 319).

to be just the right distance from this star so that water would be in liquid form, a coincidence that made life possible.[3]

We are, in a profound and puzzling sense, stardust. Every atom of every element in your body, except for hydrogen, was actually *manufactured* inside stars. Stars are made of hydrogen and helium. A young star has no carbon, oxygen, nitrogen, iron or phosphorous. These so-called heavy elements are fused in the star from supplies of primordial hydrogen dating from the early moments of the Big Bang. The production of stardust takes place through stellar fusion, one of nature's most remarkable processes. Stars are gigantic nuclear reactors that run with surprising smoothness. The unimaginably great tendency of the star to explode under the outward pressure of its ongoing nuclear explosion is delicately balanced by gravity, pulling everything into place. This perfectly balanced stellar tug of war provides a stable environment where a star like our sun can shine consistently for ten billion years, providing steady illumination for planets like earth, and for a long enough time for life to emerge, develop, evolve, and write songs about the process.

Stars were not there from the beginning. In the early universe, there were only subatomic particles that were pushed outward by the Big Bang whose considerable energy worked to separate these particles and prevent their collecting together. Gravity did its best to stop the expansion of the universe and crunch everything back together into one gigantic ball. It failed to halt the expansion but succeeded in gathering most of the material in the universe into the structures that we know as stars, galaxies, galactic clusters, and the like.

Thus begins the modern scientific story of creation, told in brief outline, with most chapters left out, and no conclusion. What is of particular interest is that the existence of human beings is tied to the physical properties of this early universe. Some of the key structural features of the Universe turn out to be prerequisites for the emergence of life, and this has given rise to a renewed and fascinating discussion about our origins. At the heart of this reappraisal is the recognition that certain properties of the Universe are far from obvious, in the sense that they are brute facts and cannot, at least for the time being, be explained by our theories. These include: (1) the expansion energy of the Big Bang; (2) the precise

[3] See John Gribbin, *Stardust*. London: Penguin, 2000, and the excellent discussion in Karl W. Giberson, 'The Anthropic Principle: A Postmodern Creation Myth', *Journal of Interdisciplinary Studies* 9 (1997), pp. 63-89.

value of the gravitational constant, which gives us stars and planets; (3) the delicate balance between gravity, electromagnetism, and the strong nuclear force, which gives a hydrogen-dominated universe and provides for an abundance of stellar fuel in long-lived stars; (4) the precise details of the nuclei of helium, beryllium, and carbon, which makes the production of carbon unusually efficient and thus facilitates the biochemistry of life; (5) the relative masses of the neutron, proton, and electron, which make for stable long-lived atoms capable of participating in a variety of chemical reactions.

Let us glance for a moment at physical constants, for example, the charge of the electron is 1.6×10^{-19} coulombs, the strength of gravity is 6.67259×10^{-11} $m^3kg^{-1}sec^{-2}$, the mass of the proton is $1.6726231 \times 10^{-27}$ kg, and Planck's constant is 6.626075×10^{-34}. These values have been measured with great accuracy but they cannot be deduced from any mathematical theory. There is no discernible reason why they have these particular values, and not some others. But although they do not have to be as they are, we know that if they were otherwise, we would not be here. They play a basic role in the structure of the universe and make possible the chemistry of life.[4]

Whether there are planets like ours elsewhere in the Universe is a matter of conjecture, but what is certain is that the particular location of our Earth is not 'average'. To be a mere 8 light-minutes from a star is most unusual; typical distances are measured in light-years. Yet only those rare locations near a star like our Sun are suitable for life. All the vast elsewhere is hostile to life. Carl Sagan put it eloquently when he wrote:

> Our universe is *almost* incompatible with life – or at least what we understand as necessary for life: Even if every star in a hundred billion galaxies had an Earthlike planet, without heroic technological measures life could prosper in only about 10^{-37} the volume of the Universe. For clarity, let us write it out: only 0.00000000000000000000000000000000001 of our universe is hospitable to life. Thirty-six zeros before the one. The rest is cold, radiation riddled black vacuum.[5]

[4] See John D. Barrow, *The Constants of Nature*. London: Jonathan Cape, 2002.

[5] Carl Sagan, *Pale Blue Dot: A Vision of the Human Future*. New York: Random House, 1994, p. 34.

Strange Coincidences

> *'Any coincidence', said Miss Marple to herself, 'is always worth noticing. You can throw it away later if it is only a coincidence'.*
> (Agatha Christie)

The average temperature of the Universe is 3 degrees Kelvin, namely 470 degrees below zero on the Celsius scale. In other words, if we were to choose a point at random in the Universe, it is overwhelmingly probable that we would find the temperature to be minus 470°C, much too cold for there to be any question of life. The very few exceptions to this numbing cold are mainly the stars whose inside temperature reaches millions of degrees. Water is necessary for life, but a place where it can be found in the liquid state, rather than as a gas or a solid, can only be at an exceptionally specific and rare distance from a star. The Earth is at one of those rare places.

The density of the Earth is also far from average, for the Universe is mostly empty space. A typical location in the Universe has about 6 atoms per cubic meter. This is about as crowded as a peppercorn in a volume the size of the Earth. A cubic meter of Earth, by contrast, contains about 10^{37} atoms. In addition to the unusual density and our location in space, the composition of our planet is also exceptional. The Universe contains about 96% hydrogen, 4% helium, and negligible amounts of the other 100 or so elements in the periodic table. There is only an insignificant percentage of elements like carbon, oxygen, and nitrogen, zinc and iron. But on Earth, the life-sustaining atmosphere contains vast quantities of oxygen, nitrogen and carbon dioxide, life-giving molecules that on the scale of the Universe are far more rare than gold on the scale of the Earth.

The probability of finding life on earth is ludicrously small, and when something is so improbable, it is sensible to ask why. Allow me two homely illustrations to illustrate how we normally behave when we are faced with very unusual coincidences.

Example 1: Near Escape

Terrorists have captured you and you are facing a firing squad. Twelve expert marksmen aim their rifles at you, and as you open one eye to get your last glimpse of the sun, you hear them pull their triggers on the command to execute. You close your one opened eye; the hammers in the rifles click against a backdrop of utter silence. You shudder ... and noth-

ing happens. All twelve of the rifles have misfired. Paralysed from dread you slump to the ground, wondering why you are still here. 'Thank God', you whisper as you pass out.

When you regain consciousness you begin to ponder your strange fate. How could twelve new rifles, operated by twelve expert marksmen, all simultaneously misfire? You recall the feeble 'thank God' that passed from your lips before you lost consciousness, but now you are beginning to wonder. Your present circumstance is the result of twelve remarkable 'coincidences'. But you don't really believe in coincidence. And you can't quite bring yourself to believe that God himself put his finger on the hammers of all those rifles and made them misfire. So you lie awake in your cell, staring at the ceiling, asking yourself what really happened.[6]

Example 2: The Lottery Ticket

My second illustration is even simpler. Suppose that the Chancellor of the Pontifical Academy of Sciences and the nine members of his staff all buy one ticket apiece in the national Italian lottery. All ten of them win prizes on the drawing, and no one else wins anything. Now it is not at all remarkable that there were ten winners; the history of the lottery could reveal that ten winners is normal. But that these ten winners should all be members of the staff of the Pontifical Academy of Sciences is not normal. The odds are vanishingly small that this could be the case. This situation seems so improbable that some sort of investigation would certainly be launched.

Now in the universe *we* have won the lottery. The number selected by each of the forces is *our* number. As far as we know *homo sapiens* has won all the prizes. So we come back to our original question: How can we 'explain' this remarkable constellation of circumstances? It is clear that there is *something* to explain for scientists cannot help being curious about these 'anthropic' coincidences.[7]

[6] See Karl Giberson, 'The Finely Tuned Universe: Handiwork of God or Scientific Mystery?' *Christian Scholar Review* XXII (1992), p. 187.

[7] I shall use the expression 'anthropic coincidence' although the more common one is 'anthropic principle' introduced in 1974 by Brandon Carter (Brandon Carter, 'Large Number Coincidences and the Anthropic Principle in Cosmology' in M.S. Longair (ed.), *Confrontation of Cosmological Theory with Astronomical Data*. Boston: Reidel, 1974, pp. 291-298. A detailed discussion can be found in John D. Barrow and Frank J. Tippler, *The Anthropic Principle*. Oxford University Press, 1986.

For the sake of this argument, and to provide additional insight into what is at stake, let us briefly examine one of the striking coincidences – the strength of the so-called 'strong force'. The strong force is the force that operates between the elementary particles known as 'quarks' binding them together into familiar particles like protons and neutrons. At about one millionth of a second after the moment of the Big Bang, during the brief epoch when quarks existed as particles, the strong force began to bind them together in trios to make larger particles like protons. While the strong force was strong enough to bind the quarks together inside individual protons, it was not strong enough to bind quarks from *different* protons together. Thus it was, for the most part, unable to bind protons to each other. The 'coagulating' of quarks stopped at the formation of single protons, rather than continuing until all the quarks were bound together into one giant mega-proton.

Furthermore, as soon as individual protons were formed, the electromagnetic force, which causes protons to repel each other, kept the protons away from one another, further discouraging runaway coagulation. Now the strong force is very precisely balanced. If it were a little bit stronger, then it would have continued to coagulate protons into ever larger nuclei, perhaps combining all of the protons in the early universe into a mega-particle; if it were a little bit weaker it would have been unable to make protons from quarks in the first place. These single protons, of course, are the hydrogen that is so essential to everything in the universe – essential as the fuel by which the stars shine, essential as the water by which we live.

The very existence of a sun that can make us warm, and water that can make us cool, depends on the precise strength of the strong force. It if were ever so slightly different, we could not exist. It has a certain value – 10^{41} times as strong as gravity, 10^{39} times as strong as electromagnetism. Why does it have *this* value, and not one of the others – one of the infinity that are incompatible with the development of life? And why is its value so carefully balanced with the values of the other forces? There would appear to be some fine-tuning here, and it is difficult to understand how there can be fine-tuning without someone doing the tuning.

This argument, which I wish to examine in some detail, turns on the precise meaning given to the phrase 'difficult to understand'. What is it that is 'difficult to understand' and what does it mean to "understand" in this context?

Variations on a Cosmic Theme

When physicists consider what an alternate hypothetical universe might be like, one of the things that they like to do is change the strengths of the force ever so slightly and see what differences that makes in the resultant universe that would evolve through the interaction of those modified forces. The astonishing result of these speculations about alternate universes is the discovery that almost *any* change in the precise values of the four forces – gravity, weak nuclear, electromagnetic, strong nuclear – results in a universe that is inhabitable. And, in many cases, the values must be 'finely tuned' to within one part in a million, a billion, or even a trillion, of their present values. Otherwise, no participants at the plenary session of the Pontifical Academy of Sciences or anywhere else for that matter.

It is obvious, however, that the values of the physical forces must have *some* value. And the values that they have individually are no more remarkable than any of the values that they don't have. Of course, the values must be such as to allow us to be here, since it is clear that we *are* here. All this is obvious. What is remarkable, however, is the large number of precisely determined, yet apparently *unrelated*, things in the universe that are, so far we understand at present, related to each other *only through their relevance to us*, as creatures who eventually evolve in this 'finely tuned universe'.

God of the Gaps

From the evidence available can we take the next step and say that the universe is designed? In the early history of science it was common, almost universal, to attribute to God those parts of the explanation that could not be provided by science. At various times in history God was moving planets, altering animal forms, blotting out the sun at midday, and so on. Even in the 'scientifically sophisticated' nineteenth century God was designing the eye, originating life, defining absolute space, etc. The conclusion that God designed the universe is not a new argument. In his widely read *Natural Theology; or Evidences of the Existence and Attributes of the Deity*, William Paley argued that anyone who examines the precision and intricacy of design of a watch is forced to conclude 'that there must have existed, at some time, and at some place or other, an artificer or artificers, who formed it for the purpose which

we find it actually to answer; who comprehended its construction and designed its use'.[8]

Whether or not God can be used to fill gaps in our understanding of the universe is not a trivial question (surely God must make *some* difference in the physical world!) but it is manifestly clear that invoking God as an *explanation* is begging the scientific question entirely. It is nothing more than an admission of ignorance. We propose to 'understand' something that is very complex by attributing it to some other thing that is more complex. It must be admitted that we cannot know something about God in a narrow scientific sense (How can He move? How fast? How far? What is his source of energy? etc.) So when we propose to *explain* some empirical problem, like anthropic coincidences or the design of the eye, by invoking God, we have not provided a 'scientific explanation' at all. As Karl Giberson has pointed out, the only way that God can serve as a meaningful 'explanation' for something like the anthropic coincidences is within the context of a larger metaphysical scheme of which God is already a part.[9] If God is already *assumed on independent* grounds, then he can perhaps be invoked to 'explain' other elements in the metaphysical scheme. This is why the argument seemed so natural prior to the Enlightenment when virtually everyone believed in the existence of God. But the epistemological criteria for metaphysics are so different from those employed in science that this effectively changes the rules in midstream. When we are searching for explanations that meet the more restrictive epistemological criteria of science, it is precisely here that the God of the Gaps is not what we want.

Possible Scientific Explanations of the Anthropic Principle

Furthermore, before concluding that the anthropic coincidences offer material for a new creation myth, we must be aware that there are a number of possibilities *within* (or at the edge of) science that should be considered even if they may have to be dismissed for giving rise to more problems than they can solve. I shall mention three:

[8] William Paley, *Natural Theology; or Evidences of the Existence and Attributes of the Deity*. London: Mason, 1817, p. 7. The work was first published in 1802.

[9] Karl Giberson, 'The Finely Tuned Universe: Handiwork of God or Scientific Mystery?' *Christian Scholar Review* XXII (1992), p. 192.

1) *Big Bang Recycling*. The current Big Bang could be followed by a Big Contraction and then another Big Bang, *ad infinitum*. The scientific information to assess this theory is not yet available but, given time, this cycling of the universe may appear no more curious than the cycling of the seasons. If the Big Bang does recycle, then it is possible, or even probable, that certain physical parameters might be 'reset' in some way at each new beginning, when the entire universe is squeezed through the eye of the needle of creation. This 'resetting' of the initial conditions would obviously influence the outcome each time. We live during a cycle when the physical parameters have the values necessary for life. Next time around life may not make it. The time after that, the universe may teem with life, far more varied than we observe at present.

2) *Multiple Universes*. Prior to the development of modern cosmology it was proposed that we could 'understand' quantum mechanics better if we supposed that quantum measurements resulted in bifurcations of the universe. This is highly speculative but we cannot at this time rule out the possibility that multiple universes might provide an 'explanation' for anthropic coincidences. In any event, the invocation of a deity to explain these coincidences is hardly an 'ontological bargain'.

3) *Inflationary Cosmology*. Certain modifications to the Big Bang suggest that our visible universe might be just one of many embedded in a much larger meta-universe. On this view our visible universe is a bubble that inflated shortly after the beginning and had some of its particular physical parameters adjusted by that inflation. According to this 'inflationary cosmology', there may be other such bubbles in the meta-universe, but ours has the right values for life.

All three of these explanations have in common that there may be many different universes, and that we happen to be in one that is 'finely tuned for life'. In this way they can be said to 'account' for the anthropic coincidences although there is no direct scientific evidence at present for any of these other universes. Their existence can only be postulated as a logical consequence of a scientific theory that is accepted for other reasons. Thus, we cannot claim that we believe in these alternative universes for *scientific* reasons but rather for reasons that we consider epistemologically more pleasing, namely because they follow from theories that are mathematically more elegant and seem less paradoxical. It is largely a matter of one's metaphysical beliefs whether these alternative universes are considered more satisfactory.

An Open Quest

In a somewhat different vein, some leading theoretical physicists have argued that we live in a 'symbiotic' or 'participatory' universe; that our presence (in the form of our consciousness) is necessary to 'collapse the wave function of the universe', which is quantum mechanical jargon for 'bring potentiality into actuality'. It is in the nature of consciousness (whose description and interaction with matter is still extraordinarily mysterious) that it can only collapse wave functions that are compatible with its existence. It is well known in quantum mechanics that things can exist in hybrid superposition states for long periods of time and then be distilled into one of the constituent components through observation by a conscious observer, such observations apparently affecting not merely the present *but also the past history of the object under observations*. The universe, in this view, needs consciousness to select from among its various latent potentialities one actual universe – one real buzzing, whirring, cosmic machine. And consciousness, without apology, selected that one which was compatible with its own existence. We think, therefore, the universe is.

I would still wish to argue, however, that God is responsible in an *ultimate metaphysical* sense for anthropic coincidences, just as I would argue that the laws of nature do not *govern* the universe but rather only *describe* it. In the worldview of the scientist who is a Christian, gravity still finds its ultimate origins in God, even though He is not personally 'pushing' on the planets.

Who is the God of the Anthropic Principle?

We must therefore exercise caution in using anthropic coincidences to tell a creation story.[10] A God so posited would be a god who is constrained – either by choice or of necessity – to operate within a very restrictive evolutionary framework. Why was the world so structured that *homo sapiens* could evolve when it would have been possible to created human beings according to the traditional formula? It would seem that a God looking for dust of the earth to fashion people could just create this dust. Why did He have it evolve in the furnace of a star, distributed into space and finally recycled by gravity? We can marvel at the fact but we cannot fully account for His intentions.

[10] See Ernan McMullin, 'Indifference Principle and Anthropic Principle in Cosmology'. *Studies in History and Philosophy of Science* 24 (1993), pp. 359-389.

Conclusion

It is certainly true that anthropic coincidences are a fascinating topic. They have sparked a renewed interest in the history of our origins, and they have started the scientific community thinking seriously about the larger context of their work.[11] Both science and religion seek creation myths, stories that give our lives meaning. From the highly theological Near Eastern creation stories of the Gilgamesh epic and the Hebrew bible to modern accounts that use mathematics and physics, every creation story is pregnant with a particular worldview. Although it may be too early to draft a new creation myth to clarify and mitigate the exhilarating, challenging, and terrifying patterns of life and death, it is fair to say that there is room for a fruitful dialogue between science and religion. History and the findings of social science confirm that human society must agree on fundamental issues if it is to cohere and endure. The creation story that underpins the larger structures of meaning is certainly a central element in this agreement. Contemporary society doe not share a common notion about how things came to be but the time may come when it will. We cannot be indifferent to the fact that the world appeared and to the meaning of its appearance.

[11] In 1951 already, in an address to the Pontifical Academy of Science entitled, 'On the Proofs of the Existence of God in the Light of Modern Natural Science', Pope Pius XII described the expansion of the universe as a strong indication that the world was created at some specified moment in the past.

DISCUSSION ON THE PAPER BY SHEA

LÉNA: Thank you, Mr. Chairman. You gave a very inspiring paper and addressed many questions which are essential, especially everything connected with the value of numbers, but there is one point where I would like to bring – I don't know if you agree – a word of caution. It's about reasoning about probabilities, because what we have is one single case of life realisation, and then we try to evaluate the probability of that by multiplying extremely small numbers like the one you've shown, by extremely large numbers, the number of possible occurrences in the universe, and on those two numbers we have no real scientific evidence. We don't know exactly what's the likelihood in the probability sense of the happening of life through the process of evolution, molecular evolution, and we begin to have very little evidence on the likelihood of habitable conditions in the universe, not to speak of the maybe not so impossible areas in interstellar space, because some of them are very well protected from radiation and aggression.

SHEA: Well, I wouldn't quite put it like that, but it is important to recollect that very small numbers times very large numbers can give about anything. I should perhaps have developed an argument along the remarkable relations between these universal constants. But I was trying to address a general problem. I believe that calling onto God to explain the origin of universe is using a methodology that is not inside science as we practice it. Why? Because the way we do science is very simple, we ask: how big, how fast, what is the mass. These are questions we cannot ask of God. In the seventeenth century, with Galileo, Newton, Descartes, Leibniz, it would have just been surprising to say: my science leads to a mere indication, not a proof, that God exists. That would have seemed absurd. Since the Enlightenment, things have changed, but we need these metaphors. Rival accounts to the one I've given exist. In the cultural context in which we live we find mainly either atheists or agnostics, who object to a singularity. I prefer living in a context that is closer to the seventeenth

century. Newton would have said: 'I know from other grounds that God exists; my science cannot be in opposition to my beliefs'.

This doesn't mean that science and religion are convergent, but for me they are consonant. My assumption is the following: science deals with the real world, so does theology.

CABIBBO: Certainly, this is a very interesting argument. Of course it is not something you can prove, unfortunately, so we remain in doubt. In other words, if the appearance of life has only a low probability, as low as you like, then the so-called anthropic principle is perfect: since we are here discussing it we hit it, we were lucky and we are in that particular universe. So, if it is only a question of probability, the argument is not convincing. If the constants of nature are fixed, and that is the only value that we have, it's not a question of probability, it's a question of absolute, then the argument becomes strong, but you cannot prove that it is so, I mean, at least not now.

SHEA: I don't say that we can prove the existence of God with this argument. I'm simply saying that modern science is consonant with religious beliefs. The way you have answered right now talking about probability embodies cultural values about how you feel about probability. So, if you say to me: 'I don't want singularity in the universe', then…

CABIBBO: No, no, I don't say that, I say that probability is a possibility; that there are many universes is quite possible.

SHEA: Absolutely.

CABIBBO: So, if there are many universes, even if it is very improbable that in one of them life exists, the fact that we are discussing it means that in this particular universe life exists. It's not a question of probability. We probably will not be able to know. Maybe when string theory is fully developed we'll know whether at least in that theory it is possible or not to have different physical constants. But at this point we don't know, we don't know whether there is one universe or many universes, whether the different universes have the same constants or not.