The Philosophy of Science and the Limits of Knowledge

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Abstract

In this essay we explore the basis of the physical sciences and what they can and cannot do. We define such terms as hypothesis, theory, fact, experiment and observation. Having established the philosophical foundation for the physical sciences, we will look at the implications of Gödel's Incompleteness Theorem for physical science and the nature of the conscious mind. We consider some of the implications of Quantum Mechanics for the role of the observer. Finally we will turn to examining the nature of physical laws and whether or not they are immutable during the evolution of any universe of finite age.

Introduction

Some members have suggested that there should be more papers with a philosophical focus than have been recently contributed. While noting that the same admonition was made by the Club founders a century ago, it was an admonition noted more by its breach that acceptance. Nevertheless, I will attempt to present a philosophical paper that focuses on the philosophy of science and some broader implications.

Lately, there seems to be some confusion among the general public and the media as to what constitutes a scientific theory and what doesn't. I confess at the beginning that the philosophy I express is my own and not an absolute dogma. There are those who claim to practice science who would disagree with some of what follows. Sadly, what I espouse is only dimly related to what is taught in most high schools as the so-called "scientific method". However, it is a philosophy that is widely held, practiced and has developed over the past several centuries. It has formed the basis for my attempts to understand the physical world for the last half century and has served me very well.

I will limit myself to the physical sciences which are those that deal with the description of the physical world. While there are interesting academic disciplines that attempt to apply scientific principles to the human animal and its behavior, when the subject is also the investigator, there may be some question as to the uniqueness of such endeavors. I will touch only briefly on them.

Logical Positivism

In defense of the science as philosophy I will quote Max Born who as described by Jacob Bronowski[1] would often say that he was convinced that theoretical physics had become real philosophy. Max Born is one of those often forgotten figures to 20th century physics and was largely responsible for creating the environment in Germany for the development of quantum mechanics. The Born-Oppenheimer approximation lies at the root of most of what we call physical chemistry.

Probably the father of the contemporary philosophy of science is Karl Popper. His foundations of the philosophy of science[2], which had been around since Galileo (1564-1642) and John Lock (1632-1704), were advanced and further expanded in the 20th century by a group of philosophers known as the Vienna Circle. Their view of the philosophy of science is generally known as Logical Positivism. One of their members was Carl Hemple who taught me the philosophy of science at Princeton more than half a century ago. I still regard it as the most important course I have ever taken and would like to take again. It defined the "rules of the Game", if you will, regarding how one does science.

He began by defining meaning. As students we would read from his monograph titled "*The Verifiability Theory of Meaning*" which was a bit mystifying for a college sophomore. However, it was clear that if folks couldn't agree on the meaning of *meaning*, there wasn't much point in further discourse. For science this basically meant ways of defining terms so there could be not disagreement on what those terms meant to different parties. The definitions usually took the form of "Operational Definitions". There would be a series of statements indicating steps to follow that would define a term such a kilometer, gram, or second. The basis for this procedure can be found in *Fundamentals of Concept Formation in Empirical Science* by Carl Hemple[3]. There is an international committee that meets periodically to agree on what will be the international standards of such terms for the world. It is worth noting that the establishment of world standards of measurement is a moderately recent nineteenth phenomenon driven largely by business.

Having established the meaning of scientific terms, the basis for what is meant by science can be discussed. It simply is the description of the physical world. Consistency demands that I define what I mean by the "physical world". It is simply that aspect of our experience that is accessible to observation and experimentation. That definition of physical science seems like a simple goal, but some find it is too limiting. However, it has kept me busy my whole life and its description remains rather incomplete even today. Those who find it limiting simply lack the imagination to see all the possibilities associated with a full description of the physical world. I would claim that these apparent limits on science are really their great strength and are responsible for its manifest success during the last century. It provides a great focus on what is likely to be possible and what may contain immobilizing intellectual traps.

A Few Definitions

Having established the basis for scientific conversations and the goal of science, it is appropriate to describe how it is done. To do that certain terms should be defined and understood. These include *experiment*, *observation*, *fact*, *hypothesis*, *theory*, *law*, *principle*, and *proof*. These are just a few of the terms one needs to understand to really understand the nature of science, but they are perhaps the most important.

There are basically two kinds of physical sciences, those based on experiment and those based on observation alone. One could argue that all experiment requires observation and you would be philosophically correct. But what is generally meant is that experiments can be repeated producing the same observations. On the other hand there are some disciplines such as astronomy where experiments with the subject matter, happily, are not feasible. One can simply observe the heavens with instruments of varying sophistication, but in some sense those observations can never be exactly repeated for the subject may have changed. Happily for astronomers, many astronomical objects change very slowly. In both cases a competent observer or experimentalist is never wrong for they are merely reporting observational results. That does not diminish their lot for there is infinite room for being clever in designing experiments or fashioning observational programs that enrich our description of the physical world.

The word *fact* is bandied about as if it represented some stone tablet concept. A fact is generally the result of an observation. Thus to say that the sun will rise tomorrow is a fact is incorrect. It is a prediction based on a good deal of "confirmatory information". If the sun does indeed rise tomorrow, that will be a fact.

The word *hypothesis* is generally what the media mean when they say "… is only a theory." It is marvelous that something as structured as logical positivism can contain room for what some have called the "*leap of faith*". Here faith has its broadest meaning, not the restrictive religious one. It is the step that is left out of high school scientific method. It is also the most creative part of science and usually arises from a question. Sadly we don't teach students how to ask important questions. We do teach them rather elegantly how to answer them.

In any scientific investigation there is usually someone asking a question like "How could that work?" Or perhaps "What would it be like to ride on a beam of light?" The answer to the latter question revolutionized our view of the physical world. The "*leap of faith*" involves the belief that the question has an answer that can be found. The initial response to the question is to sketch some form that an answer might take. That sketch is a *hypothesis* which then is subjected to careful scrutiny for its relation to other aspects of the physical world. If it is compatible with known and tested aspects of the physical world, it may be called a theory. However, the theory must make a prediction that can be tested. It should provide an answer to the question that is subject to experiment or observation. In short, it must be subject to test. Carl Hemple use to say "A theory has to make a difference to be a difference". By this he meant that an untestable theory is not a theory at all. It is nonsense.

Karl Popper[2] made the term *falsifiable* central to the notion of a theory. A theory must be falsifiable. Anyone who proposes a theory must be able to say what evidence he/she would accept to declare the theory to be wrong. If that cannot be done, the presentation is not a theory. That is a definition, not a debatable point. It is part of the operational definition of what constitutes a theory. So as Einstein observed, "*Experiment is the final arbiter of theory*."

Theories can never be proven correct; they can only be shown to be wrong, or perhaps more charitably, incomplete. In testing a theory one gathers *confirmatory information* bearing out the predictions of the theory. The amount of confirmatory information can become quite large and some are tempted to call such highly confirmed theories *Laws*. Laws are also generally simple statements. So, one has the laws of *conservation of matter/energy* or the *conservation of momentum*. These are relations have simply never been observed to fail in any experiment or observation in the physical world. There is an even more fundamental term known as a *principle*. These are generally so fundamental they are not taught. Perhaps the most important is the strong *principle of causality*. This states that all observers in the universe will agree on the order of events. If the trigger on a gun is pulled and then a bullet emerges from the barrel, all observers will agree on that sequence. They may debate details of the event, but not the order. No one will say that the bullet came out and then the trigger was pulled. Without this principle there can be no physical laws that are independent of the observer. Without that there is no physical description of the universe that is unique and independent of the observer. There is no physics. There is no such thing as science.

Proof is a word that should be reserved for mathematics. While mathematics is the language of science, one does not prove theories correct. One may show them to be wrong or, perhaps, incomplete. Science does not prove things. Science simply describes how things work. This is but an element from a large list of mis-used English words. Helen Quinn[4] recently wrote a short impassioned essay on the use of the word belief. She would essentially like it reserved for either a state of uncertainty ("I believe he'll come tomorrow") or religious certainty. She is horrified by the phrase so often found in the media "Scientists believe….". She would prefer "Scientists know…." For in general the scientific statement is neither a religious belief nor does it represent a state of uncertainty. Much of the way the universe works is indeed well understood and statements about the way it will work really do fall in the category of known results.

The term Logical Positivism suggests the relevance of logic to science and it is. But there are essentially two different kinds of logic, deductive or Aristotelian logic which is a mathematical formalism that has been around since Aristotle and inductive logic upon which most all science is based. The essential difference between the two was nicely demonstrated by Carl Hemple in what has become know as the Raven's Paradox.

The Raven's Paradox

Perhaps Carl Hemple's most important contribution to philosophy is the so-called Raven's Paradox. Since scientific theories require continually growing confirmatory evidence to acquire increased stature, it is worth looking at the process of inductive logic. Most of us have been exposed to deductive logic from time to time. The three line syllogism is commonly used, but forgotten by many. Consider

$$A \Rightarrow B$$

$$B \Rightarrow C$$

$$\therefore\ A \Rightarrow C\,.$$

This is a provable set of statements within the framework of deductive logic. Now consider the following logical statement. Assume $A \Rightarrow B$ is a true statement. Then by the laws of deductive logic, $\sim B \Rightarrow \sim A$, must also be a true statement. As an example, consider the statement “All Ravens are Black” to be a true statement. Then the statement “All things that are not Black are not Ravens” must also be a true statement.

Now consider how one would verify the truth or falsities of these statements were they scientific “theories”. One would sample, say, a thousand ravens and find that they were all black. From that you would gain some confidence that the statement “All Ravens are Black” is a true statement. This is one of the premises of inductive logic. However, consider testing the logically equivalent statement that all things that are not black are not ravens. You sample a thousand non-black things: for example pieces of chalk, some pretty flowers, dozens of tree leaves, some of your friends. Sure enough, none of them are ravens. Would you be happy concluding the logically equivalent statement that all ravens are black? Hardly. So inductive logic cannot be obtained from deductive logic. When Carl Hemple published this, a number of famous mathematicians abandon attempts to develop formalisms for inductive logic similar to those that had been developed for deductive logic. It also bears directly on the nature of confirmatory evidence for theories of the physical world. One must be very careful how you frame tests of a theory. It is inappropriate to inductively test, by say either observation or experiment the logical negative of the statement of a theory or hypothesis and conclude that you have said anything relevant about the hypothesis or theory.

Properties of a Well Posed Physical Theory.

We have laid out the fundamental requirements that a physical theory describe the physical world in a manner consistent with the existing knowledge and be falsifiable. But there is more such a theory should do. As yet there is no single theory that describes all aspect of the physical world. Thus any theory must specify its range of applicability in describing the physical world. One would not use Quantum Electrodynamics to describe the motion of a spacecraft going to the moon. Nor would Magneto-Hydrodynamics be particularly helpful in understanding how a bulldozer works. Classical Mechanics will not help much in building a TV set. But all these examples are well verified physical theories and give highly testable results in the realms where they apply. The scope of such a realm must be part of a well posed physical theory.

The Theory of Everything (TOE)

It has been the dream of theoretical physicists for more than a century that there exits a single theory from which all the well verified physical theories could be obtained. Such a theory would be the foundation of a complete description of the physical world. In the nineteenth century the work of Faraday, Hertz, Ampere, Orsted and many others led to the unification of the forces of electricity and magnetism by James Clerk Maxwell. His electromagnetic theory is one of the great triumphs of the 19^{th} century. The solution was quite simple. The two forces are different manifestations of the same source that only depend on the relative motion of the observer.

The first half of the 20^{th} century saw the development of quantum mechanics and its more elegant child quantum electrodynamics. The latter is the quantized generalization of Maxwell's marvelous classical theory. This physical theory has been tested at a level more demanding than any other theory and never failed to give the correct result for an experiment. The accuracy of the tests is about 1 part in 10^{14}. That is strong confirmatory evidence! Only the General Theory of Relativity comes close to that level of testable accuracy. Neither theory has ever given a result different from experiment designed to test the theory.

By the mid 20^{th} century there were only four basic forces of nature, the electromagnetic force, the forces of gravity, the strong nuclear force that makes bombs, and the weak nuclear force that governs radioactive decay. In the 1960s Steven Weinberg and Abduls Salem showed that the weak force was just an unusual manifestation of the electromagnetic force. They were really one force now known as the electroweak force and is described by quantum electrodynamics.

There has been some success understanding the behavior of the strong nuclear force within the broader notion of Quantum Chromodynamics as an off-shoot of Quantum Mechanics. Thus only the force of gravity remains elusively apart from the other forces of nature. There has been much effort to unify or quantize gravity and obtain a single theory of all the forces of nature. Such a unified theory would be a Theory of Everything. Physical science would then be reduced to an axiomatic structure. The description of the entire physical world could be obtained from a single theory and the basic assumptions upon which it would rest. Those assumption or principles would play the role of the axioms of a mathematical structure.

Kurt Gödel's Incompleteness Theorem.

In 1931 Kurt Gödel published the proof of a mathematical theorem that would astound the world of mathematics. He has set out to prove that correctness and self consistency of mathematics and ended up proving the reverse. At the time Alfred North Whitehead, Bertrand Russell, David Hilbert and others were focused on finding the minimum set of axioms that are required to develop all of mathematics. In short the axiomatic basis for all of mathematics. What Gödel showed that any axiomatic system complicated enough to give rise to arithmetic could never be shown to be self consistent by methods defined by that system. **Further: Any self consistent system must contain statements whose truth or falsity cannot be determined.** This was a terrible blow to mathematics. Logicians of the time abandon the search for the basic axioms. Others developed larger axiomatic systems that could prove the consistency of small sets within the larger system, but never the show its own self-consistency.

The Incompleteness Theorem which says any self consistent system must have statements whose truth or falsity cannot be demonstrated implies that there must be questions within that system that cannot be answered. They would be the questions whose answers cannot be shown to be true of false. Since this theorem applies to any non-trivial axiomatic system, one would expect it to have strong implications for the Physical "Theory of Everything".

Except for a somewhat 'tongue in cheek' letter I sent Astronomy Quarterly some years ago, considering the implications of Gödel's Incompleteness Theorem for the physical world[5]. To the extent that physics succeeds and develops a Theory of Everything based on a set of axioms, there must be questions about the physical world that cannot be answered. It is interesting to ponder what the nature of such questions would be. An immediate candidate might be Heisenberg's Uncertainty Principle which states it is impossible to now precisely the position and momentum of any particle in the universe at the same time. It is a principle and represents a fundamental property of the Universe itself. However, it is testable and has never been observed to be incorrect. Does any description of the physical world allow for determining the state of the Universe before the Big Bang? To me that might well qualify as an unanswerable question. Another might be, "Does the conscious mind have the capability of understanding itself?" It might be fair to say that such a question is already outside the realm of the physical world. However, Douglas Hofstadter[6,7] has looked at the implications of Gödel's Incompleteness Theorem for explaining the notion of the conscious mind. His explanation of Gödel's Incompleteness Theorem is one or the most approachable I have ever seen[7]. His application of that theorem to understanding the conscious mind is extremely subtle and essentially involves "thinking about thinking". He has spent most of his life trying to use the conscious mind to understand the conscious mind. In spite of his marvelous and voluminous writing, I am not convinced he has answered the question about the conscious mind being able to understand itself. He make many reference to well known physicists, but more in trying to understand how they think that using physics to understand the conscious mind. I believe he would say that the brain must follow the fundamental laws of physics, but any detailed description of that process would be largely irrelevant for understanding the conscious mind. We shall shortly see that there are other reasons to doubt the possibility of any physical description of the conscious mind.

We have laid down the bare minimum conditions for the philosophy of science. It is fair to ask if there are alternative views and what is their origin. There have been many attacks on the philosophy of science from the humanities. There is that school resulting from moral relativism that suggests scientific truth is no "better" than truth obtained from sociology, psychology, or the arts. I am not a member of that school for it fails to even define what is meant by truth which it seeks to compare to that resulting from scientific enquiry. That alone sets science apart from other intellectual endeavors. I would never say that I don't find "truth", "wisdom" and "beauty" in a Brahms symphony or a Shakespeare play, but the "truth", "wisdom" and "beauty" I find may be quite different from that found by others. That distinguishes other aspects of the humanities from science for in science we have made a great effort to define terms so that the results are agreed to by all investigators. Thus there is no debate about the nature of scientific "truth" by any who have taken the time to understand the process by which it is achieved. In short, then, science is a disciplined method of thought where the framework for that thought has been agreed upon in advance by the participants. That is its great strength and perhaps provides the basis for its limitations.

Beyond the Traditional Philosophy of Science and the limits of knowledge

So let me now adventure beyond the clearly defined aspects of the philosophy of science to see if anything interesting can be said about its implications beyond the physical world. Much has been made by some about the conflicts between science and religion. To me they are largely "much a do about nothing", but the subject has been around at least since Galileo. I take the view that has been attributed to Pope Urban VIII's secretary that "*religion should tell one how to go to heaven while science tells one how the heavens go*". This supposedly got him fired. My own view of religion is that it was created by humans largely to answer unanswerable questions; many about the physical world. To the extent that science has provided a large consistent set of answers about the physical world, some have found it a threat to religion. To me those who see such threats are simply too limited in the central questions religion had been called upon to answer in the past. I would pick as perhaps the two most central questions clearly lying beyond the realm of science to be "**Is there a God?**" and "**Is there an after life**?". Any theologian worth his salt will tell you that the answers to these questions are based on "faith".

I would be remiss if I overlooked the devout atheists who declare that there is no God. A few of the more well known recent folks are Richard Dawkins and Sam Harris. More recently a retired physicist and astronomer Victor Stenger has entered the fray with a book entitled *God, the Failed Hypothesis: How Science Shows That God Does Not Exist* [8]. Here the author formulates a hypothesis concerning the existence and nature of God and then proceeds at great length to attempt to falsify that hypothesis. If his hypothesis had the imprimatur of even one notable theologian, his case might be more persuasive. It appears to me that he has very eloquently and adroitly fallen in Carl Hemple's trap of the "Raven's Paradox". He goes at length to show that there is no evidence that a God is required to run a universe as we currently observe it. By passing its actual existence, his observation may well be the case. It seems to me that this falls into the category of observing many non-black things in order to show that all ravens are black. Since he realizes the logical pitfalls awaiting those who would "prove" a negative, he is careful to say that he hasn't proved that God doesn't exist. So I suspect that this view would be found to be irrelevant concerning the existence of their God by most schooled theologians.

Faith, by its definition, lies beyond the realm of the philosophy of science since it is not subject to test. That is the central objection to declaring "Intelligent Design" to be a physical theory. I have yet to find a proponent that can state what evidence he or she would accept to show the theory to be wrong.

The first question concerning the existence of God is severely complicated by the abilities one wishes to attribute to God. It is simply not a well-posed question. So the religions of the world have many Gods with different abilities. To my mind the most rational reason for an acceptance of God can be found in Pascal's Wager which appears in the *Pensées*[9] a posthumous collection of Pascal's notes for an unfinished treatise on Christian apologetics. Specifically, a highly condensed version might read:

> It is a better "bet" to believe that God exists, because the expected value of believing that God exists is always greater than the expected value resulting from non-belief.

Here the brilliant 17th century mathematician Blaise Pascal (1623-1662) anticipates the foundations of Game Theory laid down three centuries latter by John von Neumann. It is a reasonably useful argument regardless of the specific abilities of the God in question. However, the church at the time did not approve of his view and most dismiss it today as simplistic. However, to go beyond this is perhaps an exercise in futility. Nevertheless, the role of the observer in physics is interesting and explored deeply by Robert L. Mills in his introductory college physics text book *Space, Time, and Quanta*.[10] Robert Mills was one of the brightest theoretical physicists I have ever met and the co-author of Yang-Mills field theory on which most of contemporary quantum physics and all field theory rests.

There is a fundamental difference in the role of the "observer" in classical physics and quantum physics. In classical physics, a physical system exists, and is simply observed by the physicist. The observer need play no role in the outcome of the event. In the case of quantum physics, the observer is deeply entangled with the phenomenon being studied. This entanglement leads to some strong conditions on the role of the observer. If the observer is considered part of the experiment or event, then it is not clear that the event can ever be said to have happened and should that be the case there would be no physics at all. This statement involves understanding the foundations of quantum mechanics. Robert Mills' argument is lengthy and subtle, but if one wishes to accept the foundations of quantum mechanics as the correct description of the physical world then Mills finds it necessary to postulate the existence of a "watcher" beyond the world we deal with in physical science. That he has cast his argument in an introductory physics text is a testament to his respect for human intellect. Before you dismiss it out of hand, I suggest you read it and learn the smattering of quantum physics which underlies it. After considerable effort, I can find no holes in his logic. I find his argument to be extremely profound. While his concept of a "watcher" falls far short of most theologians' concept of God, the very requirement of such an entity within the foundations of quantum physics is unsettling to many. Indeed, the nature of the required observer may well be beyond such a description and be a Gödeliean undecideable 'statement' within the long sought axiomatic view of the physical world.

The simplest solution to deal with his argument is to dismiss it as a flaw in the foundations of quantum theory. That may be true. However, one should note that the elegant child of quantum theory, Quantum Electrodynamics, has been widely tested to about 1 part in 10^{14} and never been found to give the wrong result of an experiment. There is no theory of the physical world that has been tested to greater precision. Thus any modification of quantum mechanics to remove the role of the observer would have to be extremely subtle while preserving the role of Heisenberg's Uncertainty Principle.

Now allow me to summarize some of his some of Robert Mills thinking concerning the conscious mind with the following fairly simple deductive logical syllogism:

- A physical system cannot observe itself. (*There are fundamental aspects of quantum theory that require this to be a true statement.)*
- Without observations (an observer) there is no physics.
- A conscious mind is essential to any observation.
- Therefore it is impossible to understand the working of the conscious mind in purely physical terms.

This is almost the equivalent of Gödel's Incompleteness Theorem for an Axiomatic Physical Description of the Universe. Note. it is not necessary to have actually formulated the complete theory of a description of the universe to have such a syllogism, but merely to believe that such a description (A Theory of Everything) exists. The ability of being able to describe the conscious mind would then remain one of the undecidable statements of the physical world.

Acceptance of Mills' arguments would provide a basis for the looking at the second question about after life. Quantum Mechanics tells us something about how to describe things in the world of the small. We can fully (almost) describe the behavior of a hydrogen atom. The mathematical description involves something called a wave function. The wave function and an alternate form can be combined to yield the probability of and event happening (like the detection of say, an electron). However, the wave function is mathematically unbound. That is to say, it exists throughout all space and time. It is only when it interacts with the detection apparatus that it becomes localized and one says that an electron has been detected. Whether the wave function is "real" or not is a point of some considerable philosophical debate. The main problem revolves around what one means by "real" which is a problem we have encountered before. Perhaps it is only a mathematical description of something more profound. In either case the concept works extremely well. However, the simple description of the wave function of a single particle becomes more complex when one considers the hydrogen atom. I was told in graduate school that it would be possible to describe the wave function for an iron atom, but it would take all the particles in the observable universe for "ink" to write it down and there would be nothing left over for paper. Frankly, I am not a fan of quantum mechanics for I don't much care for theories that tell me answers exist in principle, but I can never know them.

Nevertheless there is nothing in the formulation of quantum mechanics that suggests it could not in principle be applied to large systems of particles. Indeed there is a concept known as the correspondence principle which essentially says that a new theory must correspond to an old theory in those realms where the old theory has been successfully tested. Neils Bohr developed this as a guide and requirement for quantum mechanics so that this ‘new theory’ of the world of the very small would yield results consistent with the widely tested theories of the classical world of the large. Indeed, if it is to be a correct theory it must, in principle, be able to consider wave functions that describe not only large atoms, but people, and even the universe itself. Indeed Robert Mills makes use of this in his argument concerning the “watcher”. Since he finds the conscious mind to lie beyond the realm of physical description, there is plenty of room for its existence beyond the physical realm. (Larger Discussion)

Finally, Are the Laws Of Nature Immutable and are there Limits of Knowledge?

Is the physical realm of laws immutable? Most scientists would answer yes to this and the view has been accorded the term *Platonism*. But could there be room for some yet unspecified law which would lead to the development of conscious biological beings as the universe evolves? Such statements are generally called teleological and are the bane of most scientists. The Platonist view is that a set of laws that describes what an atom can do simply has no room for a teleological statement that would tell it to do something else. As Paul Davies[11] put it “the system is causally saturated” at the micro-level by the basic laws of physics, and there is “no room at the bottom” for any competing imperative. I confess that this is a view I have held most of my life.

But Paul Davies suggests a loop hole that threatens *Platonism* and it lies at the foundations of information theory. To any logical positivist the only universe that can be the concern the physical scientist is the one subject observation and experiment. Any cosmologist will tell you that the observable universe of finite age must be finite in size and hence composed of a finite amount of observable material. The finite speed of light simple would make material beyond the distance light could travel in the age of the universe invisible and therefore inaccessible to observation or experiment. It also suggests that the visible universe, the testable universe, increases in size with time, one light-day per day. That means that in the past the visible and testable universe was smaller and contained less material than it does today. No cosmologist I know would disagree with this view. Now for the loop hole.

Consider a point in time very very early in the universe when the light travel time across the visible universe would have been so short that very little matter would be able to see any other matter. There would be so little matter that there would not have been a sufficient number of particles in the visible universe to describe the current laws of the physical world. Could those laws exist? The strict Platonist says “yes” but will look a little uncomfortable.

Einstein’s protégé, J. A. Wheeler has suggested that the laws of physics emerged “higgledy-piggledy” at the big bang in a less than precise form and gradually “congealed” over time. This would appear to allow for continuing development of the description of the very fabric of the universe itself. The interesting aspect of this is that the description of the physical world would always be incomplete at any given time in its evolution. One could never find a Theory of Everything. There might be room for an expanding universe to eventually develop principles that govern the behavior of very complex chemical systems and allow for the eventual likelihood of something we would all agree on as being alive to naturally develop. It is not hard to wallow on - even to the point of the description of the physical world evolving so as to require a "watcher". However, the Platonist would respond that a physical theory which says that the iron atom can be described, but there are insufficient particles in the visible universe to describe that solution, would not be bothered by the limitation of the available number particles being insufficient to specify the laws of nature.

However, this tiny loophole arising from the foundations of information theory, which itself is a fundamental requirement of physical science stills appears large enough to drive a multitude of intellectual trucks through. It is unlikely that they are all allowed. Many may lie within the realm of Gödel's Incompleteness Theorem. But it is clear that such an interpretation of the description of the Physical World is anything but sterile and boring.

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