Designer Universe?

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Edward Fackerell explains the astonishing improbability of the universe and its interpretations.

Our Physical Universe Had a Beginning

Half a century ago, the prospects for a modern revival of the cosmological argument for the existence of God did not appear promising, as the dominant theoretical cosmological model was the steady state theory (1948) of physicists Hermann Bondi, Thomas Gold and Fred Hoyle. Their model was without a beginning, and satisfied the condition that the universe looks the same at all times.

The chief rival of the steady state theory was the earlier model of Alexander A. Friedmann, Abbé Georges Lemaitre, H.P. Robertson and A.G. Walker. Hoyle had derisively nicknamed this model the Big Bang. The striking feature of Big Bang models is that they have a beginning with time; indeed, time and space themselves come into existence with the Big Bang.

Although both steady state and Big Bang models are consistent with Hubble's law, the Big Bang model was shown by the brilliant Russian physicist George Gamow to make an additional prediction: that the universe should be filled with black-body microwave radiation (electromagnetic radiation similar to the radiation in microwave ovens). In 1965 this radiation was found by Arno A. Penzias and Robert W. Wilson, who were awarded the Nobel Prize for Physics in 1978. The impact of their discovery was so great that, with the exception of Hoyle and a few of his closest collaborators, all of those who had previously supported the steady state model abandoned it for the Big Bang, thereby implicitly accepting that our observed universe had a beginning.

Fine Tuning in the Origin of the Elements

Gamow had shown that the hot Big Bang could account for the origin of deuterium, helium and lithium by nuclear fusion from hydrogen. Gamow furthermore thought that all other elements of matter could also be accounted for by the Big Bang. In this he was mistaken (there is a problem at element number 5, boron).

Hoyle found the intriguing answer to this problem: these elements are made in the hot interiors of red giant stars. The key step is the production of the isotope carbon-12 by the so-called 3-alpha process. In this process, the basic building blocks are alpha particles (helium-4 nuclei), which are relatively stable and plentifully at hand in the interiors of red giant stars. Two alpha particles contain exactly the right components of a beryllium-8 nucleus. Similarly, three of these nuclei contain precisely the ingredients of a carbon-12 nucleus, which is quite stable. The problem is that the simultaneous collision of three alpha particles is exceedingly rare. On the other hand, the much more frequent collisions of two alpha particles make a short-lived (one billionth of one microsecond) beryllium-8.

So how is the stable carbon-12 nucleus made? Hoyle realised that this could only occur if the carbon-12 nucleus could exist in a particular state that was just above a very precisely defined energy. When Caltech's Kellogg Radiation Laboratory looked very carefully they found this state right where Hoyle said it had to be.

However, the theoretical problem was not completely solved because the addition of an alpha particle to a carbon-12 nucleus gives another stable nucleus, oxygen-16. To avoid all of the carbon-12 being transmuted into oxygen-16, the resonant state in oxygen-16 had to be just below another precisely defined energy, and this turned out to be the case.

Without the triple coincidence of a short beryllium-8 lifetime and the two finely tuned states of carbon-12 and oxygen-16, the relative abundances of carbon-12 and oxygen-16 in the universe would not be right, with a significant effect on organic chemistry.

Hoyle, to that time an openly atheist thinker, was shaken to the core by these coincidences. In a contribution to the book *Religion and the Scientists* (1959), he wrote:

> I do not believe that any scientist who examined the evidence would fail to draw the conclusion that the laws of nuclear physics have been deliberately designed with regard to the consequences they produce inside the stars. If this is so, then my apparently random quirks have become part of a deep-laid scheme. If not then we are back again at a monstrous sequence of accidents.

Hoyle maintained this view later in his life, writing in *Annual Reviews of Astronomy and Astrophysics* (1982):

> A common sense interpretation of the facts suggests that a super intellect has monkeyed with physics, as well as with chemistry and biology, and that there are no blind forces worth speaking about in nature. The numbers one calculates from the facts seems to me so overwhelming as to put this conclusion almost beyond question.

Further Fine Tuning

Many further instances of fine tuning, both in fundamental physics and in cosmology, have been brought to light since the 1950s. For example, it is now appreciated that the strong nuclear force that holds protons and electrons together in atomic nuclei is very finely balanced. If it were but a little weaker, the only nuclei that would exist would be those of hydrogen, thereby precluding the possibility of carbon-based life. On the other hand, if the strong nuclear force were only a little stronger there would be no hydrogen, and therefore no water.

The mass of the neutron relative to that of the proton is also a very sensitive parameter. The neutron is 0.138% more massive than the proton. Because of this, fewer neutrons than protons are produced when the cosmic fireball of the Big Bang cools due to the expansion of the universe. If the neutron were only 0.1% more massive, so few neutrons would be produced relative to protons that there would not be enough neutrons to produce enough heavier elements for life.

The strength of the Big Bang is quite critical for the existence of a universe that is suitable for complex life forms. We need a suitable planet with water, minerals and dry land orbiting a suitably long-lived star at a distance such that water neither remains permanently frozen nor boiled away, with the star located in a suitable region in a galaxy (galactic habitable zone). If gravitational attraction dominates over kinetic energy of expansion in the Big Bang, the universe collapses back to a Big Crunch in too short a time and galaxies do not get a chance to form, nor do red giants have enough time to produce the elements needed for life.

Furthermore, it is important that there should be both big stars, particularly red giants, because it is in their interiors that the heavier elements are formed by thermonuclear fusion. However, their lifetimes are short. Stars that burn their nuclear fuel in a steady and reliable way are found among the smaller mass stars.

The physical parameter that controls the size of stars is the ratio of the electromagnetic force constant to the gravitational force constant. If this parameter was larger there would be no stars with less than 1.4 solar masses, and stellar lifetimes would be short and with fluctuating luminosities. If, on the other hand, this parameter were much smaller there would be no stars with masses greater than 0.8 solar mass, and heavier elements would not be produced.

General Agreement on Fine Tuning, but Not on its Interpretation

Books and articles written by physicists and cosmologists with widely varying world views (atheist, agnostic and theist) reveal that there is widespread agreement on the reality of fine tuning in physics and cosmology, but sharp differences on the conclusions to be drawn from the fine tuning. Three main lines emerge:

- we are just lucky to live in a universe that has this fine tuning; indeed, if it weren't fine tuned we wouldn't be here;

- the fine tuning of the universe is the work of God, who has created a universe richly endowed with creative potentiality; and
- there are an infinite number of universes (multiverse), each with its own constants of physics (indeed, with its own laws of physics), and we just happen to live in a universe where the laws and the constants of physics happen to allow the existence of complex life.

The first view tends to be aligned with agnostic views. Clearly the second is aligned with theistic views, and the multiverse view is taken up with enthusiasm by atheists.

However, the interesting development with the multiverse view is that its proponents have found it necessary to relax their insistence on the necessity of Ockham's razor ("Entities should not be multiplied beyond necessity"). Previously atheists had not been averse to using Ockham's razor freely against theists, alleging that the introduction of the idea of God was a prime example of an unnecessary idea for which there was no empirical evidence. Now, confronted by the wide range of examples of fine tuning in the universe, atheists have found it necessary to make statements such as: "Likewise, our universe may be just one of an ensemble of all possible universes, constrained only by the requirement that it allows our emergence. So I'm inclined to go easy with Ockham's razor: a bias in favour of 'simple' cosmologies may be as short-sighted as was Galileo's infatuation with circles" (Martin Rees, *Just Six Numbers*, 1999).

It is important to note in this context that the other universes postulated for the multiverse are not observable from our universe, and the mechanisms postulated for the production of new universes from black hole collapse of stars ignore such principles as the conservation of mass! So it is becoming clear that atheists who adopt the multiverse idea are just as much involved in a religious standpoint as theists.

The Unreasonable Effectiveness of Maths

Fine tuning of the physical universe is not the only ground for believing that the whole universe is a created entity. The philosopher and now former atheist Antony Flew lists two key influences in his change to believing that there is a God who has created the universe. Flew writes:

> Although I was once sharply critical of the argument to design, I have come to see that, when correctly formulated, this argument constitutes a persuasive case for the existence of God. Developments in two areas in particular have led me to this conclusion. The first is the question of the origin of the laws of nature and the related insights of eminent modern scientists. The second is the question of the origin of life and reproduction.
> Flew A. *There Is a God*. HarperOne, 2007

In particular Flew is impressed by Einstein's view that: "The most incomprehensible thing about the universe is its incomprehensibility" (*Physics and Reality*, 1936).

The Nobel laureate physicist Eugene P. Wigner pointed out that while the concepts of elementary arithmetic and particularly elementary geometry were formulated in such a way as to be applicable to entities in the physical world, this is not true of concepts that have been introduced in higher mathematics. Nevertheless, it has repeatedly turned out that concepts in higher mathematics have had remarkable applications in areas of modern physics that were not even dreamed of when the mathematical concepts were developed.

A good example is that of the theory of matrices, with their eigenvalues and eigenvectors, dating from before the turn of the 20th century, and the rules that the future Nobel laureate physicist Werner Heisenberg had developed in the mid-1920s for the calculation of energy levels in single electron atoms, which the Nobel laureate physicist Max Born had shown were formally identical to those of the theory of matrices. When Heisenberg's rules were applied to the hydrogen atom they gave results in striking agreement with observation.

The unreasonable effectiveness of mathematics is very difficult to explain on a non-theistic basis. In particular, explanations on the basis of "survival of the fittest" of mathematical theories are not convincing. The mathematical physicist P.A.M. Dirac used the criterion of mathematical beauty in his successful search for the relativistic quantum mechanical equation for the hydrogen atom, but mathematical beauty is a far cry from survival of the fittest.

By far the simplest standpoint for explaining the finite lifetime of the universe, the fine tuning that is to be seen in physics and cosmology, and the unreasonable effectiveness of mathematics in the natural sciences is belief in a sovereign creator God.