Toward an Integrated View of Particles and Forces

R. W. Boyer and P. Hensley

Abstract

In the ancient Vedic tradition of Sankhya, three fundamental forces are identified that can be associated with creative, maintenance, and dissolution operators. These three forces materialize five fields or constituents said to comprise the entire physical universe. This framework may be helpful for contemporary particle-force theories with a multitude of particles emerging from four quantum fields—electromagnetism, weak and strong nuclear, and gravity—that gain mass via another more recently theorized Higgs field.

Key words: Einstein locality, wave function collapse, nonlocality, spin states, Vedic tradition

Objective investigation of the essence of matter has primarily involved a reductive strategy of probing and measuring smaller and smaller time and distance scales, and higher and higher energy and temperature states. In simple form the range of scales can be depicted as follows:

Ultramacroscopic levels	~ cosmic expanse to Infinity
Macroscopic levels	~10^{-3} to ~cosmic expanse
Microscopic levels	~10^{-4} to ~10^{-8}
Ultramicroscopic levels	~10^{-9} to ~10^{-33} cm (Planck length)
Unified field level	~Infinitesimal point to Infinity

The resolving power of our ordinary senses for direct sensory observation is comparatively quite limited. The wavelength of visible light, for example, is in the range of 10^{-4} cm, too wide to observe directly anything smaller than a cell. Visual observation has been extended with the aid of equipment such as electron microscopes to about 10^{-8} cm, still larger than an atomic nucleus. Research has now gone far beyond obtaining tangible empirical evidence directly through the ordinary senses. At these ultramicroscopic scales, *indirect* methods are required. The results are macroscopic phenomena observed via the ordinary senses that are predicted by and dependent on conceptual models of processes theorized to occur at much smaller unobservable scales.

One prominent indirect method uses particle accelerators, the most powerful of which are at the Fermilab in Batavia, Illinois in the U. S. and the Large Hadron Collider (LHC) at CERN near Geneva, Switzerland with the capability to probe down to about the scale of 10^{-19} cm. However, the energy levels needed to probe the theorized smallest scales are still far beyond even these most powerful probing instruments. An alternative indirect method is to search for measurable remnants that may support predictions of events occurring near the time of the big bang. These cosmological methods are associated primarily with research on gravity and the shape of the cosmos, while particle accelerators have been used more for quantum field and super-symmetry research. In recent years cosmological methods have become prominent in both areas.

Analyses of theorized events at unobservable scales increasingly rely on conceptions of what is being measured and what measurement means. Cognitive processes of reasoning are relied upon more than sensory perception; and it becomes increasingly clear that what is observed depends on subjective mental processes in observers. Moreover at very small scales probing and measurement is thought to interact with and significantly alter theorized objects being examined.

A major change from classical to quantum physics is that these issues are now recognized, evident in the *measurement problem* and the role of the observer in creating observed outcomes. Inevitably, tacit assumptions about the object of investigation, the probe, evidence of their interaction, as well as the observer all must be considered in examining the essence of matter (Boyer, 2008)..

What is the *Matter*?

Atoms are the matter. Classical Newtonian physics conceptualized matter as atomic particles interacting in force fields within infinite space and time via an unbroken causal chain of measurable local physical events. Objects were viewed as localized in space and time, existing independently of each other and of the observer, and influenced mechanically by forces that decrease with the square of the distance. Atoms were thought to be the 'uncuttable constituents' of nature, represented mathematically as idealized dimensionless points in infinite space and eternal time. Subsequent research led to theories of subatomic and even more elementary particles. In particle-scattering experiments, 150 or more elementary particles have been theorized to exist. Sometimes particle pairs appeared to emerge that were mirror matches with opposite electric charge—a particle and *antiparticle* partner. Theorized particles and antiparticles are now classified into three groups according to the concept of mass (Greene, 1999).

Quanta are the matter. As levels of nature have been further unveiled, matter and forces have been conceptualized as excitations or waves in fields of abstract quantized potential energy. In some sense they are thought to have boundaries or discrete particle properties, but at the same time are also thought to be unbounded waves of potential energy. Quantum wave functions are amplitude distributions that model wave potentials as fluctuating only at certain potential energy states. These potential energy states are multiples of the *Planck scale*, theorized to be the fundamental unit of space and time mathematically derived from light-speed, Newton's gravitational constant, and Planck's constant.

Stable states of fluctuation are conceptualized as the *particle* quality of the field, and transient fluctuations as the *force* quality. The transient fluctuations—force carrier particles, exchange particles, messenger particles, or virtual particles—are theorized to mediate the exchange of energy between matter particles. They are conceptualized as coming in and out of existence so incredibly rapidly that they are described as *virtua*l. In quantum field theory a force is an effect on a particle due to the presence of another particle. This effect is depicted as being mediated by a virtual or exchange particle that passes between interacting matter particles—the billiard ball-like particle interaction model of causality. In addition to stable matter particles and transient virtual particles the quantum field also is described as capable of being in a least excited ground state, the *vacuum state*. The quantum field is conceptualized as inherently dynamic, continuously exhibiting 'zero point motion' or energy whether in its particle, force, or vacuum state.

Quantum force fields are the matter. According to unified field theory the universe first appeared via spontaneous symmetry breaking in three stages of increasing diversity as the extremely high levels of energy distributed and temperature dropped. The first phase transition broke supersymmetry into the gravitational and grand unified forces. In the second phase (about a hundred-thousandth of a second later and at about 10^{-27} cm, called the Grand Unification model), the grand unified force broke into the strong nuclear and electroweak forces. In the third phase (about a hundredth of a second later and at about 10-16 cm, the Standard model), the electroweak force differentiated into the weak nuclear and electromagnetic forces. The long-range forces of gravity and electromagnetism account for most activity in the physical universe; the short-range strong nuclear and weak forces were proposed later to explain processes within atomic nuclei. All particles and forces are now theorized to be excitations of these four quantized particle-force fields. Historically electricity and magnetism were separate forces, reflecting the model prior to recognizing their symmetry.

Sequential symmetry-breaking also relates to the cosmological theory of an additional field, the *Higgs field*, considered one of the most important concepts in 20th Century physics (Greene, 1999). A Higgs field is envisioned as a kind of viscosity throughout space that resists change in motion, used to explain how particles acquire mass. It is associated with *inflationary big bang theory*, which holds that at the outset of the big bang the force of gravity became a repulsive force that drove the emerging universe into a colossal expansion. This inflationary event involved a Higgs field called the *inflaton field*, contributing a uniform negative pressure to space that produced a repulsive force so strong that the universe expanded by a factor as much as 10^{90}—associated with the concept of dark energy.

An elaboration of inflationary theory proposes that the big bang emerged from a *pre-inflationary* period, in which the gravitational and Higgs inflaton fields were bumpy, chaotic, and highly disordered; and eventually a random fluctuation produced the values needed for inflationary expansion. But 'when' the theorized big bang 'began,' an orderly temporal sequence also began. At least in the world as we understand it through science, an event manifests in an orderly manner from the previous event, which implies that the source of the universe is a state of lowest entropy, not fundamental randomness. This is crucial for understanding the source of order in nature. If the universe were fundamentally random, there would be no memory or principles of order whatsoever to connect one moment to the next, no continuity through time, and no orderly laws of nature. As physicist Brian Greene (2004, p. 271) points out:

> "[I]f the universe started out in a thoroughly disordered, high-entropy state, further cosmic evolution would merely maintain the disorder… Even though particular symmetries have been lost through cosmic phase transitions, the overall entropy of the universe has steadily increased. In the beginning, therefore, the universe must have been highly ordered."

The principle of symmetry has facilitated the development of theories that unify quantum fields in the same type of *internal spin*. In this context spin is an important mathematical concept characterized as a discrete amount of angular momentum that determines properties of particles. As yet it does not have a physical interpretation, but is sometimes likened to rotational movement analogous to the external spin of a top. Particles are classified into five spin types (0, ½, 1, 3/2, and 2) in half-units of Planck's constant. Whole number or integral types (0, + or - 1, + or -2) are the force carrier or virtual particles, *bosons*, with the statistical property of unifying or collecting together in the same position and momentum. Bosons are not discrete particles and cannot be distinguished completely from each other; they relate to coherence phenomena such as laser light. Half-integral spin types (+ or -1/2, + or -3/2) are the matter particles, *fermions*, with the property of exclusion and cannot occupy the same energy state. Fermions are the matter particles that create the vast diversity of behavior throughout creation. Particles are either fermions or bosons; fermions as matter particles interact via boson force carrier particles that mediate the interactions.

The mathematical principle of supersymmetry has fostered theories attempting to unify bosons and fermions—a major step toward unification of the strong-electroweak and gravitational forces. This principle requires that supersymmetric partners (*sparticles*) exist for all the particles and antiparticles. Each particle is thought to have a supersymmetric partner with a spin either ½ larger or ½ smaller. To verify this, supersymmetric partners of all the particles need to be found (such as the photino as the theorized partner to the photon, gluino for gluon, and gravitino for graviton). They relate to *dark matter*, or the *hidden sector*, because they are not visible. Dark matter was proposed due to mathematical applications of supersymmetry, and to help explain how galaxies hold together. Dark matter is different from *dark energy*, proposed more recently to explain empirical findings that the universe is expanding at an increasing rate.

A prominent concern over the past few decades has been how to unify the three forces (electromagnetic, weak and strong nuclear) with or into the one force of gravity, which also would unify bosons and fermions. Called *super-unification*, it is believed to require integrating the two major breakthroughs of twentieth-century physics—quantum theory and the general theory of relativity—into a theory of quantum gravity. Such a theory is generally considered to be a necessary step toward a viable unified field theory of one field as the *source of everything*. In the language of spin states this means to connect the spin 2 gravity field with the other spin-type fields, to connect the spacetime continuum itself with the particle and force fluctuations of the other quantum fields. But attempts to do this have produced the inconsistency of infinite quantities, and it has been quite difficult to find the rationale to cancel out the infinities to obtain mathematically meaningful results.

Strings are the matter. String theory is believed by most physicists to be the best direction for developing a consistent theory of quantum gravity. Basically it replaces the dimensionless point particle used in classical and quantum physics with a tiny filament or string approximately the Planck size. The concept of a particle is of a point in space with no internal structure or spatial extension, with only the capability of movement through space. A string has extension in space, allowing mathematically for more complex higher-order patterns of fluctuation, which adds explanatory power. The higher-order fluctuations are significant at the ultramicroscopic scale; otherwise strings have much the same mathematical properties as dimensionless point particles.

Mathematically string theories require dimensions in addition to the ordinary four dimensions of space and time, sometimes conceptualized as spatial dimensions curled up in the internal structure of the string, called spacetime *compactification*. The classical four dimensions are thought to be the non-compactified or unfurled dimensions that make up our ordinary sensory world. The higher-order dimensions are mathematical dimensions in conceptual, imaginary space—not necessarily comparable to the ordinary four spacetime dimensions.

String theory is so complicated that its exact equations have not been able to be determined. Approximations yield many perspectives or models, but there are indicators of a smaller set of consistent ones (Types I, IIA, IIB, Heterotic-O, Heterotic-E, and 11-D Supergravity). Recent advances pull together these models into a framework called M-theory, which involves 11 dimensions: the ordinary four, plus seven compactified dimensions in mathematical space. In addition to one-dimensional strings, two, three, and higher dimensional geometrical objects called *branes* (membranes) are posited. Understanding and developing exact equations for string theory and M-theory are major current issues. The theories are said to provide a logical framework that integrates much of the progress in the past century. However, there is considerable debate whether they represent the appropriate direction to develop a theory of quantum gravity. There is concern whether supersymmetry, upon which the theories are based, exists in the natural world. Also, though mathematically compelling, experimental evidence for strings and branes is scant.

To summarize, matter is conceptualized as built of unseen atoms, composed of unseen elementary particles and forces, which are theorized to be quantum-wave fields of potential energy, which involve geometric patterns such strings, branes, or other similar mathematical objects. The overall picture is of probing indirectly the smaller and smaller time and distance scales down to the ultramicroscopic Planck scale. This scale is so incredibly tiny as to be *almost* like a dimensionless point. It is theorized that compactified at about this smallest size are mathematical geometric 'objects' that generate our ordinary world. These terms, however, may give the impression that the geometric 'objects' are physical. They are mathematical 'objects' described using spatiotemporal metaphors to help develop the theories. The Planck scale is thought to be the ultimate limit of spacetime. If these geometric 'objects' exist in nature other than being just mathematical models, they would be fundamental curvatures *of* spacetime not made of matter. The reductive search for the essence of matter has gone beyond all forms of matter—beyond elementary matter and force particles and ordinary spacetime—to a theorized *non-material* basis of physical creation. In other words ultimately there is no matter, which strongly suggests that there is more to the story than physical reality.

A new direction in M-theory explores a possibly more fundamental level from which a coherent background of string vibrations emerges that produces ordinary space and time. This relates to the concept of a zero-brane (Greene, 1999), which like a point particle has no spatial extent but is attached to strings and functions differently than classical point particles. Zero branes don't produce the same mathematical problems associated with quantum fluctuations that plagued classical point-particle theory and that string theory has made progress on resolving. Importantly this theory glimpses a more fundamental level beyond ordinary or *conventional* spacetime.

Loop quantum gravity is another approach to quantum gravity that also posits a field underlying and generating conventional spacetime. It is a mathematical theory of a non-material *pure geometry* called a spin network. This theory links the concept of bits of quantized pure geometry with bits of non-physical information in a formal mathematical relationship—the Bekenstein's bound. Accordingly the smallest possible surface area of space has an inherent mathematical limit to the amount of information it can contain. Matter is reduced to quantized units of spacetime, then to a more abstract non-material pure geometry, and then further to an even more abstract quantized *information space* that generates conventional spacetime (Smolin, 2001).

The Planck scale and underlying nonlocality. In the expanded context emerging in these quantum gravity theories, the concepts of strings, branes, or loops—however the smallest entity, process, or event is envisioned—still embody some notion of a membrane or boundary. This inevitably brings up the issue of infinite regress. The Planck scale is thought to be the smallest possible size of an object and the smallest possible physical boundary between objects. But at some point discontinuous quanta need to merge into indivisible continuity if there is a unified field that is beyond all gaps, boundaries or differences, unitary and one with itself. It seems logical that the quantum principle as applied to the Planck scale cannot be fundamental if there is a completely unified field.

The Planck length is the distance light travels (10^{-33} cm.) in the Planck time (10^{-43} sec.). The theorized four particle-forces that mediate change in the physical world are subject to this limitation. However the experimental verification in the 1980s of nonlocality cannot be accounted for within this limitation. Given that the theories and findings about the physical universe are generally correct, it would seem necessary that a subtle underlying, nonlocal field would have to be outside of conventional space and time, as suggested in the quantum gravity theories above. Measurable objects in conventional spacetime are theorized to be made of Planck-size quanta; but perhaps there are underlying non-quantized levels. There would still be no smaller scale than the Planck scale using any independent probe built of matter particles.

The Planck length thus may be the smallest curvature of spacetime from which quantized material objects are constructed, imposing on the field the quantum principle as applied to matter and associated with the Planck scale as the smallest scale of conventional space and time. Planck-scale quantization may be the limitation of a subtler underlying non-quantized field. Theorized strings, branes, loops, or other geometric objects may represent attempts to model quantization and compactification, rather than using the idealized mathematical concept of a dimensionless point. For example in string theory the classical macroscopic and microscopic world is where the four dimensions of spacetime are unfolded and unfurled, and spatial dimensions near the ultramicroscopic Planck scale are enfolded or compactified. But the *opposite* view may be more appropriate: quantization at the Planck scale may be the limiting of a more abstract, underlying, extended, unfurled, non-material, nonlocal field into discrete localized, enfolded particles. In other words, conventional spacetime may end at the Planck scale, but it may materialize from a subtler nonconventional, nonlocal field that generates and permeates it (Boyer, 2008).

A holistic perspective of levels of nature

A helpful strategy in building a more holistic understanding of levels of nature is to disembed from the reductive perspective that brings everything down through smaller and smaller scales. Instead of the universe narrowing down to an infinitesimal point such as a black hole or nothing, the big bang or whatever mechanics of nature result in phenomenal materialization might be a concretization of infinity into finite values. It might not create spacetime from nothing, but rather be a phenomenal limitation of the infinite eternal unified field *that is already everywhere*. From this perspective no new dimensions of space and time would be needed to account for nonlocality. The difference between subtle nonconventional spacetime and gross conventional spacetime may not be any new higher-order spatial dimensions, if they both are limitations of the infinite eternal unified field. In the process of manifestation the unified field would become limited into nonlocal, non-material, nonconventional spacetime, and then further limited into conventional spacetime and ordinary matter (Boyer, 2008).

The ancient knowledge tradition of *Veda* is increasingly recognized to be a holistic view that applies this strategy in modeling levels of nature. Although there are many different interpretations, the word "Veda" generally can be translated as 'knowledge,' and more specifically 'total knowledge' (Maharishi Vedic University: Introduction, 1994). The closest concept in modern science seems to be the unified field as the 'source of everything' (Hagelin, 1987, 1989). In contrast to the reductive physicalist paradigm, the holistic view of Vedic science can be understood to begin with unity, sequentially unfolding the parts of nature within infinite eternal unity as sequential limitations or localizations into finite forms, similar to the concept of sequential symmetry-breaking. The parts emerge within the whole, rather than the whole emerging from combining the parts (Maharishi Mahesh Yogi, 1972). This holistic approach may shed light on attempts to integrate forces and particles. It seems quite consistent with the direction unfolding in quantum gravity theories described above toward unified field theory.

Three fundamental forces. The aspect of ancient Vedic science called *Sankhya* enumerates levels of nature within the totality of nature or theorized unified field, from subtle and gross levels to the grossest inert levels of matter. Sankhya and Vedic literature in general can be interpreted as identifying three fundamental qualities or forces in nature—*sattva guna, rajas guna*, and *tamas guna*. These three gunas or forces are fundamentally inseparable, co-existing and co-functioning in various relative degrees to carry out every interaction at all phenomenal levels of existence. The three gunas are said to shape the infinite potentiality into relative finite phenomena of nonlocal interdependence and local independence. They also can be related to the three aspects of time—present, future, past—the three spatial dimensions—x, y, z axes or up/down, forward/backward, and right/left—as well as many other trinities throughout nature. Although their dynamics are intimately intertwined and self-interacting, they can be related to the basic creative, maintenance, and destructive or dissolution operators that can be said to conduct all change. Vedic scientist Maharishi Maharishi Yogi (1967, pp. 269-270) explains:

> "The entire creation is the interplay of the three gunas. When the primal equilibrium of sattva, rajas and tamas is disturbed, they begin to interact and creation begins. All three must be present in every aspect of creation because, with creation, the process of evolution begins and this needs two forces opposed to each other and one that is complementary to both.. Sattva and tamas are opposed to each other, while rajas is the force complementary to both. Tamas destroys the created state; Sattva creates a new state while the first is being destroyed. In this way, through the simultaneous processes of creation and destruction the process of evolution is carried on. The force of Rajas plays a necessary but neutral part in creation and destruction; it maintains a bond between the forces of sattva and tamas. "

Sattva guna can be associated more with the maintenance operator, upholding and fostering balanced change and continuity. It is the unifying principle, the attraction, balancing, or harmonizing value of nature. In the physical universe it can be associated most directly with gravity, attraction to the center point of an object, and the gravitational constant. Rajas guna can be associated more with the creative operator, activating the maintenance and dissolution operators. It provides neutral energy or activation that impels change. In the gross physical universe it can be associated most directly with the principle of energy and with expressive or diversifying processes following the law of energy conservation and relating to light-speed and Planck energy. Tamas guna can be associated more with the dissolution operator, restraining the creative and maintenance operators, and with the principle of inertia or resistance to change. In the gross physical universe it can be related to the concept of mass, Higgs field theory and possibly Planck's constant. The three components from which the Planck length is derived—gravitational constant, light-speed, Planck's constant—may correspond generally with properties of sattva, rajas, and tamas.

To apply these three abstract forces to the ordinary physical level of nature of conventional spacetime, they can be thought of as inherent in the nature of every point in an unbounded field. Thinking of an abstract field as being made up of infinity of points, if each point has a certain property then the field also has the property, which gives the field overall textural qualities or defining features. This can be associated with the concept of a medium or ether. This may give a sense of how the quantitative values of the Planck scale, light-speed, and relativistic gravity all relate to defining textural qualities of the fabric of conventional spacetime. Inherent throughout the unbounded fields of nature and embodied in each point in the field are said to be the three forces associated with creative, maintenance, and dissolution operators (Boyer, 2008).

Five fundamental constituents. In Sankhya the three gunas materialize or condense further into five fields, constituents, or elements of nature, the *mahabhutas.* The term mahabhuta is from *maha* (great, universal), *bhu* (curving back, giving form, to happen, occur, exist; *bhut* (creation), and *ta* (finished, created) (Maharishi Mahesh Yogi, 1967). These five mahabhutas can be described as frequencies or vibrations of the unified field in its grossest, most concrete localized expression. They are associated with the classical concepts of space, air, fire, water, and earth—but this terminology can be interpreted in a much too simplistic and misleading manner.

The mahabhutas refer to abstract processes that structure physical objects with the respective properties of vacuity (space), mobility (air), luminosity (fire), liquidity (water), and solidity (earth). For example the mahabhuta of *air* not only refers to what we ordinarily think of as air, but more fundamentally to the abstract principles that manifest as gaseous processes, and also agglomerations into matter. The nature of the mahabhutas or fundamental elements as abstract processes may be more obvious with respect to fire. Inclusion of the concept of fire as a fundamental constituent of material creation clearly suggests the more abstract functional nature of the mahabhutas, not a superficial description of basic elements sometimes attributed to primitive cultures. The mahabhuta of *fire* refers to the underlying laws of nature involved in transformations through processes such as radiation, combustion, oxidation, and illumination.

In Sankhya the five mahabhutas make up the entire gross relative creation, which can be viewed as comprising the ultramicroscopic, microscopic, macroscopic, and ultramacroscopic levels investigated in the physical sciences. Each mahabhuta precipitates from the immediately preceding one, and manifests an additional limitation, property or specific quality—along with the general properties of the others. The mahabhutas combine in innumerable patterns to create the vast diversity of the physical universe; but no new ontological levels are created from them.

As physical realities of the ordinary phenomenal world, the five mahabhutas must in some way correspond to the quantized particle-forces. The current state of knowledge may not be quite developed enough to establish the precise correspondences of the known particle-forces with the gunas and mahabhutas. But if both describe the same physical world, they should match up.

The five mahabhutas can be understood to be expressed in sequential enumeration. The mahabhuta of space contains in potential or latent form the other mahabhutas, but *expresses* the specific qualities associated with space. To link this system to the fundamental forces and the concept of sequential symmetry-breaking, one reasonable view is that the mahabhuta of space is most closely associated with the gravitational force. Likewise the mahabhuta of air would express the gravitational and strong nuclear forces. The mahabhuta of fire would express the gravitational, strong, and weak forces. In this speculative comparison, the mahabhutas of water and earth would express all four forces but be most associated with electromagnetism.

Space (Akasha). In the holistic view of the infinite eternal unified field as the source of everything, the universe and spacetime would not begin by blasting out in a big bang but rather many 'places' or points simultaneously (Greene, 2004). This eliminates paradoxical issues in reductive conceptions of nature emerging from nothing or a Planck-size quantum from which space and time expand outward—which impels questions of what existed before it, what it expand s into, or what remains when it contracts. Finite levels can be understood as phenomenal limitations within the infinite eternal unified field. This also is relevant to the contemporary model of space as 'flat' in the sense of extending in all three directions without being curved, which Greene (2004) describes as the front-running contender for the overall shape of the universe.

With respect to finite space in the sense of relative creation, however, space can be thought of as curved. The notion of the curvature of space—such as into a torus or sphere, or both if a sphere can be conceived in terms of curving back on itself—relates to finite limitation of infinite self-referral. To explain finite creation, it can be said that infinity curves back onto itself, infinite self-referral *[Bhagavad-Gita, 9.8]* (Maharishi Mahgesh Yogi, 1997, p. 37). This curving back onto itself can be associated on the finite manifest level with a *mandala* form. This is related to the Vedic concept of *Hiranya garbha*, sometimes called the cosmic egg or manifest form of the unified field curving back onto itself in the creation of the cosmic expanse of relative finite spacetime. On the grosser level of conventional spacetime, this dynamic of curving back onto itself can be associated with the concepts of a point particle, Planck-size quanta, and atomic structures.

From the root 'to appear,' *akasha* relates to the abstract principle of *vacuity*, and seems to be most akin to the concept of conventional spacetime. Every physical object is permeated by and shaped from akasha. In modern physics, objects existing in this level have the limitation of light-speed, and all gross movement of energy and mass in relativistic conventional spacetime reflects this limit. It is directly related to the Planck scale, zero point energy, the Heisenberg uncertainty principle, Einstein locality and the light cone, Einstein gravity, the particle interaction model of causality, and Planck-size quantization that can be viewed as the defining features or textural fabric of conventional spacetime.

The mahabhutas are sometimes described as dimensionless points, in the same sense as the point particle concept used in calculations of motion in non-relativistic and relativistic classical physics (Bernard, 1947). Physical objects involve the delineation of space into the three spatial dimensions necessary to establish volume and magnitude. The mahabhuta of akasha is not described as having a particulate structure in the sense of quantum theories which posit spacetime as fundamentally discrete Planck-size quanta or as mediated by a particle such as the hypothesized graviton. However, the principle of vacuity of akasha is sometimes conceived as having an additional textural quality of *porosity* (Bernard, 1947)—which may correspond to these conceptions, as well as to spacetime foam. Although the general theory of relativity describes space as a relational phenomenon, it is nonetheless associated with specific textural properties. It is in this sense that akasha historically has been associated with the concept of *ether*.

In *Vaishesika*, another aspect of Vedic science, there is also a delineation of the five mahabhutas. The four mahabhutas other than akasha are identified as *paramanus*, sometimes interpreted as meaning the smallest possible divisions of matter. The four paramanus (air, fire, water, earth) are characterized as having extension and magnitude in space (akasha), and can be associated with quantization and particle properties.

One way to look at the physical world as quantized is that when each point in a field has a quality of attraction or gravity, pulling toward itself from all directions—so to speak—and points in the field are differentiated or separate from each other in some sense, then the points would pull on each other. If there were only two points, they would gravitate back together to become one point. But when the pull of each point on the points adjacent to it is from all directions—for all practical purposes, of infinite extent—then they would pull against each other in the sense that a point on one side would pull in the opposite direction of the point on the other side, in all directions. There would be opposing pulls that would appear to establish each point as a specific point within an undivided field. The point could be thought of as becoming quantized with extension, determined by the strength of their attraction and other counteracting forces. This would give a texture to the field and determine the size of the quantum, in our physical world theorized to be the Planck size (Boyer, 2008).

The gravitational constant can be related to the force of attraction or sattva. Correspondingly the influences counteracting the force of gravity would seem to be directly related to light-speed and Planck's constant. The point particle field is said to be inherently dynamic, quantified in terms of the Planck energy, the amount of energy inherent to each quantum related to light-speed. It seems quite reasonable that this can be related to rajas or activation. Correspondingly the property of viscosity or resistance to motion associated with Higgs theory seems to relate to tamas, and possibly Planck's constant. The three gunas thus may be the fundamental forces or properties that define Planck-size quanta, which comprise physical objects in ordinary spacetime.
The five mahabhutas or gross constituents of nature can be thought of as fields with progressive limitations, each more expressed one embedded in the previous one. They also can be thought of as progressive layers of gross spacetime, each one taking on an additional specific quality from which is expressed a variety of different physical phenomena. One way to think about the paramanus is that they are structured by the spacetime gravitational field being further limited, drawing into its point value—sharply collecting into or curving back onto itself and compactified into discrete forms that function as independent, self-contained quanta or particles. In this speculative view the mahabhuta of space would express the gravitational force.

Air (Vayu). From the root 'to blow,' vayu can be related to the abstract principle of *mobility* or motion, and the related functions of pressure and impact, compression and rarefaction, most akin to the concept of *air*. The mahabhuta of air precipitates from the mahabhuta of space. In the increasing limitation of space, it is the nature of the gravitational unifying force to attract points of spacetime together into clumps or regions of more and less compression, which further precipitates into a gaseous state. The mahabhuta of *air* fills the available three-dimensional space—within the constraints of gravity—but has the additional limitation of not being able to permeate objects, which are properties of a gas. With respect to particle-forces, the fundamental force that binds or glues particles into atomic nuclei and compounds is the strong nuclear force. In this view the mahabhuta of air would express the gravitational force along with the strong nuclear force (but again including the weak and electromagnetic forces, latent and not yet expressed).

Fire (Tejas). From the root 'to be sharp,' tejas relates to abstract principles of *luminosity*, *form*, and *transformation*, associated with the fundamental element of fire. The mahabhuta of fire relates to heat and temperature as well as radiation, combustion, and oxidation. Fundamental to *fire* is oxygen, a core element associated with the principle of air involved in combustion. When there are aggregates of points as volumes in spacetime that cannot penetrate each other, like air, their agitation increases when further limited; pressure and activity rise, measured as increased temperature or heat. At certain temperatures, particles can be emitted in the form of kinetic energy, resulting in radiation, heat and luminance. Continuing the comparison with fundamental particle-forces, the mahabhuta of fire thus might relate to interactions of the gravitational, strong nuclear, and especially weak nuclear forces. As Greene (2004, p. 172) explains:

> "Gravity is a universally attractive force; hence, if you have a large enough mass of gas, every region of gas will pull on every other and this will cause the gas to fragment into clumps... Even though the clumps appear to be more ordered than the initially diffuse gas—in calculating entropy you need to tally up the contributions from *all* sources... For the initially diffuse gas cloud, you find that the entropy decrease through the formation of orderly clumps is more than compensated by the heat generated as the gas compresses, and, ultimately, by the enormous amount of heat and light released when nuclear processes begin to take place."

Water (Apas). Apas relates to the abstract principle of *liquidity* or *fluidity*. It has the freedom of flow or movement to fill the available space within the limitations of its permeability, but because of its lower kinetic energy and higher mass, only sort of 'downward' gravitational pull due to increased mass. The liquid state, such as water, has additional limitations over fire, air, and space. There is less internal motion, less heat, and additional restriction of flow rather than gaseous expansion. Again Greene (2004, p. 253) discusses relevant points with respect to symmetry:

> "On a molecular scale, for instance, ice has a crystalline form of H_2O molecules arranged in an ordered, hexagonal lattice... The overall pattern of the ice molecules is left unchanged only by certain special manipulations, such as rotations in units of 60 degrees about particular axes of the hexagonal arrangement. By contrast, when we heat ice, the crystalline arrangement melts into a jumbled, uniform clump of molecules—liquid water—that remains unchanged under rotations by any angle, about any axis. So, by heating ice and causing it to go through a solid-to-liquid phase transition, we have made it more symmetric... Similarly, if we heat liquid water and it turns into gaseous steam, the phase transition also results in an increase in symmetry. In a clump of water, the individual H20 molecules are, on average, packed together with the hydrogen side of one molecule next to the oxygen side of its neighbor. If you were to rotate one or another molecule in a clump it would noticeably disrupt the molecular pattern. But when the water boils and turns into steam, the molecules flit here and there freely; there is no longer any pattern to the orientations of the H20 molecule and hence, were you to rotate a molecule or group of molecules, the gas would look the same. Thus, just as the ice-to-water transition results in an increase in symmetry, the water-to-steam transition does so as well."

Liquidity embodies the concept of flow—movement of energy through or along a specific path, such as a current of water in a river or a current of electricity. With respect to fundamental particle-forces, this seems to be most closely associated with the electromagnetic force. The outer shell of charged atoms allows electrons to flow, such as current through a medium of copper wire, from negative to positive and positive to negative electrical charge. Electric current flows easily when electrons are loosely held. Mediums that hold electrons more tightly are insulators, in which the flow is restricted. In this comparison, the mahabhuta of water expresses properties of all four fundamental forces, but most specifically the electromagnetic force, with emphasis on electricity.

Historically electromagnetism was thought to involve the two forces of electricity and magnetism, before their underlying symmetry was recognized. This symmetry so intimately connects electricity and magnetism that they are not characterized as differentiating through symmetry breaking in the same way as the other forces associated with Higgs fields. However, physical objects can appear to exhibit electricity or magnetism, as well as both or neither.

Earth (Prthivi). From the root 'broad or extended,' the mahabhuta of prthivi relates to the abstract principle of *solidity* associated with earth, the most inert state. Matter associated with the principle of earth has no directional freedom, in the sense that it doesn't flow, so to speak. It involves various degrees of crystalline structures, with relatively rigid and fixed alignment of parts. It represents increased limitation over a liquid form—such as water into ice when the temperature and motion associated with heat or fire is reduced into a less dynamic state. The mahabhuta of earth is described as the endpoint of the process of manifestation. With respect to its correspondence with the fundamental physical forces, it would seem that the mahabhuta of earth would be most associated with magnetism—although tangibly expressing all the fundamental particle-forces, and all the other mahabhutas. Is there a basis to associate the mahabhuta of earth more with magnetism and the mahabhuta of water more with electricity?

An electric current flows across objects between charge sources. Attraction and repulsion between two charges occurs in a straight line between the two point sources of the charges. Electric currents generate magnetic fields. In contrast to the electric force, the magnetic force is a dipole system in which the opposites of attraction and repulsion—north and south poles—are contained in one source and travel in a defined circular path that curves back onto itself; the endpoint of the magnetic field is itself. The magnetic force most tangibly turns back on itself in a closed circular loop around an electric current—in a perpendicular direction to the current flow. This more contained quality of the magnetic force can be thought of as a further limitation compared to the more open flow of the electric force.

All matter exhibits magnetic properties in the presence of a magnetic field, and can be classified in terms of degrees to which it is attracted or repulsed by it, depending on the alignment of atoms. In some cases the attractive and repulsive forces cancel each other, resulting in net neutral magnetic properties. The association of the earth mahabhuta with magnetism doesn't mean that all materials made of earth are magnets—though they all interact to some degree with magnetic fields. It is that the abstract principle associated with mahabhuta of earth can be related to the underlying laws of nature that are expressed as magnetism a bit more closely than with the mahabhuta of water. The mahabhuta of earth expresses all the five mahabhutas; all the fundamental qualities are differentially functioning at this level of nature. In this delineation the magnetic force is based in the electric charge—which is consistent with the theory of electromagnetism. The electromagnetic force is expressed within the limitations of the other three forces (weak and strong nuclear, and gravitational).

The five spin states and five mahabhutas. The five states of internal spin also may correspond to the five fundamental constituents or principles of space, air, fire, water, and earth (Boyer, 2008). In physics, only elementary particles associated with the spin states of 1 and ½ have been experimentally confirmed; elementary particles associated with the spin states of 2, 3/2, and 0 have not yet been found in nature. (Evidence for spin 0 compound particles such as the pi meson has been found, but not the elementary spin 0 particles such as the spin 0 Higgs particle). Another way of saying this is that antiparticles and super-symmetric sparticles have not been found yet in nature. However, the model of five fundamental spin states is strongly supported by the mathematics of the theories that predict their presence in nature. Given that the five spin-states model does reflect the structure of nature, how might it match the five constituents of space, air, fire, water, and earth—which of course we do know exist in phenomenal nature? To speculate on this potential correspondence, we need more detail on the five spin states.

In the model of five spin states, spin 2 has the highest degree of freedom. Spin 2 values can be + or- 2, + or – 1, and 0, totaling five different possibilities. Spin 3/2 has four (+ or – 3/2, + or – ½); spin 1 has three (+ or – 1, 0); spin ½ has two (+ or – ½); and spin 0 has only one possibility. Thus there a nine possibilities in the five spin states (+2, -2, + 3/2, -3/2, +1, -1, +1/2, -1/2, 0) made up of three distinctions of fundamental properties that mathematical point particles in conceptual space seem to exhibit. The most fundamental distinction is between the particle families of bosons and fermions—integer versus half-integer spin (Integer spins 2, 1, and 0 particles are bosons; and half-integer spins 3/2 and ½ particles are fermions). Also there is the distinction of the value of the spin (2 or 1, and 3/2 or ½), and the distinction of the opposite signs of plus and minus which relate to opposite directions of spin in mathematical space. Adding to these three binary classifications the no-spin state (spin 0) makes for the nine possible spin states. Of the particles that have been found in nature, however, there are five.

The five types of internal spin also relate to three different types of rotational symmetry or invariance, as well as different types of mathematical fields. Rotational invariance in mathematical space concerns the transformations necessary to reestablish the same appearance. Different types of mathematically defined fields have to do with a directional component of the point particle field. The reference used here is four-dimensional space—three spatial and one time dimension.

Spin 2, associated with gravitation, relates to a *tensor* field (rank 2) in which there is magnitude and direction in all three spatial axes (plus time) associated with every point in the field. For this spin state, rotational invariance means that a 180-degree spin results in a return to the same appearance or original state. Spin 3/2, associated with connecting gravitation to the other forces, relates to a *pseudo-tensor field*. It is a tensor field (rank 2) but with a change in orientation about the axis of rotation to the opposite sign. In this case, a 180-degree rotation results in change in orientation or the opposite sign of the axis of rotation. Thus rotational invariance involves a 360-degree spin in order to return to the original state. These tensor fields might correspond to properties of the mahabhutas of space and air.

Spin 1, associated with electromagnetism, relates to a *vector* field (rank 1 tensor) in which there is magnitude and a particular direction in one axis—a directional force field. For this spin state, a 360-degree spin also results in a return to rotational invariance of the original state. Spin ½, associated with matter fields, relates to a *pseudo-vector* field involving a vector with opposite sign. For this spin state, when the directionality of the field is rotated 360 degrees, there is a change to opposite sign, so a 720-degree rotation is needed to return to the original state for rotational invariance. Spin 0, associated with the Higgs field and particle mass, relates to a *scalar* field (rank 0 tensor) which has only magnitude and no directional meaning—no internal spin.

In this delineation the mahabhutas of space and air may correspond to tensor fields. The mahabhuta of fire, and to some degree the mahabhuta of water, may correspond to vector fields. The mahabhuta of earth may correspond to a scalar field—the most inert, least dynamic level of nature characterized by magnitude but no inherent directional component.

However, there is an important difference with respect to the underlying basis of the four fundamental particle-forces (presumably the unified field) and the underlying basis of the mahabhutas. The underlying basis of the mahabhutas is the subtle level of nature. As discussed earlier, Sankhya (as well as ancient Vedic science generally) identifies three fundamental levels—which can be interpreted as the gross relative, the subtle relative, and the unified field. Recognizing these three levels of nature—and especially the intermediate subtle relative level now emerging in cutting edge quantum gravity theories—provides the needed bridge to account for many unresolved paradoxes in the reductive physicalist paradigm.

The precise matching of fundamental particle-forces and spin states in modern physics with the three fundamental forces and five constituents in ancient Vedic science has yet to be established. But even at this point the possible correspondences encourage additional research. Hopefully this research will lead to more integrated models of particles and forces, toward holistic appreciation of the natural world and our place in it.

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