How Maharishi Vedic Science Answers the Questions of the Unreasonable Effectiveness of Mathematics in the Sciences

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Abstract

Mathematicians and scientists have for a long time tried to understand why mathematics, a subjective creation of the human intellect, is so effective in the sciences, which study the objective, physical world. Satisfactory reasons have not been found because there has not been a comprehensive understanding of the relationship between the subjective and the objective aspects of life. In this paper we will see that Maharishi Vedic Science, by explaining the link between the subjective realm where mathematics is located and the objective world that science examines, can resolve this problem in a natural way.

Introduction

Mathematics is fundamental to all areas of science and technology. The language of mathematics has been used since antiquity to express our knowledge of the physical world, to derive new knowledge from old, and to predict the behavior of physical systems. For example, Newton's Second Law of Motion says that a force exerted on an object is the product of its mass times the resulting acceleration, $F = ma$. Newton used this law, together with his newly developed calculus and the law of gravitation, to derive the elliptical shape of the planetary orbits. Today, mathematical analysis similar to Newton's has placed a man on the moon.

With such dramatic successes, it is not surprising that many people, particularly those who have been at the forefront of developing new applications of mathematics, have wondered why mathematics has proven to be so practical and why the laws of nature are so effectively expressed by mathematical formulas. Mathematics is theoretical and completely abstract, created in moments of inspiration and afterward verified by the intellect. Science, on the other hand, seeks to accurately and objectively describe and predict how the physical world around us behaves. Nevertheless, these two approaches to knowledge have been intimately linked since we began observing and thinking about the world. The basis for understanding the role of mathematics in science must depend on an understanding of how the subjective world of the mind and intellect, the source of mathematics, is connected to world of matter, forces, and energy studied by science. This connection can be understood through Maharishi Vedic Science[SM], which gives a comprehensive explanation of the nature of consciousness and its manifestations in the physical world and how the subjective world of consciousness and the mind is connected to the objective physical world around us. Because Maharishi Vedic Science is so comprehensive, an analysis of the nature of mathematics according to its principles can provide the link between the subjective and the objective aspects of knowledge necessary to properly explain the role mathematics plays in the sciences.

According to Maharishi Vedic Science, the mind and the physical world are not two separate entities, but two different aspects of one reality. The mind is subtler, more abstract, and more intimate than the physical world, but both exist simultaneously and inseparably. As we will discuss in later sections, Maharishi sees both the mind and the physical world as having their source in the self-interacting dynamics of pure consciousness, which he identifies as the total potential of Natural Law (Maharishi Mahesh Yogi, 1984). Both mathematics and science are studying those aspects of natural law which are quantifiable and exact, although using different methodologies. Thus, the effectiveness of mathematics in the sciences is no surprise but is, in fact, natural and expected.

Moreover, this understanding of Maharishi Vedic Science shows us that to make mathematics even more powerful, effective, and complete, mathematicians must go even deeper into their subjective nature

and connect themselves to their source in consciousness. The same can be said for scientists, who can make science more productive by linking the objective, natural world that they study to the same source in consciousness.

In this paper, we will first look at mathematics and the question of its effectiveness in the sciences as it has been posed by the physicist Eugene Wigner and the mathematician Richard Hamming. This will be followed by a discussion of points from Maharishi Vedic Science relevant to this question, a resolution of the question based on these ideas, and a look at the implications of this resolution.

The Question: The Role of Mathematics in the Sciences

Throughout time, mathematics has been always been associated with its applications and from these applications, mathematicians have derived new impetus and new directions. For example, the Sulba Sutras, one of the earliest records of mathematics from the Vedic civilization, includes geometric constructions that were used to describe the procedure for the construction of ceremonial platforms (see Henderson, to appear, and Price, to appear). The Rhind Papyrus of the Egyptians gives computational techniques alongside sample problems for applying the techniques to everyday situations such as computing the size of a barn used to store grain. Babylonian clay tablets give mathematical tables for astronomical predictions as well as for business transactions (van der Waerden, 1971).

With the Greeks, however, the discipline of pure mathematics was separated from its applications. As seen in Euclid's *Elements*, mathematicians had become concerned not with applied problems, but rather with the logical foundations (or postulates) of geometry and the rigorous, systematic derivation of new results from the postulates and previously established results. Mathematical proof became the central feature of the research, communication, and exposition of mathematics.

As mathematics progressed from the classical study of geometry and calculus to the more abstract areas of group theory, non-Euclidean geometry, and topology, its ancient connection to applications weakened still further. In the nineteenth and twentieth centuries, mathematics became replete with concepts that, on the surface, appear to be unrelated to science and the physical world. For example, in certain abstract algebraic systems, the equation $2 + 4 = 1$ can be correct. In hyperbolic geometry, one can draw many different lines through a point parallel to another line, something strictly forbidden in Euclidean geometry. Topologists and analysts regularly study infinite-dimensional spaces, even though the space around us is only three-dimensional. As mathematicians pursued these and other more abstract ideas for their own intrinsic interest and without regard for possible applications, a large body of seemingly "useless" mathematics was developed. This mathematics nevertheless proved to be beautiful and profound. It provided new insights into applied mathematics and became the core of mathematical research. Some purely theoretical mathematicians, notably G. H. Hardy, even expressed disdain for concerns with applications and pride that their work could have no applications. For Hardy (1976), the value of mathematics is purely subjective, purely in the realm of ideas:

> A mathematician, like a painter or a poet, is a maker of patterns. If his patterns are more permanent than theirs, it is because they are made with ideas. . . . A mathematician . . . has no material to work with but ideas, and so his patterns are likely to last longer, since ideas wear less with time than words. . . . The mathematician's patterns, like the painter's or the poet's, must be beautiful; the ideas, like the colours or the words, must fit together in a harmonious way. Beauty is the first test: there is no permanent place in the world for ugly mathematics. (pp. 84–85)

Hardy sees mathematics as essentially disconnected from the world of applications. In discussing the mathematical significance of the proofs of the infinitude of the number of primes and the irrationality of $\sqrt{2}$, Hardy (1976) says,

> There is no doubt at all, then, of the 'seriousness' of either theorem. It is therefore the better worth remarking that neither theorem has the slightest 'practical' importance. In practical applications we are concerned only with comparatively small numbers; only stellar astronomy and atomic physics deal with 'large' numbers, and they have very little more practical importance, as yet, than the most abstract pure mathematics. I do not know what is the highest degree of accuracy which is ever useful to an engineer—we shall be very generous if we say ten significant figures. Then
>
> 3.14159265
>
> (the value of π to eight places of decimals) is the ratio

$\frac{314159265}{1000000000}$

> of two numbers of ten digits. The number of primes less than 1,000,000,000 is 50,847,478: that is enough for an engineer, and he can be perfectly happy without the rest. (pp. 101–102)

He goes on to claim that what he considers "real mathematics," the purest, most abstract mathematics, is without applications (Hardy, 1976):

> There is one comforting conclusion which is easy for a real mathematician. Real mathematics has no effects on war. No one has yet discovered any warlike purpose to be served by the theory of numbers or relativity, and it seems very unlikely that anyone will do so for many years. (p. 140) . . . I have never done anything 'useful'. No discovery of mine has made, or is likely to make, directly or indirectly, for good or ill, the least difference to the amenity of the world. (p. 150)

These deep-seated ideas notwithstanding, history had a surprising twist in store for mathematicians. At the beginning of the twentieth century, developments in quantum physics and relativity theory required the most abstract theories of algebra, analysis, and geometry. Furthermore, computer technology has required precisely the mathematics that Hardy felt to be impractical. In fact, one multi-million dollar company, RSA Cryptosystems, specializes in finding for its customers prime numbers 100 to 200 digits long, primes which far exceed the numbers considered by Hardy to be "enough." This mathematics has even proven to be crucial to the military; for instance, extremely large prime numbers are used daily in securing military communications.

As the abstract mathematics that had seemed so irrelevant to the pragmatic world began to have exciting and unexpected applications, it was inevitable that scientists would search for an explanation. One such individual was Eugene Wigner. Noted for his deep insights into mathematical physics, he gave fresh insight into the usefulness of mathematics in his now classic paper, "The Unreasonable Effectiveness of Mathematics in the Natural Sciences," first published in 1960 (Wigner, 1967).

Wigner begins his paper with the belief, common to all those familiar with mathematics, that mathematical concepts have applicability far beyond the context in which they were originally developed. Based on his experience, he says "it is important to point out that the mathematical formulation of the physicist's often crude experience leads in an uncanny number of cases to an amazingly accurate description of a large class of phenomena" (Wigner, 1967, p. 230). He uses the law of gravitation, originally used to model freely falling bodies on the surface of the earth, as an example. This fundamental law was extended on the basis of what Wigner terms "very scanty observations" (Wigner, 1967, p. 231) to describe the motion of the planets and "has proved accurate beyond all reasonable expectations." Another oft-cited example is Maxwell's equations, derived to model familiar electrical phenomena; additional roots of the equations describe radio waves, which were later found to exist. Wigner sums up his argument by saying that "the enormous usefulness of mathematics in the natural sciences is something bordering on the mysterious and that there is no rational explanation for it" (Wigner, 1967, p. 233). He concludes his paper with the same question he began with:

> The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve. We should be grateful for it and hope that it will remain valid in future research and that it will extend, for better or for worse, to our pleasure, even though perhaps also to our bafflement, to wide branches of learning. (p. 237)

Wigner has drawn many others into this discussion on the applicability of mathematics. R. W. Hamming repeats Wigner's observation about its usefulness: "constantly what we predict from the manipulation of mathematical symbols is realized in the real world. . . . The enormous usefulness of the same pieces of mathematics in widely different situations has no rational explanation (as yet)" (Hamming, 1980, p. 82). Hamming carefully examines his own experiences of using mathematics, his understanding of the origins and history of mathematics, the nature of mathematics, mathematical discovery and proof, the foundational crisis of mathematics, and the nature of science and scientific laws, and then finally proposes some explanations. Nevertheless, he is unsatisfied with his reasoning and must, like Wigner, leave the question of the role of mathematics unanswered:

> From all this I am forced to conclude both that mathematics is unreasonably effective and that all of the explanations I have given when added together simply are not enough to explain what I set out to account for. I think that we—meaning you, mainly—must continue to try to explain why the logical side of

> science—meaning mathematics, mainly—is the proper tool for exploring the universe as we perceive it at present. I suspect that my explanations are hardly as good as those of the early Greeks, who said for the material side of the question that the nature of the universe is earth, fire, water, and air. The logical side of the nature of the universe requires further exploration. (p. 90)

Thus, we are left with the question of why mathematics, which is developed and verified by mathematicians according to human logic and reasoning, is so perfect a tool for investigating the physical world around us.

Maharishi Vedic Science

This question of the effectiveness of mathematics can be answered by considering the Vedic knowledge brought to light by Maharishi Mahesh Yogi in his Vedic Science. Everywhere we look in nature, whether as a scientist or not, we see orderliness and growth. Natural laws, still not yet understood by scientists, govern the universe of billions and billions of stars moving throughout space in perfect harmony. The delicate balance of the environment on earth is the result of thousands of species living together in an intricately organized way. Maharishi points out that observations such as these lead us to recognize that intelligence is inseparable from life.

> We see things around us exist. We also see that things around us change and evolve. We also see that there is order in evolution—an apple seed will only grow into an apple tree, etc. Thus it is obvious that existence is endowed with the quality of intelligence—existence breathes life by virtue of intelligence. (Maharishi Mahesh Yogi, 1994, pp. 57–58)

Maharishi (1994) goes on to locate consciousness at the basis of life, as fundamental as existence and intelligence, "Consciousness is the existence of everything, and consciousness is the intelligence of everything" (p. 58). Science and mathematics are intimately linked to questions of existence and intelligence, so knowledge of the field of consciousness is important for the question of the role of mathematics in science. To give experiential knowledge of the total range of consciousness, Maharishi has made available the Transcendental Meditation® technique, a simple, natural, effortless technique:

> During this technique, the individual's awareness settles down and experiences a unique state of restful alertness: as the body becomes deeply relaxed, the mind transcends all mental activity to experience the simplest form of human awareness—Transcendental Consciousness—where consciousness is open to itself. This is the self-referral state of consciousness. (Maharishi Mahesh Yogi, 1994, p. 260)

In the pure self-referral state of transcendental consciousness, consciousness is conscious of itself, and the subject of knowledge is the same as the object of knowledge. Since consciousness is the link between itself as subject and as object, it is also the process of knowing. Maharishi (1986) describes the importance of this fundamental relationship, "This state of pure knowledge, where knower, known, and knowledge are in the self-referral state, is that all powerful, immortal, infinite dynamism at the unmanifest basis of creation" (p. 27). In particular, this dynamism of consciousness is the source of subjective experience: "When consciousness is flowing out into the field of thoughts and activity, it identifies itself with many things, and this is how experience takes place" (Maharishi, 1986, p. 25). Furthermore, since knowledge has organizing power, Maharishi concludes that the field of pure consciousness is also a field of absolute organizing power and from there the Laws of Nature emerge (Maharishi Mahesh Yogi, 1980):

> Knowledge has organizing power and therefore in the absolute structure of knowledge, in the state of the absolute observer-observed relationship, we have absolute organizing power. Once we have the field of absolute organizing power in this state of pure transcendental awareness, the seat of absolute knowledge, we have the source of all the streams of organizing power in nature. All the laws governing different fields of excitation in nature, all the innumerable laws known to all the sciences have their common source in this field of absolute organizing power. (pp. 74–75)

In this way, we see that the self-interacting dynamics of pure consciousness is at once the source of subjective experience and of the laws of nature governing all aspects of the world around us. The principles of intelligence and orderliness inherent within consciousness therefore govern all the expressions of consciousness—and, as Maharishi explains, that is all that there is.

> All speech, action, and behaviour are fluctuations of consciousness. All life emerges from and is sustained in consciousness. The whole universe is the expression of consciousness. The reality of the universe is one unbounded ocean of consciousness in motion. (Maharishi Mahesh Yogi, 1994, pp. 67–68)

Since every part of life is sequentially unfolded from its source in consciousness, the full range of life is from the unbounded field of pure consciousness, the home of all the Laws of Nature, to the subjective realm of the mind where mathematics is located to the objective physical world around us. As Maharishi (1980) puts it:

> All the relationships and activity in the different parts and structures in the universe are nothing other than expressions of Natural Laws, and we have discussed that the Natural Laws themselves are the expressions of consciousness. The expressions of consciousness in their turn are the expressions of the non-expressed, non-changing value of pure consciousness. (p. 78)

Furthermore, Maharishi goes on to explain that one whose consciousness is fully developed is able to perceive at an extremely refined level the sound of the eternal process of the transformation of the singularity of consciousness into the diversity of the physical world and the transformation of the diversity of the world into the singularity of consciousness. And it is this process of transformation expressed in a sequence of sound and silence in consciousness that is the Veda:

> All the material and non-material expressions of creation have specific frequencies (sounds). These fundamental frequencies, non-material values, are the sounds of the Vedic Literature: the intellect, the hum of the intellect, and with the hum, the flow and stop of it in sequence. The expression of melody, forming the whole Vedic Literature, gives us the entire process of the basic mechanics of transformation within the self-referral state of consciousness. (Maharishi Mahesh Yogi, 1994, p. 66)

Since all the fundamental frequencies of creation are lively in the Veda, Maharishi refers to the Veda as the Constitution of the Universe, “The structure of this level of self-referral pure intelligence is the structure of Veda, which is the very well structured Constitution of the Universe” (Maharishi Mahesh Yogi, 1994, pp. 208–209). Thus, the laws that govern all manifest and unmanifest aspects of creation are structured within the consciousness of each individual.

With this explanation of the fundamental role of consciousness and the intimate connection of consciousness and the physical universe, we are ready to answer the question about the connection of mathematics, a subjective creation of the human mind, with the structure of the objective physical universe around us.

Resolution of the Question

We now consider how the description of consciousness as the source of life in Maharishi Vedic Science resolves the question that Wigner and Hamming have set before us. The question is, simply put, why is mathematics, which is developed as a subjective discipline, so effective in its applied forms in the natural sciences, which describe nature in a purely objective manner. First, we clarify what is meant by mathematics so that we can more easily put it into the framework of Maharishi Vedic Science.

Mathematics is the search for and study of abstract and precise patterns of orderliness in number, shape, and form. The objects studied by mathematics—numbers, shapes, sets, patterns, relationships, and so on—do not have any real physical existence. Rather, as pointed out by Hardy, they exist as ideas in the awareness of the mathematician, and they are, therefore, part of the subjective realm of life. Accordingly, new mathematical ideas are discovered on the subjective level by intuition, insight, and creativity, and mathematics is considered to be an art by those who practice it. The results of mathematics are expressed in very precise language as formulas and theorems and are verified and proved according to strict standards of logic, so mathematics has the reliability and objectivity associated with science, but it is nevertheless a subjective study.

Mathematics investigates the structure of the laws governing the subjective values and functioning of intelligence and consciousness; it quantifies subjective and abstract patterns in a precise way; and it offers an exact and systematic description of purely subjective phenomena. Science, on the other hand, investigates the underlying structure of objective phenomena. Wigner and Hamming made the seemingly obvious assumption that mathematics and science were therefore studying two completely separate worlds.

However, in Maharishi Vedic Science, we understand that these two worlds are both the expressions of the same underlying field of consciousness and are both governed by the same natural laws.

Thus, mathematicians and scientists are both studying the same laws of nature. Furthermore, they are both looking for those properties of natural law that are general enough to capture the underlying structure of many different situations, as for example in the way the law of gravity applies to objects on earth, planets orbiting the sun, and galaxies in the heavens or in the way the quadratic formula can solve all possible quadratic equations. Mathematicians and scientists are both looking for exact, concise, and systematic representations of their discoveries. Both demand that knowledge be non-variable and verifiable.

There are differences between mathematics and science, however, and these differences have given rise to the question of the effectiveness of mathematics in science. Mathematicians, by going deep into the structure of their own intellect, are studying how the laws of nature govern subjective aspects of creation, and they verify their discoveries by the intellect. Scientists, by looking out at the world around them, are studying how the laws of nature govern objective aspects of creation and they verify their discoveries by experimentation. The understanding given by Maharishi Vedic Science allows us to reconcile these differences. Although from two different vantage points, mathematicians and scientists are both looking at the same phenomena, the same "unbounded ocean of consciousness in motion," so the patterns and structures which the mathematician sees on an abstract level are exactly those that the scientist studies on the physical level. There must be not only parallels in what they find, there must be perfect coincidence—and this is exactly what so puzzled Wigner and Hamming. Maharishi (1996) explains this as follows:

> This universality of applications can be traced back to the fact that all aspects of Nature and areas of life are governed by the same principles of order and intelligence that have been discovered subjectively by mathematicians by referring back to the principles of intelligence in their own consciousness. Great scientists like Einstein have marveled in the past about this profound relation between the subjective and objective aspects in creation, a relation which has its foundation in the identity of the Unified Field of Natural Law and the field of pure self-referral consciousness displaying the universal principles of intelligence and order. (pp. 304–305)

Working on the level of the intellect where understanding about natural law can be expressed in concise and exact mathematical formulations, the mathematician is able to provide powerful and comprehensive tools for the scientist. Abstract mathematical formulations are able to capture in a simple way the understanding of the scientist, and scientific laws are generally expressed as mathematical equations. Since the principles of order and intelligence expressed in the mathematical model of a physical system are the same as the principles governing the behavior of the system, we see that the computational consequences of a mathematical model of a physical system can exactly describe or predict the evolving conditions of that system. The great speed and efficiency with which the mind can derive predictions from a mathematical model give science great power. For example, in a few minutes, one can set up and solve the equations describing a trajectory that can take a comet months or years to traverse.

Finally, then, in Maharishi Vedic Science, we are able to find a resolution to the question of the role of mathematics in the sciences. The same Laws of Nature, with their source in consciousness, are responsible for both the subjective and objective aspects of creation. The mathematician intellectually studies the subjective side of creation; the intimacy of the intellect with the subjective side of creation gives mathematics its profundity, elegance, and naturalness. The scientist intellectually studies the objective side of creation. The subjective language and tools of the mathematician provide the precise and appropriate intellectual structures for the scientist to comprehend the physical world.

Conclusion

This explanation of the role of mathematics based on the principles of Maharishi Vedic Science allows us to come to a number of conclusions and to suggest some new directions. Firstly, because mathematicians are studying the same principles of order and intelligence that are studied by science, but in a subjective and abstract way, mathematics is the natural language for scientists to record their understanding of the physical world and the methodology of mathematics provides the natural means for predicting the behavior of the physical world. On the other hand, new discoveries and problems arising in the sciences are naturally a resource for the mathematician looking for new ideas and directions.

Next, we see the value for mathematicians to pursue pure mathematics without consideration of its applications. There has been concern in the discipline that by following their individual aesthetics and judgments, mathematicians might go off in directions that are unproductive. But we see here that it is precisely by following their own tastes and preferences that mathematicians are able to uncover deeper and deeper principles governing the structure of subtler and subtler values of natural law. According to Maharishi (1996), "These principles describe the dynamics of Cosmic Intelligence—the Unified Field of Natural Law—as it functions within itself, and are directly cognized on the level of the consciousness of the mathematician " (p. 302). Since these principles are also responsible for the physical world, they must have some reflection in the physical world, and whether they have been located now or not, eventually they will be. As Lobachevsky, a founder of non-Euclidean geometry, said, "There is no branch of mathematics, however abstract, that will not eventually be applied to the phenomena of the real world." (Lobachevsky, 1984)

Finally, this understanding of the role mathematics plays in the sciences shows us that in order to have a complete science, we must have complete mathematical knowledge, and in order to have complete mathematical knowledge, we must have complete knowledge of all levels of life. This means that mathematicians must have complete knowledge of the structure of pure knowledge and complete knowledge of the structure and functioning of consciousness. To be a good mathematician, one must develop one's consciousness fully—from the finest level to the grossest level. Maharishi Mahesh Yogi has provided theoretical knowledge and practical techniques, including the Transcendental Meditation and TM-Sidhi® programs, for this purpose. In his Vedic Mathematics, Maharishi has gone on to show how this knowledge of consciousness can be applied to fulfill the goals of modern mathematics. Maharishi's Vedic Mathematics is the mathematics of consciousness itself.

> Vedic Mathematics is the mathematics of the absolute, eternal, unbounded, which deals with the absolute reality, self-referral singularity—the total potential of infinite diversity at the unmanifest basis of creation, the transcendental level of consciousness. (Maharishi Mahesh Yogi, 1996, pp. 366–367)

With the comprehensive knowledge of Maharishi's Vedic Mathematics (see also Price, 1997), mathematics will be able to rise to its full potential and guide life in a more holistic, mistake-free, and evolutionary way.

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