The Role of Reductionism in Modern Science

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Abstract. Reductionism expresses the idea that the universe is built of very small basic building blocks and that the forces between these building blocks explain all structures built from them. The basic building blocks have a finite size, continuous shape and great strength compared to elementary particles, atoms, nuclei, and molecules. They are able to change their properties to reflect the environment of the universe around them and the electromagnetic fields emanating from God. All the laws of science for elementary particles, atoms, nuclei, molecules, crystals, planets, moons, stars, and galaxies can be explained from the force laws governing the smallest building blocks of nature. Thus the primary goal of modern science is to discover the forces of interaction between these building blocks and the role of combinatorial geometry in forming larger structures.

Introduction. In the book **Dreams of a Final Theory** Nobel Prize winner Stephen Weinberg presents the fundamental idea of reductionism, i.e. some truths are less fundamental than others from which they may be deduced. Thus the operation of the cell in biology could be explained in terms of the molecules of the chemists. The properties and characteristics of the various molecules in chemistry could be explained by the atoms of the atomic physicists in terms of the protons, neutrons and the electrons that make up the atom. Then the properties of the elementary particles such as the protons, neutrons and electrons could be explained by elementary particle physicists in terms of quarks, leptons, etc. Finally the quarks and leptons could be explained by theoretical physicists in terms of a fundamental theory such as a string theory.

For Weinberg reductionism is more than just a guideline for the most productive approach to scientific research, but an attitude toward nature itself. This attitude is based on the perception that scientific principles at different levels are the way they are due to deeper scientific principles and that all these principles can be deduced from one simple connected set of laws. At this time in the history of science, it appears that the best way to approach these laws is through the physics of elementary particles. Weinberg believes that reductionism is a statement about the order of nature that is simply true. Thus elementary particle physics is more fundamental than atomic physics, nuclear physics, molecular physics and other branches of physics, because it is simply more fundamental.

In testimony before congressional committee hearings on funding the Super Collider project which was projected to cost more than any other science project in U.S. history, Weinberg noted that the principles of elementary particle physics are fundamental to nature on all size scales. In this way Weinberg argued for spending a major portion of the government's budget for scientific research on the Super Collider project, because that approach would lead to more efficient and productive progress in science in the long run. After a few years of support for the Super Collider project, the U.S. Congress terminated the project, because many scientists believed that the approach currently being pursued by elementary particle physicists was less productive than the alternative scientific research that other scientists were pursuing. This left only the Large Hadron Collider (LHC) at CERN as the world's largest and most powerful accelerator to search for the Higgs particle and the deepest and most fundamental laws of nature.

Quantum Mechanics. The discovery of quantum effects and the invention of the Copenhagen version of quantum mechanics in the mid-1920s began one of the most profound revolutions in physical theory since the birth of modern physics under Isaac Newton and others in the 17^{th} century. All the mathematical theories that physicists have pursued since that time, i.e. quantum field theories, gauge theories, and superstring theories, are formulated within the framework of the Copenhagen version of quantum mechanics. This change was so profound that physicists now use the word "classical" to mean before quantum mechanics.

Niels Bohr's classical theory of the atom with electrons orbiting the nucleus had been struggling with a number of problems. Why do electrons in atoms occupy only certain allowed orbits with certain definite energies? Why do orbiting electrons not spiral into the nucleus following the laws of electrodynamics? Werner Heisenberg decided to make a fresh start. Since he thought that no one would ever be able to directly observe the orbit of an electron in an atom, he decided to deal only with quantities that could be measured, i.e. the energies of the quantum states in which all the atom's electrons occupy allowed orbits and the rates at which an atom might spontaneously make a transition from any one of these quantum states to any other state by emitting a particle of light or photon.

Heisenberg made a table from these rates or transition amplitudes and introduced mathematical operations on this table that would yield new tables for each measureable physical quantity such as the position, velocity, or the square of the velocity of an electron. Knowing how the energy of a particle in a simple system depends on its velocity v and position r, Heisenberg was able in this way to calculate a table of energies of the atomic system in its various quantum states. This is in sharp contrast to the way that the energy of a planet is calculated in Newtonian physics from knowledge of its position and velocity. In some sense Heisenberg was a magician.

By contrast Einstein was a sage-physicist who reasoned in an orderly way about physical problems on the basis of fundamental ideas of the way that nature ought to be. After creating special relativity in 1905, Einstein developed the general theory of relativity playing the role of a sage. He had to fit the theory of gravitation into the new view of space and time that he had introduced in the special theory of relativity. The observation of the astronomer Galileo that the motions of small bodies in a gravitational field are independent of the nature of the bodies suggested that gravitation might be a property of the aether or space-time itself. Using the well-developed mathematical theory of curved spaces developed by Riemann and other mathematicians, Einstein was able by 1915 to mathematically express his general theory of relativity.

Max Planck was also a magician in inventing his 1900 theory of heat radiation. Einstein was also playing the part of a magician when he proposed the idea of the photon based on his wife Mileva's work on the photoelectric effect.

Heisenberg, working with Max Born and Pascual Jordan in Germany and Paul Dirac in England, fashioned his original ideas into an understandable and systematic version of quantum mechanics called matrix mechanics. Wolfgang Pauli was able to use matrix mechanics to calculate the energies of the quantum states of the hydrogen atom. However Pauli was not able to extend his calculations to the next simplest atom, i.e. helium, or any heavier atom.

A little later Erwin Schrödinger introduced a more convenient formalism. In his version of quantum mechanics each possible physical state of a system is described in terms of a quantity known as the wave function of the system. It is similar to the way that light is described as a wave of electric and magnetic fields. The wave-function approach to quantum mechanics had appeared before the work of Heisenberg in the 1923 papers of Louis de Broglie. De Broglie assumed that the allowed orbits of the electrons in a hydrogen atom would have to be just large enough for some number of complete wavelengths to fit around the orbit. Thus there would be one wavelength for the lowest energy state, two wavelengths for the next lowest, and so on. In 1925-26 Schrödinger transformed de Broglie's rather vague ideas about electron waves into a precise and coherent mathematical formalism that applied to electrons or other particles in any sort of atom or molecule.

At the heart of the Schrödinger approach was a dynamical partial differential equation (now called the Schrödinger equation) that predicted the way that any given particle wave would change with time. Some of the solutions of the Schrödinger wave equation for electrons in atoms simply oscillate at a single pure frequency like the standing sound wave produced in a toroidal tube of gas or air. Such special solutions correspond to the possible stable quantum states of the atom or molecule with the energy of the atomic state given by the frequency of the wave times Planck's constant. These are the energies that are revealed through the colors of the light that an atom can emit or absorb. The Schrödinger wave equation successfully predicted the absorption and emission spectra of all sorts of atoms and molecules.

Despite this success, neither de Broglie nor Schrödinger knew what sort of physical quantity was oscillating in an electron wave. The electron wave was described at any moment as a list of numbers, one number for each point of space in and around the atom. This list is known as the wave function. The individual numbers are called the values of the wave function. From the work of James Clerk Maxwell in the 1860s it was clear that light was a wave of varying electric and magnetic fields. But what is it that is varying in an electron wave.

In 1926 Max Born proposed to interpret the behavior of the wave function in terms of probabilities. In other words, electron waves are not physical waves of anything. Their significance is simply that the value of the wave function at any point tells us the probability that the electron is at or near that point. Neither de Broglie nor Schrödinger were comfortable with this non-physical interpretation of electron waves. That explains why they stopped contributing to the development of quantum mechanics at this point. Despite their misgivings the probabilistic interpretation of the electron waves found support in a remarkable argument offered by Heisenberg the following year.

Heisenberg considered the problems that are encountered when a physicist sets out to measure the position and momentum of an electron. In order to make an accurate measurement of position it is necessary to use light of short wavelength, because diffraction always blurs images of anything smaller than a wavelength of light. Since light of short wavelength consists of photons with correspondingly higher momentum, then when photons of higher momentum are used to observe more accurately an electron's position, the electron will recoil from the impact carrying off some fraction of the photon's momentum. Thus the more accurately one tries to measure the position of an electron, the less accurately one knows the electron's momentum. This observation is commonly known as the Heisenberg Uncertainty Principle.

Since the late 1920s most scientists agree on how to use quantum mechanics to make calculations of various physical quantities, but there is serious disagreement about how to think about what scientists are doing when they use it. Quantum mechanics lacks a physical interpretation of the wave function. Thus the wave function has no objective reality, because it cannot be measured. Also it lacks the determinism of Newtonian physics. Engineers do not like the uncertainty that it introduces into all systems.

The Boscovich Force Curve. In his book **Theory of Natural Philosophy Derived to the Single Law of Forces Which Exist in Nature** [3], Boscovich presented his famous cyclical force curve between particles of matter as shown in Figure 3 below.

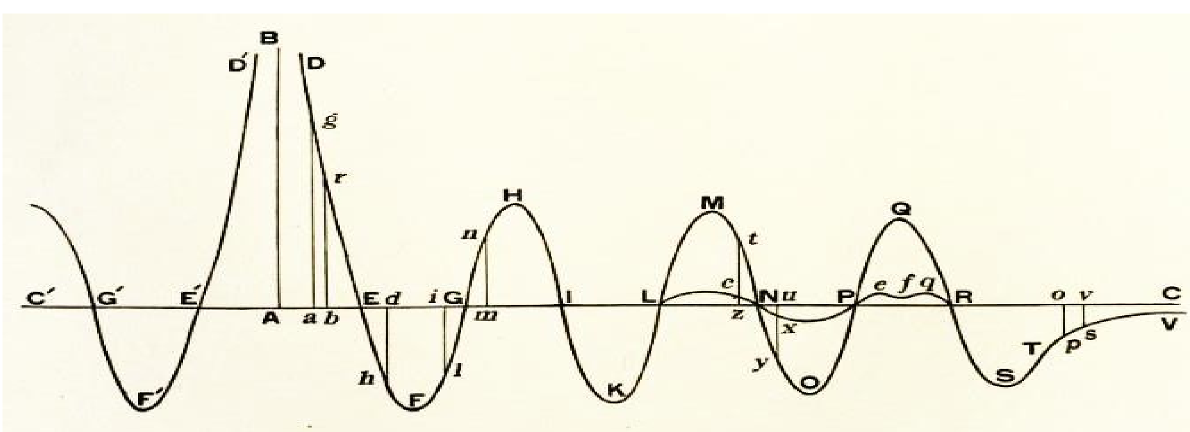

Figure 1 Boscovich Cyclical Force Curve between Particles of Matter [3]

The vertical parameter is the force and the horizontal parameter is the distance between the particles of matter. When the curve is below the axis the force is attractive and when it is above the axis the force is repulsive. For Boscovich this force curve represents the empirical forces between collections of atoms in the form of bodies or particles. At a large distance R the curve represents the attractive $1/R^2$ gravitational force. As bodies are brought closer together in astronomy, they reach certain distances of separation which are in equilibrium where there are no net forces. This is similar to the orbit of the sun going around the center of the Milky Way Galaxy, the Earth moon system going around the sun, and the moon going around the Earth. At even smaller distances we see a rock sitting at rest on the surface of the Earth. One could go even further and talk about the forces between chemical atoms in a crystal or molecule or the forces between quarks in elementary particles like protons and neutrons within the atom.

Principle of Continuity. According to the Principle of Continuity Boscovich's force curve must be continuous. All forces in nature up to that time had been observed to be continuous.

One can break rocks into smaller rocks and the centers of these smaller rock pieces can get closer together, but they cannot occupy the same space. Two liquids can intermix, but if they do not chemically react with one another the net volume is just the sum of the two separate volumes indicating that no two atoms occupy the same space. However if the liquid atoms react chemically to make larger molecules, the net volume of the reactants will decrease. This indicates that the original atoms or molecules have gotten larger by combining to form a larger molecule. The new combined molecule is larger and occupies more space than the original molecules. However, since there are now fewer molecules the space between the molecules has been reduced. This continues to support the idea that no two atoms can occupy the same point in space.

As the two particles get very close to the origin and one another on Boscovich's force curve, the $1/R^2$ forces such as gravity or the electrostatic force get very, very large approaching infinity in magnitude. The Principle of Continuity does not allow the forces between the particles to become infinite. They must have some finite limiting value to correspond to what is observed. This suggests that "atoms" must have a finite size and are sufficiently strong to not break apart under the normal forces in nature.

Principle of Simplicity. The Principle of Simplicity suggests that in order to have simple continuity, there should be only one force. Newton called this force a universal force. The universal force must be both attractive and repulsive in different circumstances at different distances. Thus the force of gravity, which is only attractive, cannot be a candidate for the universal force. It must be a special case of the universal force that is always attractive due to special circumstances.

The key to explaining Boscovich's cyclical force curve is to discover the special circumstances or arrangements of Leibniz's monads that could produce attractive only forces at very large distances and different attractive and repulsive forces at smaller distances. Thus the properties of Leibniz's monad structures would hold the key to the discovery of Boscovich's universal force.

The Monad. The word monad comes from the Greek monas (μονάς) or "unit" and from monos (μόνος) which means "single" or "unique". [4] Epicurus (341 - 270 BC) described monads as the smallest units of matter, much like Democritus's (460 – 370 BC) notion of an atom. Many other Greeks including Pythagoras, Parmenides, Xenophanes, Plato, Aristotle, and Plotinus used monad also as a term or symbol for God the first being or the totality of all beings. The Monad was the source or expression of the one being without division. In cosmogony monism is the metaphysical and theological view that all is of one essence. The monad is the expression of that essence. According to Diogenes Laertius (3rd century BC) [5] these monads combined geometrically to form dyads, triads, quatrads, etc. culminating in the four elements or (forms of matter), i.e. earth (solid), water (liquid), fire (electrodynamic plasma), and air (gas).

Leibniz's Monad. Leibniz (1646–1716) pursued the problem of describing the real and indivisible unit of substance. He was unhappy with both the Cartesian and the atomist theory of matter. The ancient Greek atomists believed that matter could be cut into smaller and smaller pieces and that there was a void between the pieces. If that were true then Newton's (1643 – 1727) $1/R^2$ force of gravity would become infinite between atoms. Descartes (1596 – 1650) believed that the basic laws of motion depended on the somewhat illusionary concept of hard extension which was incompatible with atomism. Atomism was more arithmetical in nature and Cartesianism was more geometrical in nature. Leibniz realized that force was a better concept to describe motion and interactions between the basic units of matter. It avoided the problem of defining hard extension and the geometry of the monad.

The essence of Leibniz's approach is that a quantitative conception of the relation of whole and parts affords an inadequate theory of substance. The common element in the contrary positions of the Cartesians and the Atomists is the explicit or implicit reduction of qualitative to quantitative differences. To Leibniz the solution of the dilemma is to be found in the hypothesis that the essence of substance is non-quantitative such that the relation of whole and parts must be conceived as intensive rather than extensive. Thus a simple substance has no parts or quantitative elements, but it must have a simple unity. It must consist of something. It must have some properties.

Leibniz reasoned that extension enters into the essence or nature of matter, but it does not constitute its whole essence. Similarly magnitude enters into the essence of extension, but is not equivalent to it. Number, time, and motion have magnitude, but they are not extension. Extension is nothing but an abstraction and requires something which is extended. It presupposes some quality, some attribute, or some nature in the thing which extends or diffuses itself along with the thing continuing itself.

A mathematical point may be regarded as indivisible, but only because there is nothing in it to divide. A point cannot have unity, for there is nothing to determine its unity. Descartes's mathematical points are indivisible, but they are only mathematical modalities or abstractions having no real physical existence. The continuous monad, though it can be described in terms of indivisible points, is not composed of them. [6]

Leibniz's monad is an attempt to describe a unit of substance which avoids the imperfections of both Cartesian and Atomist theory. This unit must be real and indivisible. It must have a finite size and a continuous structure so strong that it cannot be easily broken. The monads may be aggregated together to form larger structures with new properties. These aggregates may be broken apart into smaller aggregates or its basic monads.

Leibniz believed that "the smallest part of matter must have a certain spontaneity or power of acting from within itself." It must be in equilibrium with the rest of the universe. He describes the individual substance as essentially a "force" rather than a quantity. The smallest part of matter must have a "perception" of its environment and "appetition" or potential to realize itself. In the past Greeks imagined atoms as having specific geometrical shapes. Leibniz's atoms or monads are characterized by continuous forces which have no "hard" boundaries which normally define shape. The monads are flexible to some extent.

Monads are the basic substances that make up the universe but lack a well defined spatial extension and hence are immaterial. [7] Each monad is a unique, indestructible, dynamic, soul like entity whose properties are a function of its perceptions and appetites. All are perfectly synchronized with each other by God in a pre-established harmony. The objects of the material world are simply organized collections or structures of monads.

Leibniz's monads have perception (or awareness of environmental forces) but not in the sense of consciousness. For consciousness is not the essence of perception, but merely an additional determination belonging to certain kinds or degrees of perception. Conscious perception is called by Leibniz "Apperception". Monads alone are real. Every change in nature must be reflected by change within monads. The monad is perceptive in a dynamic and not a static way. A human can be perceptive without choosing to react (passive or static perception). Each monad is a part or element of the universe in the sense that each represents it or reflects it as in a mirror from some particular angle or perspective. In some sense the whole universe must be the infinite totality of all monads representing the universe from every possible point of view.

While monads are entirely separate from one another, each must represent the universe at its location which is different from all other locations. No two monads or aggregates of monads can occupy the same point in space or be exactly the same. This is a consequence of the Principle of Continuity.

In the system of monads the Principle of Continuity replaces the "void" in the older atomism. Leibniz substitutes for an extensive plenum of mass an intensive continuum of force. The conception of continuity escapes the contradictions that are involved in the idea of a void. Everything in the world acts and reacts upon everything else. The influence may in some cases be imperceptible or infinitely small, but it exists.

Leibniz operates under the hypothesis that God is the sole real cause of all monads. They have no power or existence of their own.

Summary of Boscovich's and Leibniz's Atomic Model. From an analysis of his atomic force curve and the Principles of Continuity and Simplicity Boscovich determined by logic that on the smallest scale the universe is made of monads or atoms which are finite-size continuous entities of great strength that do not break apart under normal circumstances and have no inherent property of mass. This model is most appropriate for the ancient model of the atom originated by Mochus the Hebrew lawgiver as recorded by the Indian Jains [8] which has been identified with quarks and leptons which are the building blocks of elementary particles. The chemical model of the atom would be developed later and built from the electron, proton, and neutron elementary particles which in turn are composed of quarks and leptons. Is there any experimental evidence to support Boscovich's atomic model that avoids the $1/R^2$ infinity problem at very small distances and supports the notion of a single continuous universal force?

Experimental Evidence to Support Boscovich's and Leibniz's Atomic Model. The evidence to support Boscovich's atomic model based on monads all came after his death. It started with the discovery of solitons or the monad of matter. Solitons are long lasting semi-permanent standing wave structures with a stable algebraic topology. [9] The soliton can exist in air or water as a toroidal ring. Solitons in water are usually formed in pairs known as a soliton and anti-soliton. Their structure is weak and they decay away after 10 or 20 minutes.

Bostick's Plasmons. Winston Bostick (1916-1991), the last graduate student of Nobel Prize winner Arthur Compton (1892-1962), experimentally discovered how to make "plasmons" or solitons from the electromagnetic field within electromagnetic plasma. [10] These structures were very strong 10^{40} as strong as solitons in air and water. They had very long lifetimes and could not be destroyed by normal processes in nature. Bostick proposed that electrons were just simple solitons and positrons were contrary or anti-solitons. All other elementary particles were built of more complex geometrical structures such as dyads (pairs of monads), triads (three monads), quatrads (four monads), etc. All plasmons or solitons in the electromagnetic field are of the same shape, i.e. a toroidal ring. The plasmon was of very great strength. Bostick tried to create a bottle from plasmons to hold controlled thermo-nuclear fusion. All materials known to man up to that time slowly disintegrated when exposed to controlled thermo-nuclear fusion. Only the plasmon was strong enough, but Bostick failed to succeed in building a bottle from plasmons.

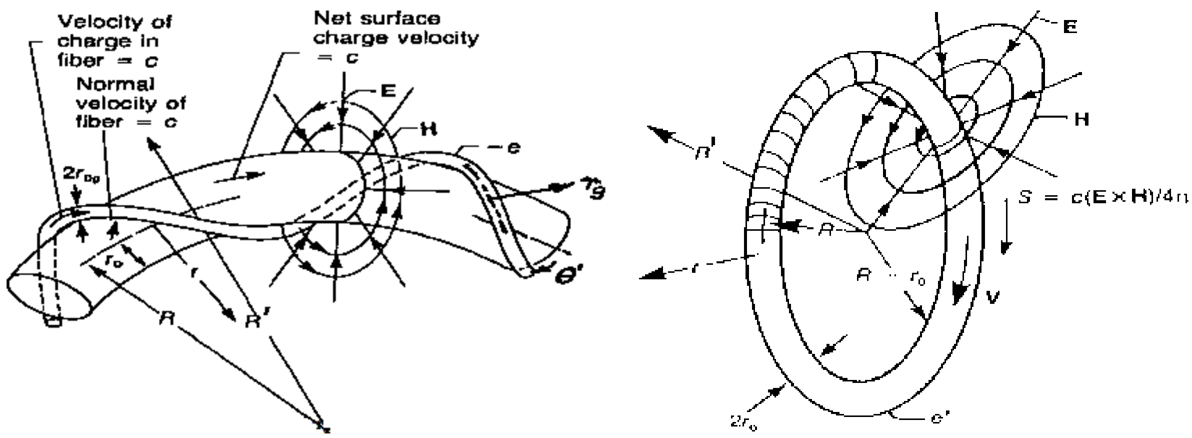

Figure 2 Bostick's Plasmon in the Shape of a Toroidal Ring [10]

Hooper's Electromagnetic Field Experiments. The nature of the plasmon, electromagnetic soliton, or monad was more completely revealed by another modern day scientist, William J. Hooper [11]. He discovered that charged elementary particles, such as the electron, were not only made out of the electromagnetic field, but variations in the field around them due to their structure extends to great distances. Thus there is not a well defined size associated with a soliton. This same feature is easily observed from solitons in water.

Hooper [11] also discovered that there are three types of electric and magnetic fields. One of these types is due to velocity effects from Lenz's Law causing it to have the property that it cannot be shielded. Thus portions of the electromagnetic field exist everywhere in the universe.

Conclusions. Experimental evidence has been found for the existence of the Monad of the Indian Jains, Epicurus and the Greek philosophers, Leibniz, and Boscovich. The Monad is a soliton or standing wave of the electromagnetic field which is of great strength. Its field extends to great distances. All elementary particles, atoms, nuclei, molecules, etc. are built from geometrical combinations of Monads. The electromagnetic force is the universal force of Boscovich. [12]

The Bible says in Colossians 1:16-17 that God is the creator and sustainer of all things in the universe. The Bible also claims in Habakkuk 3:4 that God exerts his power and control of the universe via electromagnetic fields and lightning emanating from him. [13] If God is the source of all electromagnetic fields in nature, then this explains how he could create solitons from a great distance and form from them all the atoms and matter in the universe. By means of the electromagnetic field emanating from him, God could also sustain all the monads and create all the larger structures comprising all the matter in the universe.

Thus there appears to be some agreement between the Indian Jains, Epicurus and the ancient Greek philosophers, Leibniz and Boscovich that the universal force is electromagnetic and all matter is composed of monads or toroidal ring standing waves of the electromagnetic fields emanating from God. This is the subject of the author's new book to be published soon. [14]

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