Looking for the God Particle at the Large Hadron Collider

Mary Beth De Repentigny

The Large Hadron Collider at CERN is scheduled to begin colliding protons in October of this year. Two of its main goals are to look for both the Standard Model's Higgs particle and supersymmetry's sparticles. An objective overview of these theories, along with string theory, reveals the precarious balancing act that high-energy physics is in because of theorists' attempts to explain away fine-tuning which points to an intelligent designer. Ironically, their foundational theory is rooted in a faith in very large numbers that they hope will cancel out impossible odds.

In the autumn of 1993, a vote came before the United States Congress to continue funding construction of the Superconducting Super Collider near Waxahachie, Texas. It was to be a machine that would produce 40 trillion electron-volts (TeV) of energy, twenty times the total energy of the Tevatron near Chicago, which was, at the time the highest-energy particle accelerator in the world. Although two billion dollars had already been poured into the project, and 22 km of the total 87 km tunnel had been excavated, the demise of the project turned out to fall on the answer to a profoundly misplaced question. A congressman asked a consulting physicist if we would find God with this machine. If so, he would vote for it. The physicist replied in a rather lackluster fashion that we could find the Higgs boson. Knowing the difficulty of justifying $12 billion for another subatomic particle, Congress voted down the great-American particle smasher.[1] When men refuse to acknowledge God as Creator and believe the lie of evolution, they find themselves looking for God in all the wrong places, even in particle accelerators! The long tentacles of Darwinian philosophy, which attempts to explain the emergence of life without God, reach even into the mathematical world of theoretical physics. The theories of supersymmetry and string theory endeavour to wipe out the fine-tuning of different parameters that make our universe conducive to life as we know it. An objective survey of these theories, however, reveals that they bring in more problems than they solve for evolutionists in their efforts to conceal the fingerprints of the Designer on his design.

When the Americans dropped the baton of particles physics by nixing the Texas supercollider, the Europeans at CERN quickly picked it up and ran with it by building the Large Hadron Collider. CERN is a French acronym for the European Organization for Nuclear Research. It is the international laboratory that houses the Large Hadron Collider, or LHC. Straddling the Swiss-French border, the tunnel of this $8 billion collider is 27 km in circumference. As 'the world's most powerful hammer', the LHC will catapult particles to an energy of 7 TeV, effectively smashing protons together to see what they are made of and to give new particles a chance to form. These protons will make 11,000 loops per second around the circle, reaching a speed to within 10 km per hour of the speed of light, making 50 million collisions within a second. Powerful particle detectors will register the direction and energy of the resultant particle debris and collect a full DVD's worth of data every five seconds. According to current schedule, the first beam of protons will circulate through the entire LHC on September 10, 2008. The first collisions will occur after its official unveiling on October 21, 2008.

Scientists say the Large Hadron Collider takes us back to the big bang

The LHC is being promoted as a machine that will take us back to within a fraction of a second after the big bang. What physicists actually mean by this dramatic claim is that by colliding nuclei, they will create very high temperatures, exceeding 100,000 times the temperature in the core of the sun, in a volume smaller than an atomic nucleus. Scientists who believe that such high temperatures prevailed during the big bang naturally surmise they will be looking back into our remote origins. Creationists, on the other hand, can separate these subjective conclusions of historical science from the hard facts of empirical science and analyse the information coming out of the LHC without swallowing the evolutionary hype. Nevertheless, the great energy of the LHC should untie quarks and create the quark-gluon plasma in which quarks and gluons roam freely. The elementary particles called the strange, charm, beauty and top quarks can only exist in these extreme conditions. Physicists will be recreating them in the LHC. As the temperature cools, these particles quickly decay, leaving the surviving up and down quarks permanently glued together inside protons and neutrons by gluons which transmit the strong nuclear force. This is the purpose of the ALICE experiment at the LHC: to study how elementary particles are organized under the action of the strong force.[2]

Background for the Higgs particle

As for the elusive Higgs boson whose mention to Congress derailed the Superconducting Supercollider, it is like the missing piece to an otherwise complete puzzle of

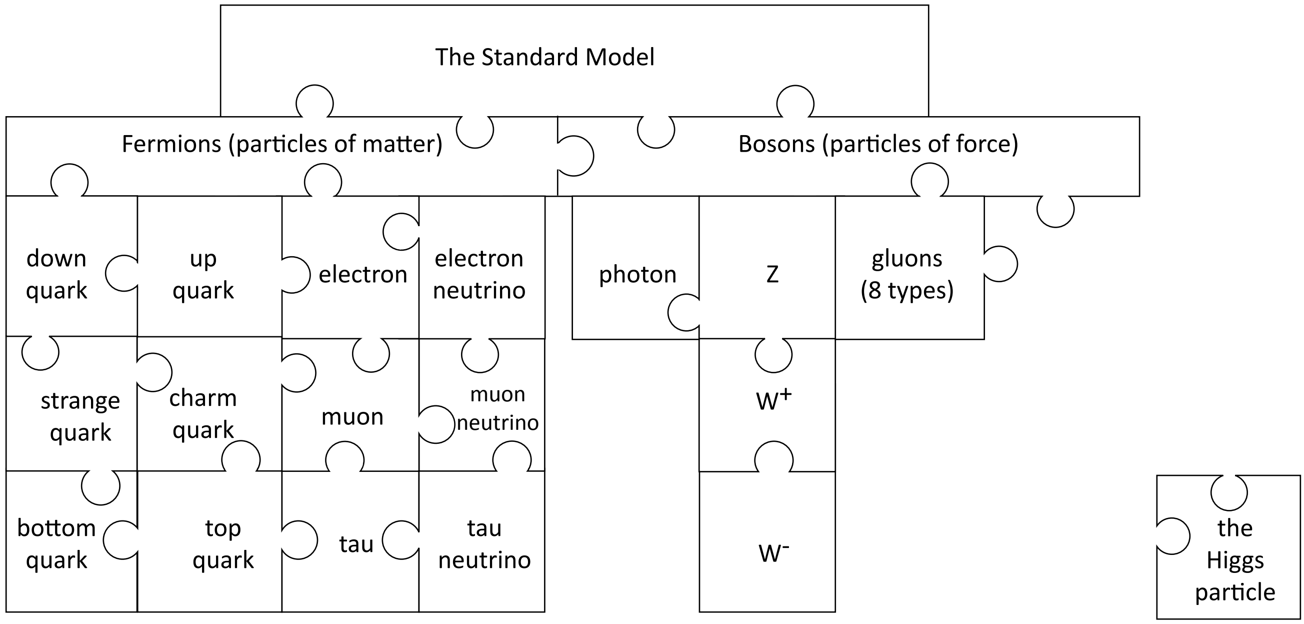

Figure 1. Since all the other elementary particles have been experimentally confirmed, the Higgs particle is the missing piece to an otherwise complete Standard Model of particle physics. Without it, however, the math would be consistent only if all particles are massless, moving at the speed of light. Fermion = particle of half-integral intrinsic spin, and are the building blocks of matter. Boson = particle of integral intrinsic spin; the fundamental forces are mediaters by bosons, although some have mass.

particle physics called the Standard Model. The Standard Model is the current explanation of the known elementary particles and their interactions with electromagnetism and the strong and weak nuclear forces. The Standard Model holds that electromagnetism and the weak force merge into one force around 10^{13} GeV. The LHC is built to probe physics at this weak interaction scale. The Standard Model says all particles in the universe would be massless at this energy, travelling at the speed of light and unable to settle down into atoms. When the hypothesized Higgs field froze out of the primordial cosmic soup, the symmetry broke, electroweak forces split and the weak force was unable to propagate freely.

The Higgs field is a scalar quantum field. Nobel laureate Leon Lederman referred to the particle that carries the force of this field as the ‘god particle’, for this Higgs boson is touted as being the godlike source of all mass in the universe. Apart from being a high-tech version of the ancient animistic error of projecting attributes of the Creator onto the creation, this notion is a scientific misrepresentation as well. The Higgs field can only account for the mass of elementary particles because composites such as the proton and neutron have binding energy that acts as mass. Nevertheless, the Weinberg–Salem model of the electroweak force in the Standard Model has been very successful. It has led to predictions of three particles that carry the weak force, called the W^+, the W^-, and the Z. All three of these have been found with the exact properties predicted by the theory. We are left with only one prediction that has not been experimentally verified in this version of the Standard Model, and that is the Higgs particle.

How the Higgs saves the Standard Model

In order for electroweak unification to work mathematically, it requires that the force-carrying particles have no mass. Experiments show this is not true. If, however, all particles had no mass until the Higgs field congealed, then any particles that interact with the Higgs field are given a mass via the Higgs boson. The importance of this hypothetical particle to the Standard Model cannot be overstated. If physicists do not find it with the LHC, they will be forced to develop a completely new theory to explain the origin of mass. In the words of Lee Smolin in his book *The Trouble with Physics*, ‘First of all, we want the LHC to see the Higgs particle, the massive boson responsible for carrying the Higgs field. If it doesn’t, we will be in big trouble.’[3] The Higgs, you see, is the saviour of the Standard Model.

A fine-tuned problem for the Higgs mass

Trouble comes with the fact that the Higgs mass is undetermined and must be put in by hand, while all we know is that it should be greater than about 120 times the mass of a proton. The large differences between the masses of the particles of the Standard Model (example: electron mass = 1/1,800 × proton mass) require fine-tuning of their intrinsic masses (mass minus quantum effects). The intrinsic masses of bosons (the category for particles of force) and fermions (the category for particles of matter) is proportional to the mass coming from quantum effects. Thus we say their masses are 'protected'. In other words, if their intrinsic masses are small, so are their total masses. The Higgs boson, it turns out, is the only unprotected particle in the Standard Model. It exhibits an intense self-interaction by emitting particles and reabsorbing them, the energy of which acts as mass. The only way to keep its mass from being pulled up to the Planck mass where quantum gravity effects come into play, a whopping 10^{16} times too heavy, is to fine-tune the score of constants in the Standard Model to an incredible precision of 32 decimal places. There is no room for inaccuracy in any one of these 32 decimal places; otherwise the Higgs mass becomes much too large. The miraculous fine-tuning required to keep the Higgs mass low is more extreme than the precision needed balance a pencil on its sharpened end. This dilemma is known as the Higgs hierarchy problem.

Hand-picking just the right numbers to make them fit in the Standard Model feels like fudging the answers to many physicists because it implies intelligent design in our universe. Since life can only exist in an extremely narrow range of all physical parameters, they feel the need to find a physical explanation as to why nature fell precisely on those fortunate values that give rise to life. Improbable yet fortunate coincidences, in the minds of evolutionary scientists, need an explanation, and the obvious answer that the universe has been designed to accommodate man is not a viable option for them. Theorists lament that they see fine-tuning as almost certainly a badge of shame which reflects their ignorance.[4] So, they create a new theory to get around the need for fine-tuning.

Background for supersymmetry

Supersymmetry is a theory introduced to try to explain away the fine-tuning of the Higgs mass. Supersymmetry theory relates fermions to bosons by saying that every boson has a fermion partner whose spin differs by one-half and every fermion has a boson partner with the same one-half spin difference.[5] None of these hypothetical supersymmetric partners have been seen in thirty years of looking, but they have been named 'sparticles'. Seeking sparticles is one of the main goals of the LHC.

Besides providing a way to keep the Higgs mass 'naturally' low (i.e. without fine-tuning), there are several other advantages gained with supersymmetry. First, by extending the Standard Model to a supersymmetric quantum field theory, the strong force, the weak force and the electromagnetic force strengths all converge around 2×10^{16} GeV. In the Standard Model without supersymmetry, these same interaction strengths do not quite come together at the same point. Thus supersymmetry neatly unifies the three forces of the Standard Model. Another big plus for supersymmetry is that by pushing up the energy at which these three forces converge, supersymmetry slows the predicted decay of the proton to 10^{35} years, which would explain why no one has seen a single proton decay, but not for lack of trying, in huge underground water tanks like the Super-Kamiokande detector in Japan.[6]

How supersymmetry solves the Higgs hierarchy problem

Sparticles must be heavier than their particle partners, otherwise we would have detected them in less energetic accelerators by now. To explain why supersymmetric particle pairs need not have the same mass, supersymmetry must be spontaneously broken, but in just the right way to give particles their properties conducive to life as we know it. Lisa Randall, a leading theoretical physicist, discusses the situation in her book *Warped Passages*,

> 'We want supersymmetry breaking to be small enough to make the supersymmetry-breaking mass difference between superpartners and Standard Model particles sufficiently small to avoid fudging. It turns out that the quantum contribution to the Higgs particle's mass from a virtual partner and its superpartner, though nonzero, will never have a magnitude much greater than the super-symmetry breaking mass difference between the particle and its superpartner.'[7]

If it were the case that supersymmetry was broken on the scale of the weak interaction, the LHC will see sparticles along with the Higgs particle. Supersymmetry solves the Higgs hierarchy problem because the Higgs field would be emitting a sparticle with each particle. The quantum effect of these sparticles would negate the quantum effect that pulls the Higgs mass up way too high, thus keeping the Higgs mass low, with no fine-tuning required.

Problems for supersymmetry

Because the weak-interaction scale is 10^{13} times smaller than the Grand Unified Theory (or GUT) energy, using the Higgs field to break supersymmetry so far below the GUT scale only substitutes the Higgs hierarchy problem for a new supersymmetry breaking hierarchy problem. Then only by carefully fine-tuning every term in the perturbation expansion can physicists keep the weak interaction scale from ending up about the same size as the grand unification energy. Considering this, even with all of its explanatory powers, supersymmetry is not a solid foundation for the Higgs mass to be resting on. Not the least of its other problems is the simple fact that no supersymmetric sparticles have been found in 30 years of looking. Another problem is that introducing spontaneous symmetry breaking to supersymmetry makes a very complicated theory called the minimally supersymmetric standard model with 105 more free constants than the standard model's original 20. This leaves theorists to adjust the free constants by hand to get predictions that agree with experiment. Conveniently, there are many ways to adjust the free constants to make the undetected sparticles too heavy to see. With so many free constants, the supersymmetry theory is difficult to prove or disprove, leaving it open to suspicion. In the words of Lee Smolin, 'The story of supersymmetry is one in which, from the beginning, the game has been to hide the consequences of unification.'[8]

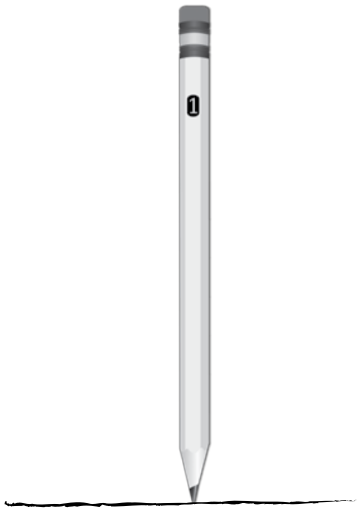

Figure 2. Imagine the precision needed to balance a pencil on its sharpened end. The extreme fine-tuning required to adjust a score of parameters in the Standard Model to keep the Higgs mass from being pulled up way too high by quantum contributions is much more precise than this.

The most devastating consequence of supersymmetry can be alleviated by string theory which requires that spacetime have ten or eleven dimensions, six or seven more spatial dimensions than the three we experience in everyday life. With these extra spatial dimensions, many internal symmetries (symmetries concerning internal properties of particles) could actually be spacetime symmetries (symmetries concerning external properties of particles). For example, the abstract rotations of the internal symmetries could be real rotations, but in higher dimensions. The following is a good explanation of this important link between internal and spacetime symmetries:

> 'What makes supersymmetry so super is that it forges a link, not just between the particle categories but also between spacetime symmetries and internal symmetries. Using an abstract version of rotation, you can transform particles into sparticles and then back again. In the process, the particles scoot over a little bit in space. A change in an internal property affects an external one. Before they discovered supersymmetry, physicists had reckoned such a feat impossible.'[9]

Since supersymmetry causes motion in a particle, and motion is described by special relativity, and the local (or 'gauge') symmetry of special relativity is general relativity, then it follows that the force associated with supersymmetry is gravity. Supersymmetry thus unites the elements of quantum theory with gravity into a theory of supergravity. One big perplexity within this apparently happy union is that the particle that transmits gravity, called the graviton, would spiral out of control. String theory provides supersymmetry with a way out of this debilitating dilemma.

Background for string theory

In order to understand how string theory solves the problem of supersymmetry's spiralling graviton, we first need some background on string theory. Veneziano's formula is an approach that successfully describes the probabilities for the pattern produced when two protons collide at high energy by treating particles as strings that stretch when they gain energy and give up energy when they contract, like a rubber band.[10] The various states of vibration of these strings correspond neatly to the various kinds of particles produced in the proton-smashing experiment. With enough inventive design, the theory can produce all the particles and forces of the Standard Model. String theory holds that the ends of an open string are charged particles. For example, an electron could be on one end of a string and its antimatter counterpart, the positron, on the other end. The massless vibration of the string separating them describes the photon which carries the electrical force between them. When the two ends of the string come together, the ends go away, the photon is released, and a closed loop of string is left behind. This disappearance of particles corresponds to the annihilation that occurs when an electron and positron meet, creating a photon in their place. According to string theory, photons come from vibrations of either open or closed strings, while gravitons come only from vibrations of closed loops. The difference between gravity and the other three fundamental forces is naturally explained as the difference between open and closed strings. 'For the first time, gravity plays a central role in the unification of the forces.'[11] Indeed, a unification of force and motion arises from string theory as well, in that the law of motion dictates the laws of the forces because all forces come from the breaking and joining of strings.

In string theory there are only two fundamental constants: string tension (energy per unit length) and the string coupling constant (the probability of a string breaking into two strings, giving rise to a force). A string's coupling constant is fixed by its multidimensional environment rather than being fixed by the theory. This is an important aspect of string theory, namely that constants migrate from being arbitrarily fixed properties of the theory to being properties of the environment. Another attraction of strings is that they have one underlying law that unifies all their properties. Strings move so as to minimize the two-dimensional surface area which their one-dimensional line draws out as it moves through time, very similar to the way a soap bubble's shape is the result of its surface taking up the minimal area it can.

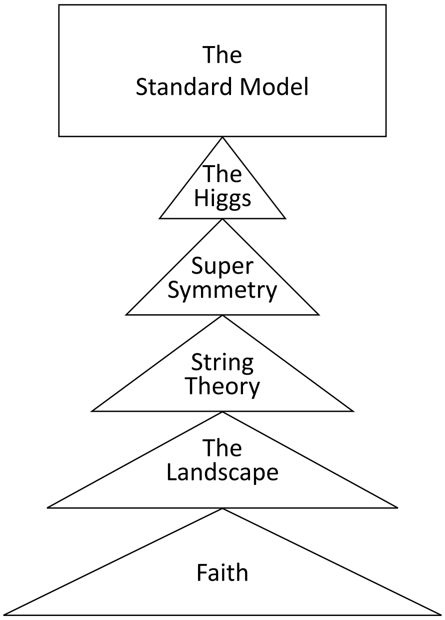

Figure 3. The validity of the Standard Model of particle physics is balanced on the existence of the Higgs particle which in turn balances on supersymmetry to avoid extreme fine-tuning to keep the Higgs mass low. Supersymmetry balances on string theory to save it from its spiralling graviton. Likewise, string theory balances on the Landscape concept which balances on faith in exceedingly large numbers of possible universes to make the highly improbable fine-tuning of the observed cosmological constant a mathematical certainty.

Advantageously, string theory unifies the Standard Model and gravity because all particles and forces arise from the vibrations of strings stretched in spacetime following the simple law that the area be minimized.

How string theory saves supersymmetry

In string theory, particles of matter can change into particles of force. Part of a string can pinch off, creating a new particle, travel through space, and get absorbed by another string. In this way forces are exerted between strings. The strengths of the four fundamental forces are determined by a string's in and out pulsations, called 'dilation'.

A closed string can vibrate by expanding in one direction and contracting in the perpendicular direction, then vice versa. Interestingly, this is the way in which gravitational waves vibrate. Therefore theorists conclude that a string vibrating like this must be a graviton. These graviton loops can split, and split again, but the splitting has a limit in that it can only continue until the loops are too small to divide further. Being a one-dimensional string keeps the graviton from becoming infinitely small as it would be if it were a dimensionless particle. Thus string theory shields supersymmetry's graviton from spiralling into infinity. This solution has problems of its own, though.

A problem for supersymmetry's string theory solution

The way string theory saves supersymmetry from its spiralling graviton is not without an unsettling snag of its own. The difficulty is that supersymmetric string theory does not allow the gravitons to reshape the spacetime around them. This violates Einstein's essential idea that the geometry of spacetime is dynamical and evolving. Although superstring theory recovers all the solutions to general relativity in which some dimensions are flat and others are curled up, these are very special cases. A quantum theory of gravity should describe how different shapes of spacetime change into each other. 'String theory provides a series of snapshots, but ultimately theorists would like a movie.'[12] Thus string theory cannot be a theory of gravity since many gravitational phenomena involve time dependence.

Let's recap what we have so far. The Higgs field is the theorists' tool that saves the Standard Model by giving the elementary particles their mass. Supersymmetry, in turn, rescues the Higgs from its hierarchy problem by proposing sparticles that cancel out quantum effects on the mass that would otherwise require extreme fine-tuning to keep the Higgs mass low. Next, we need string theory to salvage supersymmetry by keeping its graviton from spiralling into infinity. So what saves string theory? 'I didn't know string theory was in trouble', you say. Oh, it is in big trouble, and it takes a theory as large as the vast *Landscape* to rescue it.

Background for the cosmological constant

The cosmological constant is thought to represent an energy that accelerates the universe's expansion. Quantum theory appears to require a huge cosmological constant. This is because at absolute zero temperature, when a particle is exactly still, it cannot have a definite position and momentum without violating the Heisenberg uncertainty principle. Consequently, there is a small residual energy, called vacuum energy, even at absolute zero. This energy generates virtual particles that pop in and out if existence too fast to be seen individually, but collectively their effect lingers. It turns out that this vacuum energy is synonymous with the cosmological constant.

Fine-tuning of the cosmological constant

Fields have a huge number of modes of vibration. When quantum mechanics is applied to a field, a vacuum energy exists for each of these different modes of vibration, thus quantum mechanics predicts a huge cosmological constant. It cannot be that big in reality because such a large cosmological constant implies an expansion rate of the universe so fast that no structure at all could have formed in the big bang scenario. The fact that galaxies exist puts a limit on the cosmological constant of some 120 orders of magnitude smaller than predicted by quantum theory! The cosmological constant represents a universal repulsion whose value must coincide with the acceleration rate of the universe. Observations from type I supernovas have allowed scientists to calculate the acceleration of the universe very precisely. It turns out that the negative and positive contributions to energy density provided by the virtual particles of quantum theory cancel each other out to 119 decimal places. If the energy density cancellation had been only an order of magnitude or two bigger, no galaxies, stars, or planets could have formed in the presumed big bang. If the cosmological constant were not extremely small, its universal repulsion would have instantly destroyed the universe. The cosmological constant is so incredibly fine-tuned that no one could imagine it accidental. It is exactly the value that would make our universe hospitable to life.

How the Landscape saves string theory from a finely-tuned cosmological constant

These observations of type I supernovas came out in 1998. They appear to indicate that the expansion of the universe is accelerating, giving a positive cosmological constant. String theory until this time had concluded that the cosmological constant could only be zero or negative. The work of a group of theorists at Stanford University solves the problem of making string theory consistent with a positive cosmological constant, as well as the problem of stabilizing its higher dimensions, but with very bizarre consequences. They start with a string theory that has a flat four-dimensional spacetime with a small six-dimensional geometry over each point. Wrapping a large number of electric and magnetic fluxes (which can only be wrapped in discrete units) around the compact six-dimensional spaces over each point tends to stabilize the geometry. Next, they wrap antibranes (which are the antiparticle analogue to the two-dimensional 'branes' that string theory also predicts) around the geometry. In this way energy can be added so as to make the cosmological constant small and positive in accordance with the common interpretation of the astronomical observations. To get a small cosmological constant, you have to wrap many fluxes, and there are many ways to wrap a flux. There is evidence for 10^{500} solutions to this string theory, each having different predictions for the elementary particles and the parameters of the Standard Model. The problem comes when we realize that there is no principle that selects a unique string theory, so one can get any outcome he one wants. The term *Landscape* was coined by the co-discoverer of string theory, Leonard Susskind. It denotes a mathematical space representing all the possible environments the theory allows, each one having its own laws of physics, its own elementary particles, and its own constants of nature. He sees us as living in one tiny pocket of a megaverse where these values happen to be consistent with our kind of life.[13] The unlikely odds of a small but positive cosmological constant are outweighed by the gargantuan number of other possible universes. A theory with an enormous Landscape causes unfathomably improbable events to be completely inevitable. To evolutionists, the Landscape makes it a mathematical certainty that some parts of space will evolve into a universe like ours where life is possible.

The problem with the Landscape

The Landscape notion of string theory results from a flailing attempt to explain away the fine-tuning of the cosmological constant. It is described by a mathematical solution so complicated that nonspecialists often feel they are not qualified to form a responsible judgment of the situation. String theorists seem to perpetuate other scientists' feelings of inadequacy with a widespread intellectual arrogance that thinks only real geniuses are able to work on the theory, and anyone who criticizes their work is probably too simple to understand it.[14] With all of the mathematical sophistication involved in string theory, it takes childlike forthrightness to expose the true state of affairs by exclaiming the equivalent of, 'The emperor has no clothes!' or rather, in this case, 'The theory has no science!' Because string theory makes no predictions, it is a theory that cannot be falsified. This makes it debatable whether it can be called science at all. The great Cal Tech physicist Richard Feynman commented on the unscientific nature of string theory with these words:

> 'I don't like that they're not calculating anything. I don't like that they don't check their ideas, I don't like that for anything that disagrees with an experiment, they cook up an explanation—a fix-up to say, "Well, it still might be true".'[15]

Lee Smolin describes the Landscape's deplorable lack of vindication by commenting thus, 'If an attempt to construct a unique theory of nature leads to 10^{500} theories, that approach has been reduced to absurdity.'[16] Most string theorists do not acknowledge this *reductio ad absurdum*. They turn an equally deaf ear to recent results that raise questions about whether any of these theories describe stable worlds. This lamentable lack of objectivity causes many scientists to worry that string theory is becoming a religion rather than a science. 'Some physicists have joked that, at least in the United States, string theory may be able to survive by applying to the federal government for funding as a faith-based initiative!'[17] It seems, then that when the science of high-energy particle physics gets boiled down to its basic ingredients, scientists are left with a simple choice, namely to believe in the divine Designer, or to believe in the Landscape of 10^{500} possible universes. Both options are a matter of faith.

The conclusion of the matter

In their attempts to offset the implications that the fine-tunings of the Higgs mass and the cosmological constant imply, some physicists find themselves doing suspicious science. They propose one theory to bolster the shortcomings of another in a chain that ends in a belief system which falsely perceives the vast Landscape of possible universes as being a more rational explanation for apparent design than an intelligent designer.

These are exciting times to be a physicist! Results coming from the Large Hadron Collider at CERN will give us all a lot to mull over in the next few years. Anything that addresses the fine-tuning problems that evolutionists try to obscure should have measurable experimental consequences in the LHC, such as the absence or presence of sparticles and the Higgs boson.

These are equally exciting times to be a creationist! I, too, eagerly await the results to come out of the LHC, for I see the whole endeavour as one way, in the words of Solomon, 'to seek and search out by wisdom concerning all things that are done under heaven' (Ecclesiastes 1:13a). The problem comes when men begin to suppress the obvious truths and prefer giving glory to the created things rather than to the Creator, as Romans 1:18–25 outlines. Instead of having a worldview that hangs by the proverbial thread, as most string theorists do, creationists have their worldview built on the firm foundation of Jesus Christ and His written Word. The prophet Job encourages us in the book that bears his name to ask the beasts, the birds and the fish about their origins, 'or speak to the earth, and it will teach you … who among all these does not know that the hand of the Lord has done this?'[18] So, be assured that whatever is found at the LHC, when interpreted correctly, will point to God the Creator, even His eternal power and Godhead.'[1]

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Erratum

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Austin, D., Is Darius, the king of Ezra 6:14–15, the same king as the Artaxerxes of Ezra 7:1? On page 48, first column, line 21 should read, '… he came to Jerusalem (7:9).'