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The God Question in Contemporary Physics

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St. Ignatius ends his *Spiritual exercises* with a prayer concerned with "finding God in all things." For him this was not a difficult exercise. We may say, of course, that it was not difficult because he was a mystic. Yet even as a mystic his finding of God built upon his human consciousness and, thus, on his basic human knowledge. After his theological studies at the University of Paris, his human knowledge of God incorporated the medieval European view, which saw God as Creator and Redeemer. This, in turn, was compatible with the understanding of the physical world of the time—an earth-centered Universe with humankind at the center of a static earth, about which revolved the rest of creation.

As we remember Matteo Ricci and his contribution to Chinese culture we also recall how he built his Christian message on the Chinese interest in astronomy and science, especially as this astronomy showed a stable, static cosmos where the world is receptive to the rule of the Emperor. As has been said: "Ricci and his fellow Jesuits considered their religious message and European science an integrated whole, precisely called 'heavenly studies' where science and theology supported each other..." (Criveller 2010).

Today, then, in the same spirit as Ricci can we "find God in all things" in a universe which science shows us is far from static and even the oneness of the "Uni-"verse is called into question?

The aim of this essay is to answer this question. Or maybe better still, the point addressed here is to pose the question in such a manner that the reader will be assisted to seek an answer. In the traditional language of academe, what we are doing is 'natural' theology. We are probing the natural world to see if it can point out to us the Supreme Reality. In this, we follow a long tradition where the philosopher sought to find God through the natural world. In the Scholastic tradition, this is summarized in the philosophical tract called "Cosmology" and is very much what Ricci did as he spoke of the Lord of Heaven. This, in turn, would presuppose that the philosopher was willing to accept that the world has a Creator, though the way this term was construed could vary a good deal. This was the approach made famous by St. Thomas Aquinas in his "Five Ways" as set out in the *Summa theologica*. In time, this approach to prove the existence of God and possibly gain some knowledge of His attributes became known as "natural theology." It is 'natural' because it starts from nature, the natural world; it is natural 'theology' because it attempts to have knowledge of God.

Science enters this scene and philosophical cosmology, and its questions begin to be taken over by science. This is usually considered to start with Isaac Newton and his *Principia mathematica*. By the time of the French Revolution and its "Enlightenment," the world of the natural was to be understood by reason alone, and what was not 'rational' was suspect. Nature was basically a mechanistic complexity based on laws of science, which the human mind could fathom as witnessed, for example, by the great unification of the laws of electricity and magnetism by James Clarke Maxwell in the 1860s. That this unity was expressed in the language of vector calculus all the more strengthened the 'reason first' mentality.

One of the consequences of this approach to nature and its laws was the suspicion that teleological arguments have no place in this scheme. Whereas before, the teleological and the theology of nature were seen to be bedfellows, the union was severed or at least greatly weakened with the rise of mathematical physics. Pierre Laplace's famous remark to Napoleon that he saw no need to introduce the 'hypothesis' of God in his monumental work on mathematical physics some one hundred years after the work of Newton summarizes the spirit of the age. For him, as for the age, once the initial conditions were specified, the natural world could take care of itself. It had no need of an end or purpose.

The work of Charles Darwin, of course, removed the last place that teleology might lurk—the world of the living. Living things had been reduced to machines ever since the thought of Descartes had made them so. Darwin sealed their fate by declaring that survival of the fittest has its own natural law analogous to those of Newton and Maxwell (Fabian 1998).

This would all change with the physics upheaval of first Relativity Theory and then Quantum Theory in the twentieth century (Ryder

1996; Bell 1987; Brown and West 2000). But time will not allow us to pursue that upheaval here. Rather, let us return to a cosmological viewpoint and consider the modern vision of the world (Close 2000).

The contemporary vision of the Universe that modern astrophysics provides has removed the static from our thinking. We see every day on Internet, for instance, dramatic pictures taken by the Hubble orbiting telescope of worlds in collision. Galaxies eat other galaxies or better said, "ate" other galaxies as the scenes we view by means of the instrument in space actually took place millions of years ago. We see seething, billowing roils of interstellar gas writhing in the pangs of starbirth. We worry about seeing the small planets about us whose relatives have, in the past and may in the future, pay us a visit in no uncertain terms. Our very life on earth could come to a violent end with just such a visit.

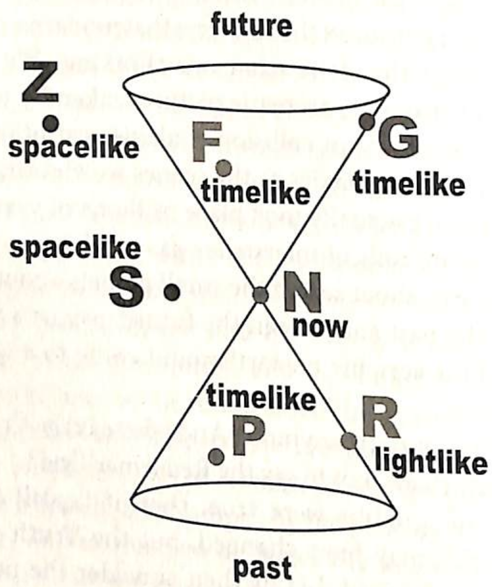
No, the world is not static anymore. And where is the Creator God in the midst of such chaos, not to say the Redeemer God?

If the vision of Ignatius were true, then it is still true. The model of our worlds may have changed, but the Truth is eternal and could not have changed. Let us then consider the model that contemporary physics gives us of this world, a world violent and nonstatic (Dembski 1998).

We have a model of the Universe built upon the basic physical insights handed down to us by the scientists of the past. Starting with Isaac Newton, we see the law of gravity working everywhere there is mass. Using Kepler's laws we situate ourselves on the third planet for the G2 star we call Sun. The solar system so orderly conceived we know today has plenty of chaos within it. Let us look more closely at this.

Today, the science of physics enshrines the laws of the universe in the language of Einstein. For modern science, space and time are no longer separate entities but put together in a picture or model of the universe. We are accustomed to think of 'our' time as the universal time and this, indeed, is how even the great Newton conceived of time—there is but one time and it applies to all places in the universe. With Einstein, however, the twentieth century was given another version of the relation between space and time. Now, we see them as inextricably linked so that to speak of the 'time' over there at some other place, we need to distinguish as to whether or not that other place is moving or not. If it is moving, then we cannot simply say that 'our' time is their time (Ryder 1996).

The following diagram shows the elements of the theory in pictorial form.



Here the light cone refers to all those light signals coming to us from the past or sent out by us to the future. In the diagram we are at the center (N). Time is plotted in the upward direction; and so, the future lies in F above us and the past in P below us. Since time is on the vertical axis the other two axes represent all of the three dimensions of space—*x*, *y*, and *z*. But since we only have two directions remaining on the piece of paper, we let two typical spatial dimensions, such as S and Z, stand for all three. In the diagram you are at N and in time, this is time = zero or your *now*. If you turn on a light at this point (the central dot), then the light travels away from you into your future. Since this is the fastest speed at which anything can travel, it defines a certain region in the diagram, which is called the light cone. In the diagram, a typical light ray is that at the point G. Note that symmetrically to G there is a light ray coming to you from the point R in your past—downward in the diagram. All such rays form the past light cone. If you are looking at someone, this would mean that you see them in *your* past. The light by which you see them takes an instant of time to reach your eye so you see them, you 'know' them, as they were, not as they are.

When we reflect on this necessary corollary of modern physics we see that our knowledge of the world—everything we know and

everyone we know—comes to us from the other side, as it were, of the invisible knowledge line, the demarcation line of possible interaction drawn by the physical speed limit law: the speed of light. Each knower then knows only her past. Of course, the same can be said of her future, considering the symmetry in the space-time diagram. Thus, modern physics reaffirms the Thomistic and Scholastic concept of individuation: each knower is an individual divided off from the known, even as she conceives the known in herself by the act of knowledge. Such individuation in the act of knowing emphasizes the dualistic nature of the knowing process. It throws yet another span onto the bridge separating the knower from the known. "How do I know that I know?" and "Do I know the thing-in-itself?" is now joined by "How can I know the Now?" The knower is an isolated Monad in a sea of monads constantly emerging into their own private Nows. Thus, the name "Theory of Relativity" can be taken from the realm of physics and brought into that of epistemology and philosophy with a totality of meaning.

Yet the theory is really not about what is relative so much as to what is thereby nonrelative or absolute, viz. the laws of physics. The theory places them as the common ground that enables the physical world to be known by the mind and upon which a common vision of the world is possible. The physical world has physical rules, which in their own way not so much determine as 'pre-scribe' what is possible, what can be, what can come to birth in its womb. The world has infinite possibilities within it, but they are circumscribed by the laws of the same physical realm. The speed of light is the speed limit of knowing; but light is composed of electric and magnetic fields. They in turn sprang from the first primeval energy source. All is contained in their matrix and its derivatives in time, million and billions of years of time. We are individuals, but individuals in a fertile womb of infinite potential.

Thus, starting with Relativity Theory we return to the ancient concept of 'potential.' In fact, Werner Karl Heisenberg, one of the founding fathers of that other cornerstone of the modern physical worldview—quantum theory—placed the concept of potential in a central position in his interpretation of the theory. However, for our purposes in cosmology and whether God can be found there, the potential of the cosmos leads us in another direction. This is the Anthropic Principle (Barrow and Tipler 1986).

The Anthropic Principle was coined in the second half of the twentieth century to encode data found by the astronomers in their search to answer the questions of human life in the cosmos. As more and more data became available with breakthroughs in optical and radio astronomy, the scientists noted certain 'coincidences' in the data. It was realized that one way to capture the relevance of these coincidences was to note that they all seemed necessary for human life to be possible. If the numbers were not such and such, as was in fact the case, then human life would not be possible in the universe. The Anthropic Principle places this fact at the fore by saying that we see the world as it is because we are here to see it. If the numbers were not as they are, we could not be here.

The Anthropic Principle can obviously be seen as the granddaughter of the Design Argument as put forth by St. Thomas. There, St. Thomas argues that the natural world shows a great deal of teleology and thus, implies a Designer. From the fact that causes exist, St. Thomas says we may infer the First Cause (*Summa theologica* I, 103). The argument has flourished over the centuries, finding one of its recent forms in the classic book of William Paley entitled *Natural theology* (1802). Here, Paley uses the simile of creation as a fine watch that one finds lying on the ground one day and examines closely, opening it to see the intricate play of the wheels and cogs. Such fine workmanship would imply a Design is at work. Thus, there must be a Designer.

The argument is brought to the fore today by the work of Barrow and Tipler (1986). They distinguish between the weak and the strong forms of the Anthropic Principle. In the weak form, the Anthropic Principle accepts the present situation. It declares that the physical constants of nature—quantities that rule the laws of the physical world—are not arbitrary but must have such values so as to give rise to carbon-based life. In its strong form, the Principle says this is because they are designed to have these values. It leaves open the question as to why this should be so.

The parameters in question are given by the equations listed here, as given in standard school text form. What is to be noted for our discussion of the Anthropic Principle is the appearance of the constants of nature in these equations: *h*, Planck's constant; G, the gravitational constant; *k*, Boltzmann's constant; *c*, the speed of light; and *e*, the fundamental electric charge, the latter two constants being hidden in Maxwell's Equations.

Table 1. Fundamental laws of nature

Mechanics (Hamilton's Equations)	$\dot{p} = \frac{\partial H}{\partial q} \quad \dot{q} = \frac{\partial H}{\partial p}$
Electrodynamics (Maxwell's Equations)	$F^{\mu\nu} = \partial^{\mu} A^{\nu} - \partial^{\nu} A^{\mu}$ $\partial_{\mu} F^{\mu\nu} = j^{\nu}$
Statistical Mechanics (Boltzmann's Equations)	$S = -k\Sigma P_i \, ln \, P_i$ $\frac{dS}{dt} \geq 0$
Quantum Mechanics (Schrodinger's Equations)	$i\hbar \mid \psi \rangle = H \mid \psi \rangle$ $\Delta x \, \Delta p \geq \frac{\hbar}{2}$
General Relativity (Einstein's Equations)	$G\mu\nu = -8\pi G T_{\mu\nu}$

These equations express the four fundamental forces we need to understand the physical world. They form the so-called Standard Model of physics. This theory is the latest formulation of a comprehensive model of the physical world, encompassing work done in the twentieth century but, of course, building upon all earlier work. It is often called the most precise physical theory of the world ever fashioned. This precision refers to the experiments, which have measured the values concerned to extraordinary precision. Take, for example, the agreement between theory and experiment in the measurement of the electron's magnetic moment. The theory or prediction = 0.001159652? while the experiment =0.01159652? (Ryder 1996). Here, the question mark indicates an uncertainty in both the predicted value and the experiment for that particular place in the decimal number. In other words, the Standard Theory has agreement between theory and experiment to nine decimal places! Thus, this has been called the most precise theory in the history of the world.

Further appreciation of the Anthropic Principle brings us to what are often called 'coincidences' in the laws of nature that make it possible for us to exist (Barrow and Tipler 1986). These coincidences refer to the numerical values of certain universal constants and elementary particle masses that appear in the basic mathematical laws governing the cosmos. Basic as they are, the argument states they cannot be changed significantly without the appearance of human beings being affected. This is seen in the so-called Fine Structure Constants (Bradley 1999).

Table 2. Universal constants, mass of elementary particles, and fine structure constants

Universal Constants	
Boltzman's constant	$k = 1.38 \times 10^{-23}$ j/°K
Planck's constant	$h = 6.63 \times 10^{-34}$ J/s
Speed of light	$c = 3.00 \times 10^{8}$ m/s
Gravitational constant	$G = 6.67 \times 10^{-11} \dfrac{N-m^2}{kg^2}$
Mass of Elementary Particles	
Pion rest mass/energy	$m_\pi = 0.238 \times 10^{-24}$ kg/135 MeV
Neutron rest mass/energy	$m_n = 1.675 \times 10^{-27}$ kg/939.6 MeV
Electron rest mass	$m_e = 9.11 \times 10^{-31}$ kg/0.511 MeV
Proton rest mass	$m_p = 1.673 \times 10^{-27}$ kg/98.3 MeV
Unit charge	$e = 1.6 \times 10^{-19}$ coul
Mass-energy relation	$c^2 = \dfrac{E}{m}$ J/kg
Fine Structure Constants	
Gravitation fine structure constant ("Alpha-G")	$\alpha_g = [\dfrac{m^2_e}{hc} \bullet G] = 0.5 \times 10^{-40}$
Fine structure constant of the weak interaction ("Alpha-W")	$\alpha_w = [\dfrac{m^2_e c}{\hbar^3} \bullet g_f] = 10^{-11}$
Electromagnetic fine structure constant ("Alpha-E")	$\alpha_e = [\dfrac{1}{\hbar c} e^2] = 1/137$
Fine structure constant of the strong interaction ("Alpha-S")	$\alpha_s = f = 3.9$

Following Bradley, consider each of the Fine Structure Constants. Using Table 2 on the opposite page, we can compare the electromagnetic force to the gravitational force. Electromagnetism wins by a factor of 10 with 38 zeros! It is that much larger than gravity. Why such a huge difference? As Bradley (1999) states:

> It is the force of gravity that draws protons together in stars, causing them to fuse together with a concurrent release of energy. The electromagnetic force causes them to repel. Because the gravity force is so weak compared to the electromagnetic force, the rate at which stars "burn" by fusion is very slow, allowing the stars to provide a stable source of energy over a very long period of time. If this ratio of strengths had been 10^{32} instead of 10^{38}, i.e., gravity were much stronger, stars would be a billion times less massive and would burn a million times faster.

Next consider the strength of the nuclear strong force. The most critical element in nature for the development of life is carbon. Yet, it has recently become apparent that the abundance of carbon in nature is the result of a very precise balancing of the strong force and the electromagnetic force, which determine the quantum energy levels for nuclei. Only certain energy levels are permitted for nuclei, and these may be thought of as steps on a ladder. If the mass-energy for two colliding particles results in a combined mass-energy that is equal to or slightly less than a permissible energy level on the quantum "energy ladder," then the two nuclei will readily stick together or fuse on collision, with the energy difference needed to reach the step being supplied by the kinetic energy of the colliding particles. If this mass-energy level for the combined particles is exactly right, or "just so," then the collisions are said to have resonance, which is to say that there is a high efficiency of collisions for fusing the colliding particles.

On the other hand, if the combined mass-energy results in a value that is slightly higher than one of the permissible energy levels on the energy ladder, then the particles will simply bounce off each other rather than stick together or fuse. In 1970, Fred Hoyle predicted the existence of the unknown resonance energy level for carbon, and he was subsequently proven right. The fusion of helium and beryllium gives a mass-energy value that is 4 percent less than the resonance energy in carbon, which is easily made up by kinetic energy. Equally important was the discovery that the mass-energy for the fusion of carbon with helium was 1 percent greater than quantum energy level on the energy ladder for oxygen, making this reaction quite unfavorable. Thus, almost all beryllium is converted to carbon, but only a small fraction of the carbon is immediately converted to oxygen. These two results require the specification of the relative strength of the strong force and the electromagnetic force to within approximately 1 percent, which is truly remarkable given their large absolute values and difference of a factor of 100, as seen in Table 2.

More generally, a 2 percent increase in the strong force relative to the electromagnetic force leaves the universe with no hydrogen, no long-lived stars that burn hydrogen, and no water (which is a molecule composed of two hydrogen atoms and one oxygen atom), the ultimate solvent for life. A decrease of only 5 percent in the strong force relative to the electromagnetic force would prevent the formation of deuterons from combinations of protons and neutrons. This would, in turn, prevent the formation of all the heavier nuclei through fusion of deuterons to form helium, helium fusion with helium to form beryllium, and so forth. In 1980, Rozental estimated that the strong force had to be within 0.8 and 1.2 times its actual strength for there to be deuterons and all elements of atomic weight 4 or more.

If the weak force coupling constant (see Table 2) were slightly larger, neutrons would decay more rapidly, reducing the production of deuterons, and thus of helium and elements with heavier nuclei. On the other hand, if the weak force coupling constant were slightly weaker, the big bang would have burned almost all of the hydrogen into helium, with the ultimate outcome being a universe with little or no hydrogen and many heavier elements instead. This would leave no long-term stars and no hydrogen-containing compounds, especially water. In 1991, Breuer noted that the appropriate mix of hydrogen and helium to provide hydrogen-containing compounds, long-term stars, and heavier elements is approximately 75 percent hydrogen and 25 percent helium, which is just what we find in our universe.

The frequency distribution of electromagnetic radiation produced by the sun is also critical, as it needs to be tuned to the energies of chemical bonds on earth. If the photons of radiation are too energetic (too much ultraviolet radiation), the chemical bonds are destroyed and molecules are unstable; if the photons are too weak (too much infrared radiation), then chemical reactions will be too sluggish. The radiation produced is dependent on a careful balancing of the

electromagnetic force (alpha-E) and the gravity force (alpha-G), with the mathematical relationship including (alpha-E)^{12}, making the specification for the electromagnetic force particularly critical. On the other hand, the chemical bonding energy comes from quantum mechanical calculations that include the electromagnetic force, the mass of electron, and Planck's constant. Thus, all of these constants have to be sized relative to each other to give a universe in which radiation is tuned to the necessary chemical reactions that are essential for life.

Another fine-tuning coincidence is that the emission spectrum for the sun not only peaks at an energy level that is ideal to facilitate chemical reactions, but it also peaks in the optical window for water. Water is 10^7 times more opaque to ultraviolet and infrared radiation in the visible spectrum (or what we call light). Since living tissue, in general, and eyes, in particular, are composed mainly of water, communication by sight would be impossible were it not for this unique window of light transmission by water being ideally matched to the radiation from the sun. Yet this matching requires carefully prescribing the values of the gravity and electromagnetic force constants, as well as Planck's constant and the mass of the electron.

This is only an illustrative and not an exhaustive list of cosmic coincidences. They clearly demonstrate how the four forces in nature have to be very carefully scaled to give a universe that provides long-term sources of energy and a variety of atomic building blocks necessary for life. Many other examples involving the fine-tuning of these forces are described in the books previously cited. Even so, the fine-tuning of the universe is not confined to these four forces (Behe, Dembski, and Meyer 2000). As it turns out, the elementary particles, as well as other universal constants like the speed of light and Planck's constant, also have to be very precisely specified.

Given these coincidences one might consider the Design Argument alive and well. But interestingly enough, the above arguments are not above cavil. Many a theoretical cosmologist today, such as Stephen Hawking, Martin Rees and many more, would simply say that there is an alternative explanation for these numbers. For them, the Anthropic Principle is true enough in its weak form. But the strong form does not hold for there is no Designer. Just chance.

By chance, you say, that all these numbers are fine-tuned to this exact value? Is not this but a secularist 'act of faith'? Their answer would be "By no means!" for they would direct our attention to the Many Worlds interpretation of Everett and its implications. This theory holds that the answer to the Anthropic Principle is that there are many other universes. We live in the one that supports our carbon-based life. There could well be life forms in the other universes, but we will never know. For the Everett interpretation of Quantum Theory holds that these other universes are totally distinct from ours, and we never and can never interact.

At this point let us get ready to stop. At the outset, I said our aim would be to inform the reader so that she could make an intelligent answer to the "God question" in the Standard Theory of Cosmology today. Thus it behooves me to make one final observation before I end: a comment about probably the most well-known physicist of our age, Professor Stephen Hawking.

Stephen Hawking has gained popularity mostly due to his serious medical disability and the remarkable ability he has shown to do theoretical physics despite his broken body. That is not to say his theoretical science is not world class. It is within the genre of his specialization. But when he comes to generalizing his thoughts beyond the realm of physics, questions must be asked.

Professor Hawking builds on his popularity by venturing into philosophical questions. His latest book, *The grand design* (Hawking and Mlodinow 2010), begins by dismissing the philosophers as unable to answer the "big" questions. This is to open the door to Hawking's answers, which come from his discipline of quantum gravity. So in this work he espouses one of his favorite theories, the Multiverse. We see through the lens of quantum gravity a universe populated with an infinite number or worlds, or universes, if you will, that are by definition unable to be placed in a single Universe as they are totally incommunicado with each other. One has to wonder if the well verified methodology that Multiverse proponents use, called Statistical Mechanics, has not led them into its own Black Hole. This methodology was developed over a hundred years ago to deal with the unseeable world of atoms and molecules with its huge number of entities and has had remarkable success at that level of explanation

of the physical world. But to extrapolate it so as to give us an infinite number of 'universes' seems stretching a point, to say the least. The final step in this extrapolation from Hawking is to declare that there is nothing exceptional in the "fine-tuning" we see in our world, which I have been pointing out in this essay. For him this is simply the fact that we live in that particular universe out of all the infinite others, that has these properties and so human life, **us**.

I trust that if we end the story here with the Multiverse, the reader will note that while the Age of Faith of a thousand years ago pondered how many Angels can dance on the head of a pin, the Age of Reason now asks how many Universes can we never know!

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