THE WAVES OF SPACE:

A NEW MODEL OF THE UNIVERSE, WITH SPACE AS ITS FUNDAMENTAL SUBSTANCE, WAVES NOT PARTICLES, AND NEW CONCEPTS OF GRAVITY, UNIVERSE EXPANSION, DARK ENERGY, MASS, FIELDS, AND MORE

Ronald P. Hattis

ABSTRACT: An innovative new "Waves of Space" model is presented, providing more unified and inter-related explanations of phenomena in physics. It might help to bridge gaps between general relativity and quantum mechanics, and to resolve other mysteries. Space, composed of uniform quantized units ("volons"), is proposed as the fundamental substance of the universe, and the medium of waves and fields. That agrees with super-substantivalist philosophy, and provides physical mechanisms that help make that concept feasible. Included are intuitive new conceptions of gravitation (deletion of space units, bringing bodies together, with gravitational potential energy absorbed into spatial pressure), and of the Hubble expansion (accelerating addition of space units, pushing bodies apart). Universe expansion and contraction phases might alternate, a "Big Bang" alternative. Waves and other processes in space produce properties of matter and most energy. "Standard model" particles are actually waves in the medium of space. Most are unsustainable and inconsequential transitional waves. Time is a relationship to repetitive motions in space. Four-dimensional spacetime is geometrically optional and complicates calculations. Space deletion in moving bodies generates the Lorentz transformations. Thermodynamics' second law is a probability phenomenon, not universal. "Singularities," dimensionless points, and infinity lack physical reality. Mass can survive matter shrinkage or disintegration. Supporting this model, space has known physical properties and is expanding; particles have wave forms. This alternative to current theories offers causal mechanisms where currently only equations exist. New plausible hypotheses from outsiders have been resisted, but may be needed for physics, and associated philosophy, to progress.

KEYWORDS: Physics; Space; Waves; Waves of Space; Gravity; Mass; Dark Matter; Hubble Expansion; Big Bang; Lorenz Transformation

1. INTRODUCTION

An innovative new model presented here may help make sense of many inadequately explained physical phenomena. The reader is invited to join an adventurous exploration of a universe in which space, once thought of as a void, is actually the fundamental substance of the universe (as suggested by super-substantivalist philosophy). In such a universe, waves within that substance rather than particles could constitute matter and most energy. Gravity, space expansion, "dark energy" and "dark matter" would receive new interpretations. Extrapolations demonstrate the model's ability to define time and motion, to show impacts on geometry, mechanics, and thermodynamics, to consider an alternative to the "Big Bang," and to explain some findings of other models and theories, such as relativity and quantum mechanics, but by different mechanisms.

This alternative model is proposed in hopes of explaining both observations that do not fit current theories and models, and older data that were considered as evidence for them. Mechanisms, structures, and inter-relations that are lacking in current theories are prioritized over mathematical abstractions. This is an alternative way of viewing the physical world, with certain advantages that will become apparent. It should not be rejected or bypassed simply because it is different, because that is its intent. Readers may enjoy the ride.

Four quotations provide a suitable send-off for this project:

Niccolo Machiavelli (1513) in his famous book, *The Prince*:

> *"It ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new. This coolness arises partly from fear of the opponents, who have the laws on their side, and partly from the incredulity of men, who do not readily believe in new things until they have had a long experience of them."*

Isaac Newton, in a famous (and unanswered) letter to antagonist Robert Hooke (Popova 2016):

> "*If I have seen further it is by standing on the shoulders of giants*."

Richard Feynman in his Nobel Prize lecture (Feynman 1965):

> *"…I, therefore, think that a good theoretical physicist today might find it useful to have a wide range of physical viewpoints and mathematical expressions of the same theory (for example, of quantum electrodynamics) available to him. …possibly the chance is high that the truth lies in the fashionable direction. But, on the off-chance that it is in another direction…who will find it? Only someone who has sacrificed himself by teaching himself…from a peculiar and unusual point of view; one that he may have to invent for himself…"*

Art Hobson, in his book "*Tales of the Quantum*" (Hobson 2017):

> *"Science, because it accepts only evidence and reason, goes frequently against the conventional grain. Science does not accept authority as sufficient reason for reaching conclusions. So beware: Science can be dangerous to your beliefs."*

Those quotations inspire the following perspectives: That a new proposal, if it achieves attention at all, will likely be strongly opposed at first; that the developer will be deeply indebted to many past and present leaders in physics and astronomy, for what may seem at first to be a radical departure is often just a small step further than they have already reached; that creative thinking, openness to multiple possibilities, persistence, and courage will be required of both the developers of new proposals and those who will dare to test, apply, or support them; and that authority and conventional or personal beliefs should not restrict either the developers of new scientific proposals or those who come across them. In consideration of the above, this article is dedicated to all creative and open-minded theoretical physicists, cosmologists, and philosophers of science, plus their students who are the future.

1.1 The Pathways of Thinking that Generated the "Waves of Space" Model

The genesis for the ideas presented in this article was the author's realization over three decades ago that if distant galaxies are receding in all directions at rates proportional to their distances (the Hubble effect), the most reasonable explanation is that more space is being added during every unit of time to every amount of existing space. The addition of space between any bodies in the universe makes them more distant from one another. Each volume of space, and the next and next more distant after that, grow similarly with the addition of new space, and carry the objects within them still farther away from each other per unit of time. That is why the speed of distancing due to the added space (the velocity of recession) is in proportion to how far they already are away from each other.

If the expansion is due to more space being added, then space must be "something," some sort of substance and not a void. In order for tiny amounts of space to be added to each measure of existing space, and for the Hubble expansion to be roughly homogeneous throughout the universe, the substance must be made up of very small units, most likely uniform and three-dimensional.

If the expansion process occurs in proportion to existing space, yet increases that very existing space, the expansion of the universe should be accelerating ("dark energy"). There could be additional mechanisms for acceleration, and counter-mechanisms of deceleration to limit the acceleration to the actual observed values.

If it is possible to add space, it should conversely be possible to delete it. Space deletion between bodies could move them toward one another, producing the effects of gravity. The strength of gravity is proportional to mass, and all matter has mass. Mass might therefore be the property of matter that enables space deletion and thereby brings other matter closer. Since gravity and space expansion tend to oppose one another, it might seem fitting if one functioned by adding space and the other by deleting it.

But added space should require a source (a possibility that has been overlooked in most discussions of the expansion until now), and deleted space should need somewhere to go. When new space appears, it might theoretically be coming from a set of unseen dimensions. When space is deleted, it might be transferred to those same extra dimensions. The ability of space to be added and deleted, especially if it does this by transferring back and forth to alternate dimensions, could be considered to support the possibility of an alternative to a one-time "Big Bang." In this hypothesis, there could be alternating expansion and contraction phases.

If matter properties can be attributed to waves, particles might not be necessary at all. The only substance needed for all functions in the universe could be space, made of just one type of unit. This would seem to be the "holy grail" of simplicity, vs. the multitude of subatomic particles of the "standard model."

Space could be a medium for waves if its units oscillate between positions. Deletion of space within objects at high velocities could cause shortening, deletion within clocks could slow time, and deletion of space being traversed could enhance inertia and resist further acceleration. If space deletion is responsible for both gravity and inertia, it is reasonable to suppose a close relationship between them.

Based on the above and similar thinking, and on pre-existing science and philosophy, a new model for the universe is introduced in this article. It will be discussed in detail and explained below, topic by topic. It is lengthy because it attempts to explain each aspect of the model. In its entirety, it creates a new paradigm for understanding reality. All parts of the model are inter-related, leading to a certain amount of inevitable redundancy, and the usefulness of cross-referencing. ***Many of the key statements, starting with this paragraph, will be in bold italics for prominent display.***

The basic thesis or "Fundamental Principle" of the model, drawn from the above reasoning, is that many of the unsolved mysteries of science could be unraveled by conceiving of space as the fundamental substance of which the universe is made, as well as the medium of electromagnetic waves, gravity, and fields. It should be a substance, made up of discrete, universal units, which can however be added and deleted and can behave consistently with quantum mechanics. Matter and most energy would be made up of waves and other processes occurring in this space. ***The proposed waves would be truly "of space," both constructed of oscillating units of space and able to travel through space.***

Much of what is proposed below flows logically, directly or indirectly, from that "Fundamental Principle." There are some commonalities with currently accepted physics theory, including among other things that space has physical properties, that it is expanding, that particles are already considered to have wave equivalents, and that familiar waves (such as mechanical ones, see 7.4) have media to transmit them. Therefore, the model should not be rejected out of hand by physicists.

On the other hand, there will be novel concepts, mostly new ways of thinking about familiar phenomena. Among other things, new conceptions of space and its expansion, gravity, and motion are included. The concepts of particles and of four-dimensional spacetime are suggested to produce unnecessary complexity.

The model supports an alternative to the "Big Bang" theory that is somewhat different from previous proposals. The predictions of special and general relativity are suggested to result from different mechanisms. Such ideas in the model are not as radical as they may seem at first; as they flow logically from existing theories and data and borrow from the work of other scientists and philosophers. They are offered in a spirit of humility, with a realization that they contradict elements of some major current theories that have been developed by prominent physicists and accepted by numerous others over a considerable period. The model is proposed as a contribution to the philosophy of science, specifically of physics, space, and time, and to theoretical physics and cosmology. An attempt has been made to incorporate the history and evolution of past and present theories. ***The net result is a conception of many, though not all, aspects of physics and of the universe, that should arguably be simpler, more integrated, and more elegant*** (see 5.1) ***than suggested by current theories.***

1.2 Limitations of Standard Physics Theories

Why should anyone develop a new model for the universe? Physics and cosmology (the latter considered over time as part of physics, astronomy, metaphysics, or philosophy) face unresolved mysteries. There are no consensus theories about a number of issues, including the following among others:

A complete and generally accepted "grand unified theory" theory uniting general relativity (which is not quantized) with quantum theory, and gravity with the other forces (Krauss 2017; Sanchez 2019).

A reconciliation of the expansion of the universe with the standard forces in physics, and a convincing explanation for "dark energy," thought by some as "the greatest mystery in the universe" (Panek 2010).

- A verified explanation for "dark matter," thought to be a main component of the universe and much more common than regular matter, but still not understood (Fore 2020; Horvath 2023).
- Theories for the origin of the universe and for black holes that do not rely on imaginary constructs like "singularities" and "inflation," which are inconsistent with the rest of science.
- Causes and actual explanations for many of the physical processes that are expressed in so-called "laws" of physics. In most cases, those "laws" are

merely or predominantly mathematical relationships expressed in equations, without adequate reasons or physical mechanisms. Aristotle taught that "The highest science is that which gives both the fact and the cause," and that science that gives only the fact is at a lower level (Bouchier 1901). In that respect, this model may be said to strive for a higher science than physics orthodoxy currently accepts.

These gaps suggest that there is a current need for new and more flexible thinking about the nature of the universe, and this model is an attempt to address some of that need. The proposed model has a sound scientific basis, and even if only a few of its many innovations proposals prove to be useful or to stimulate fresh thinking, it should be a significant contribution to theoretical physics and to the philosophy of science.

1.3 What is "Real"? Overcoming Errors of Reification and Denialism

In interpreting the world around them, humans are prone to two types of errors, reification and denialism. Reification is the assumption that something abstract is a physical substance, and denialism is the assumption that something does not exist as an entity, regardless of evidence to the contrary.

In some cases, unnecessary phantom entities have been created to explain observed properties. The understanding of heat, for example, went through an evolution in the 17^{th} and 18^{th} centuries through several fallacious reifications as concrete entities (see 10.2).

Similarly, in particle physics, when a resonance has been found at a particular combinations of mass, charge, and spin, and energy level, a particle has been hypothesized by reification, and has been named and added to the "standard model." On the other hand, the physical existence of space has traditionally been denied or underemphasized.

The best way to avoid both types of errors is to carefully consider the properties of the physical world, and their simplest adequate explanations, as has been attempted in the development of this model. As examples, it sees particles as a reification, and attempts to offer a pathway to do without them. It also attempts to correct the denial of space as a substance.

1.4 Unity, Composition, Simplicity, and Effectiveness

Physics includes multiple complex concepts, but the human mind longs for unity, which is relevant to mention in this introduction. A "grand unified theory" of the four recognized forces of physical science including gravity has been a dream in physics for at least 50 years (Krauss 2017, Georgi 1989). Three of the four forces are at least somewhat compatible with quantum theory. However, no satisfactory theory of "quantum gravity" has yet been developed, that is considered complete or has been generally accepted (Rovelli 2008; Fernandez 2024). Those issues may leave an opening for the present model, and for other new ideas to come in the future.

Humans have also always been curious about the composition of the universe, what everything is made of, and philosophers since at least ancient Greek civilization have theorized about fundamental substances (Stanford Encyclopedia of Philosophy 2016). It would be philosophically satisfying to unify the substances of which the universe was constructed. Particle physicists may be well pleased by the "standard model" that will be discussed (see 7.3), but to some outsiders, it may seem like a chaotic and not very satisfying system, because there are so many different particles, and so many of them are unstable. The model proposed here proposes a single substance as the basic building block for the universe.

Another thing that the human mind craves is simplicity. Members of the lay public with an interest in science would appreciate a new model comprehensible to them. The math of a new theory should add up, but if possible it should also be simple enough to be understandable without years of specialized training. The model proposed here may involve simpler mathematics, because complex metric tensors in curvilinear four-dimensional spacetime may be unnecessary. Unifying what the world is made of to one substance is also simpler than having dozens of different particles. Fewer unexplained concepts will need to be accepted by faith (a common feature of physics and religion).

Consistent with the aim of simplicity, this article contains a minimum of jargon, undefined acronyms, and math compared to most physics articles. For convenient access, most of the references selected are posted on the Internet.

Yet another thing that the human mind craves is ideas that work. They should be adequate and effective. There are criteria for "effective theories" (Wells 2016). Readers of this article are encouraged to make their own assessment of the extent to which the objectives above of unity, fundamental composition, simplicity, and effectiveness have been met.

1.5 What this Model Will and Will Not Do, and the Requirements of Science

The model will not negate well-established experimental evidence, but will propose alternative explanations, interpretations, and implications for some existing data. It lacks new experimental data, but hopefully will inspire experimental research to test its new predictions, which will admittedly be technologically challenging. It offers only limited new mathematics, but more can be developed to fit the model. It covers many aspects of physics, but the strong and weak nuclear forces and some aspects of electromagnetism are not explained. ***Its greatest value may to create a new alternative theoretical framework, in which more of the components of the physical world would explain and cause each other than in current theories.***

The question arises of whether hypotheses as proposed in this model are scientific, as the traditional scientific method requires experimental verification of hypotheses before they can be considered as theories. However, theoretical physics has produced unverified (and possibly unverifiable) concepts that are taken seriously, such as string theory. Physicists debate the value of theories without new experimental data (Walker 2015), but explanations for experiments already done are also valuable. ***There is scientific merit in hypotheses associated with a model that can explain recent experimental findings inconsistent with older theories, as well as findings that were considered as confirmations of those theories, and/or can propose previously lacking mechanisms to explain confirmed mathematical relationships.***

The goal is not to find ultimate truth. As recognized by James Wells (2016), "*all theories are incomplete*," and in today's environment "*no competent scientist should retain an unfailing commitment to any theory*," but rigorous thinking about existing theories *"can lead to the thought processes that generate significantly better theories."* Whether a true and complete understanding of the natural world is theoretically achievable by humans is subject to considerable doubt, and is left to philosophers and psychologists as a continuing question of ontology (the study of being) and epistemology (the study of knowledge)

1.6 Some Unfamiliar Definitions

The proposed model seeks to redefine and refine some scientific terminology. Clear definitions can enhance the understanding by scientists of how certain entities and processes operate in the natural world. Space, energy, and time are defined and discussed in detail in the text (see 2.1, 4.3, and 9.1). Here are the innovative meanings of a few other key terms as used in the model and in this article. They are listed alphabetically, and will be further explained as the discussion continues:

Field: ***A region of space passively conducting and propagating waves, additions or deletions, or other processes.*** Gravitational fields ultimately extend throughout the universe, and Qin argued (2002) that they could not logically impart or store positive or negative energy density, charge, momentum, or inertia, since an incredible amount of these would be needed with no identifiable sources or sites of disposal. Instead, any area of space in which each location acquires a value (as a field is traditionally defined) may obtain it transiently from the wave or process being transmitted. This concept is not consistent with current theories on electromagnetic fields.

Mass: ***A property possessed by matter waves that deletes units of space, and thereby produces the features of gravitation and inertia.*** This term is often used synonymously with matter, but on deeper analysis, its nature has been mysterious, confusing, and difficult to define precisely since at least the time of Newton (Roche 2004). In most physics equations, it relates to two specific features of matter, gravitation and inertia, and not to other properties such as charge or spin. Gravitation and inertia are proposed to be caused by space deletion (see 5.1 and 6.3), and the quantity of mass and distance from it determine the rate of that deletion. Since in this model, matter consists of waves, ***the term mass will be presumed to be a wave property or component of matter (which is itself made up of spatial units organized into waves), that deletes space (other spatial units whether or not organized into waves).*** According to special relativity, $mass = energy/c^2$. Using a water analogy, just as a drain removes water from a tank or tub, mass drains space from our dimensions and facilitates its transfer to alternate dimensions. However, mass may also be able to exist after destruction of its associated matter, e.g., if matter waves break down due to excessive deletion of their units of space. That might occur at the event horizon of a black hole (see 9.5), and in "dark matter" (see 5.4). ***Thus, all***

matter has mass, but not all mass may have matter.

Matter: ***Standing wave complexes that are constituted of units of space and that may move through space, which possess the property of mass along with others*** (e.g., charge, spin, "color"). They are composites of less complex waves joined together in discrete quantities that are commonly but misleadingly referred to as particles (e.g., electrons, protons, and neutrons, or and up and down quarks). Waves on a macroscopic scale have measurable wave lengths and amplitudes; others on an atomic scale have quantum properties. Material means relating to matter.

Space: ***The fundamental substance of the universe, made up of uniform units that in this model are named "volons."*** Space also serves as the medium for electromagnetic and gravitational waves. Units of space may be added or deleted. Where there is motion, space is traversed by matter or energy, which are thought to also be made up of space units.

Time: ***A ratio of the occurrences of specified events in space, to the number of repetitions (or fraction of a repetition) of a selected repeating motion in space.*** Time can therefore be considered as a function of space, and not necessarily a separate dimension. The repeating motion has historically been a regular astronomical phenomenon such as the rotation or revolution of the earth or moon, but more recently oscillations within atoms have been used as well. In common experience, this measurement only goes in one direction. It can optionally be thought of as a dimension.

Wave: ***An oscillating disturbance, usually but not necessarily regular and repeating, of space between two locations or values, lacking duality with so-called particles.*** This is similar to standard definitions (Kaylegian-Starkey & Howard 2023), but includes unique provisions of the current model, specifically that what have been commonly called particles of matter are actually waves in space. Mechanical waves require a material medium in addition to space; electromagnetic waves and gravitational fields require only space as a medium. In some waves proposed by this model, there may not be a neutral baseline between fluctuating positions (see 5.3). Orthodox definitions apply to several features: In traveling waves, the disturbance is transmitted through the material medium or across space. If the oscillation is in the direction of the transmission, the wave is longitudinal; if perpendicular to it, the wave is transverse. Standing or stationary waves are produced by two superimposed waves of the same frequency (which is the inverse of the wave length), speed, and amplitude, moving in opposite directions, and are not propagated across space (Vitz et al. 2024). In this model, however, matter is made of standing waves, and it may be moved through space by separate energy waves. A vibration is a regular and repeating oscillation that does not meet the criteria for either a traveling or a standing wave.

SPACE, THE FUNDAMENTAL SUBSTANCE

In Section 1, the logical train of thought leading to this model was laid out. This was followed by a wide-ranging discussion, from the gaps in current physics theories to the quest of humanity to understand the world. Some proposed new definitions that will be used in this model were presented. Now, we shall move on, and consider what space is, including its properties as a substance and the arguments for it in fact being the only substance, its units and dimensions, and fallacies in its measurement. The earlier ether theory will be included for historical perspective.

2.1 Space as a Substance, Super-Substantivalism, and Physics vs. Philosophy

One common philosophical conception of space, dating to antiquity, was that it consisted of nothingness. Leucippus, Democritus and Lucretius wrote that the world was constructed out of "atoms and the void," and the void was a truly empty place. This concept persisted in Epicurean philosophy during the Greek and Roman periods (Stanford Encyclopedia of Philosophy 2016). However, not all classical philosophers thought that space was devoid of properties. Plato, in his work Timaeus, described physical bodies (matter) as a part of space limited by geometric surfaces, which themselves contained nothing but space (Jammer, 1954).

The early Greek atomists provided an ontological service by introducing the idea that the universe was composed of tiny units. However, their conceptions of "atoms and the void" have turned out to be inaccurate on both counts, and those errors unfortunately may have helped shape human thinking for more than two millennia, extending to the present. Atoms were thought to be tiny solid chunks in different shapes, representing different types of materials, and after all the centuries later, the Western lay public still has an inherited (and admittedly intuitive though inaccurate) concept of particles as being somewhat solid. The idea of space as a void has also had lasting negative impacts through the present day. A void or a vacuum, which refers to space without matter, also implies emptiness, neglecting the fact that it is filled by space itself. Those conceptions can subconsciously influence the thinking of students and some scientists. This model, and similar proposals from a number of other theorists cited in this article, strive to overcome these conceptual barriers.

Centuries after ancient Greek civilization, philosophers debated about whether space was a substance of some kind. This could not be settled by experiment, and seems to have been a purely philosophical dispute. Dennis Lehmkuhl (2015) described the two dominant positions in that debate as follows: *"Either spacetime is fundamental, i.e. a substance in its own right (substantivalism), or only material bodies are fundamental, and space and time are just abstractions of, or derive from, the relationships between material bodies (relationalism)."*

Newton supported a nuanced version of the substantivalist position, calling "absolute space" a real physical entity (Greene 2004), but not really material, part of the physical, not mental, realm. Gottfried Leibniz supported the relationalist position, and their arguments became famous (Lehmkuhl 2015; Wells 2016). These two geniuses, who were physicists, mathematicians who dually invented calculus, and philosophers, debated about this as they did about many other scientific and theological matters (Huggett & Hoefer 2021).

René Descartes suggested that vortices in ether actually created matter (Marder 1971; Pilkington 2004). Albert Michelson also hypothesized about ether vortices (Goodman, 1994). That idea has similarities to the current model, if space is substituted for ether.

The debate about space continues today. Tim Maudlin (1993) did a historical and philosophical review and concluded that substantivalist arguments were stronger. Peter Jackson (2012) argued strongly against the persistent idea that space is nothing, suggesting instead that it is a "diffuse dielectric medium" of intergalactic extent, which he thought should be helpful in unifying relativity with quantum systems. In "*The Substance of Spacetime,*" Andrew Ryan complained (2016) that "*relativity treats spacetime as a mathematical abstraction…not a "thing" in any tangible sense...it merely serves as the background needed to describe the behaviors of the "real" things that exist within it,*" and he argued for its being a substance.

But substantivalism and relationalism are not the only possible views about the nature of matter and space. There is a third school of thought, which has historical origins in the philosophical works of Plato, Descartes, and Spinoza, but was set aside and little discussed until the last 50 years. Lawrence Sklar (1974) is credited with originating the term super-substantivalism. As summarized by Lehmkuhl (2015): *"Substantivalists claim that there are two kinds of fundamental substances in the world: spacetime and matter. Relationalists claim that there is only one kind of fundamental substance: matter. Super-substantivalists agree that there is only one (kind of) fundamental substance in the world. But, they hasten to add, this fundamental substance is not matter but spacetime. According to the super-substantivalist, everything in the world is spacetime."*

Super-substantivalism in turn has been described (Duerr & Calosi 2021) as being divided into three views. The differences are subtle:

In the "Identity View," material objects are identical to spacetime regions.

In the "Constitution View," material objects are constituted by spacetime regions.

In the "Priority View," material objects derive from spacetime regions.

The current model offers a fourth view, also subtly different. ***Material objects are constituted of waves and other processes taking place in space (see 2.3), and they are defined by those processes rather than simply by the space they occupy. Spacetime is an optional and complicating concept.*** The waves and other processes can also move through regions of space.

Jonathan Schaffer (2009) claimed that most philosophers today are substantivalists, and distinguished between dualistic substantivalism (material objects being one substance and regions of spacetime being another), vs. monistic substantivalism (a synonym for super -substantivalism), in which spacetime is "*the one substance*." He supported the latter, and concurred that it comprises several schools of thought. His conception was that regions of spacetime define material objects (similar to the "Identity View"), and he claimed that Descartes had held a similar view.

Henry Lindner, a physician and philosopher, described space as "*a gravitoinertial-electromagnetic quantum fluid,"* and said that it "*…unifies all physical phenomena, as due to various motions or distortions in and of a single substance."* He also quoted Nobel physics prize winner Frank Wilczek as writing in 2008 that space is "*the primary ingredient of physical reality, from which all else is formed*."

The present author (until 2022) and some of the other innovative thinkers cited in this article were unaware of the philosophical school of super-substantivalism. They came upon their similar views independently.

Super-substantivalist literature to date has had some limitations. There has been relatively little effort to explain how space, or regions of spacetime, can fulfill the various properties of matter. A structural model capable of that explanation has apparently been lacking, at least since ether fell out of favor, and there has not been as much extrapolation to various areas of physics as has been attempted in the present model. An exception (Duerr & Calosi 2021) was a mathematical argument that general relativity is consistent with super-substantivalism.

Philosophy literature generally contains relatively little math but a lot of theorizing and references to the thoughts of prior philosophers, while most physics literature generally contains little new theorizing (mostly applying and testing existing theories), and is crammed with calculus equations. The two also frequently use different vocabularies. The gap has been difficult to bridge, even though some philosophers of science address issues highly relevant to physics, and a small percentage of physicists dare to propose important new theories that imply a philosophy. The latter are generally difficult to publish, and usually receive considerable pushback from the physics community.

Some specialists on each side have had negative things to say about the other. The physics Nobel Prize winner Steven Weinberg wrote a chapter entitled "Against Philosophy" (1992). He said that we should not expect philosophy *"to provide today's scientists with any useful guidance about how to go about their work or about what they are likely to find,"* and that *"…a knowledge of philosophy does not seem to be of use to physicists…"*

On the other side, modern physics theory has been lambasted on philosophical grounds, as being mathematical but not relating to actual cosmic entities (Lindner 2015). Current *"theoretical models and fundamental views"* have been criticized as "*extremely contradictory,"* and *"a lot of other fundamental contradictions do not have any solutions in theories"* (Pastushenko 2019). A rare philosophically-oriented critique by a physicist declared that the foundations of physics are "*profoundly and disturbingly flawed*" (Cahill 2017).

The present model, which attempts to make connections between the fringes of the two specialties, may not satisfy either side. That is unfortunate, because a physical theory is more comprehensible if it has a philosophy, or at least a geometrical representation that can be pictured and imagined. Scientific findings can generate a philosophical explanation. Conversely, a philosophical idea can inspire scientific research. Physics and philosophy are thus interdependent (Sklar 1974). As already noted, early physicists like Descartes, Newton, and Leibniz were also philosophers (Huggett & Hoefer 2021). Optimally, the two intellectual approaches can alternate, so that science and philosophy can nudge each other forward, much as theoretical physics does with experimental physics and with mathematics (Strogatz & Tong 2022).

2.2..The Properties of Space, including the Speed of Light

In support of space being a substance, it has a number of physical properties of its own, which strongly suggest that space is a substance and an integral and essential component of the universe.. Its expansion implies that it is "something" that can be increased, a consideration that inspired this entire inquiry (see 1.1). It conducts electromagnetic waves and gravitation, and their fields and quantum wave functions exist within space. The electromagnetic field can be considered as a property of space (Hobson 2017). Space also allows matter to exist within it and to travel through it. Dimensions and geometry of course relate to space. Space has permittivity and permeability. Permittivity ( ) measures the resistance offered by the material in the formation of an electric field, while permeability (μ) measures the ability of the material to allow magnetic force to pass through it or to develop a magnetic field.

One of the most definitive properties of space as a substance is a uniform velocity of transmission, in space with a negligible amount of matter (only occasional hydrogen molecules, there being no space totally empty of matter), for electromagnetic radiation and presumably for gravitational effects. We refer to this as the speed of light, and in equations as c. This speed is rather mysterious, because while light in space travels at exactly that rate, recessional velocity of very distant objects resulting from space expansion can exceed it, while mechanical motion cannot reach it. The product of permittivity and permeability equals c^2, so they are related to each other and to the speed of light in space (Yadav 2023). Light travels more slowly in any other material (gases, liquids, or solids) or may be reflected or absorbed, and its rate in matter may represent a combination of the rate-limiting effects of both the material and space.

The present model proposes **that** ***the universe is not surrounded by space, because space is what is inside and not outside of it.*** Today's experimental physics cannot receive any information from beyond the universe we know. Therefore, hypotheses about other universes that might be part of a "multiverse" cannot be experimentally tested or verified (Hooper 2014; Fernandez 2020).

2.3 Units of Space, and Comparison with String Theory

All known macroscopic substances are built out of subunits. This is consistent with the thinking of the Greek atomists, (see 2.1) except that they did not suggest that space was one of the divisible entities, since it was nothing but a void. Indian Upanishads (dates uncertain) recognized that perceptible objects are composed of parts (Berryman 2022). Space, too, is proposed in this model to be made up of units.

The distribution of galaxies is similar in all directions (Guth 2018), indicating that they are homogeneous and suggesting that they may also be isotropic (see 3.3). If this expansion is due to space units being added to existing amounts of space, however small, and if the effects of added space are similar in all directions, then space can be hypothesized to exist in extremely small units of uniform size. If units of space are the building blocks of everything, there cannot be anything smaller, because a whole entity cannot be smaller than one of its constituent parts. The units must also be so small that they can be inserted into the shortest light wave lengths, in the gamma spectrum.

Space is therefore hypothesized to be made up of extremely small, uniform units, unchanging in size over space and time. A new term, "volon," is proposed for the fundamental unit of space or volume, in the naming style of electron, proton, etc. [1]

Physics is said to break down at measurements smaller than a Planck length (approximately $1.616255*10^{-35}$ meter), for a number of reasons including practical

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[1] No association is intended with any past or present commercial or other unrelated use of the term "volon" (e.g., https://www.masarishop.com/brands/the-volon.html), or to Rousseau's term "volonté" to refer to the general will.

immeasurability (Gilliland 2024) and quantum uncertainty. It is appealing to conceptually associate the size of the theoretical fundamental component of the universe with a cubic Planck length, because that would assure that it could not be made up of subunits. Edwin Cartlidge noted that "*most attempts to devise a theory of quantum gravity require space–time to come in discrete grains at the smallest (Planck-length) scales.*"

"Volons" are unlikely to have complex internal structure, because that would imply having separable parts, which would be ruled out if they are the smallest, most basic components of space and of the universe. However, they are not just units of volume, in this model, they are subdivisions of a space substance that has properties (see 2.2), and are also components of matter and energy, so they should have the capabilities to perform those roles.

Individual "volons" should be able to oscillate, rotate, and spin, to be added and deleted, and to also move past and displace other "volons." "Volons" should also be able to work in groups. Such group action by "volons" will be termed "volon mechanics" (see 5.3). This can include the generation of waves, which are central to this model. It should also permit more complex properties and functions such as charge and space deletion, which together with the capabilities of individual "volons" constitute the other processes in space (processes among "volons") referred to throughout this article.

The "volon" concept is a partial parallel to string theory. In that theory or group of related theories, all of matter is made up of one-dimensional strings on the order of one Planck length long, and the properties of particles are produced by different vibration patterns within the strings (Greene 2004), though mechanisms for that to create matter do not seem to be clear. One of the vibration patterns in strings supposedly could produce "gravitons," the theoretical particles of gravitational waves, but those have not been found. Vibrations in the current model, might in contrast involve oscillations of groups rather than individual "volons."

In string theories, one-dimensional "open" strings would supposedly be attached to another substance, the membrane-like "branes," on which they could travel. Strings in which both ends attach to each other are called "closed" strings, which should require at least two dimensions if lying on a plane surface. Strings are not proposed as the material of spacetime, which requires 11 dimensions in

"M-theory," the leading version of string theory (Greene 2004). Since they would be one-dimensional, they apparently could not constitute three-dimensional space, or be the sole component of the universe. "Volons," in contrast, would not be anchored on any other substance, although some would participate in waves and "shells" with variable structures.

"Volons" of space are also reminiscent of the loops of spacetime in loop quantum gravity theory (Rovelli 2008). That theory postulates quantized units of spacetime (though not simply of space) in "spin networks" of approximately Planck length size.

2.4 The Dimensions of It All

Most comprehensive modern theories of the universe require more than three dimensions (Melbeus & Ohlsson 2012). The Kaluza-Klein theory requires five. Current string theories depend on the existence of 10 (Superstring theory), or 11 (M-theory). An earlier version, bosonic string theory, required 26 dimensions (Greene 2004). Special and general relativity combine time with space, to make four dimensional spacetime (Einstein 1921).

The new model presented here includes the capacity for space to be deleted from or added to an existing manifold. If "volons" of three-dimensional space suddenly appear and disappear, the question naturally arises, where does this space go to or come from? ***A convenient way to imagine this is to suppose theoretically that there are three dimensions in our universe and an additional three dimensions, for a total of six, and that units of space can be transferred between them and our familiar three dimensions.*** A three-dimension "volon" deleted from one set of dimensions would likewise be three-dimensional in the other set, and the six dimensions would function as two sets, with space moving space back and forth between sets of three.

The hypothesis regarding three extra dimensions does not imply that they have separate time dimensions. The two sets of dimensions are proposed to share a common passage of time, though possibly subject to the relativity of simultaneity in special relativity (Einstein 1921). If time common to both sets of dimensions is considered optionally as a dimension, there would be seven dimensions. For those preferring to think in terms of four-dimensional spacetime which is not encouraged by this model (see 9.2), there would be four rather than three dimensions in each set, for a total of eight, but that would count two different time dimensions rather than one shared passage of time, raising the question about how the expansion of one set could be coordinated with the contraction of the other set. For the discussions in this article, three dimensions in each set and a total of six will be described, and time will be explained as a function of three-dimensional space rather than a true dimension or a component of spacetime (see 9.2). Differences of perspective regarding time as a dimension and spacetime need not interfere with following the other useful ideas presented here.

In the present proposed model, both sets of dimensions would always be present in every location, attached to and reaching out from our current location or from any other, just as our familiar dimensions do, but in additional and unseen directions. ***A suggested way of thinking about this is that every "volon" has six dimensions, only three of which are accessible to us.*** We cannot see them, because light (including the entire spectrum of electromagnetic radiation) as we know it is limited to transmission through the three dimensions that we know, and in addition, our brains are limited to three-dimensional visualization. Hypothetically, there could be a different equivalent of electromagnetic waves in the alternate dimensions. We cannot travel in the extra dimensions as intact material beings, and none of our senses can perceive anything occurring in the extra dimensions. However, we do perceive gravity, which may be the process of units of space ("volons") being transferred by mass from one set of dimensions to the other (see 5.1),

The six-dimension concept cannot be proven, but will be shown to be useful conceptually in explaining an expanding universe (see 3.2), the origin and future of the universe "dark energy" (see 4.1), and hypothetical explanations of some quantum phenomena (see 8.1).

2.5 The Ether Hypothesis, and Space as its Successor

Ether, an ancient Greek concept sometimes referred to as a fifth element, appears to have entered into physics theories in the 17th century (Marder 1971). Descartes is believed to be the first scientist to have introduced the concept of the ether as a mechanical medium (Meschni & Lehto 2025). From then until the late 19th century, the ether concept enjoyed remarkable durability, and most scientists seemed to support the idea. The "luminiferous ether" was conceived as a medium that filled space, and conducted light and presumably also gravity and electromagnetism. Newton, who declined to characterize ether in detail, nevertheless thought at first that it was a necessity as a medium between celestial bodies for gravity to exist (Meschni & Lehto 2005). However, he seems to have ultimately rejected it as a substance providing a physical connection between bodies interacting gravitationally, because he thought it would make the planets unstable (McMullin 2002).

The Michelson-Morley experiment of 1887, repeated and confirmed many times subsequently, showed that if there were an ether, it could not be a medium that could speed up or retard the speed of light, by means of its own motion relative to observers on earth. Henri Poincaré also tried to measure velocities with respect to an ether in 1899 and was unsuccessful (Meschni & Lehto 2005). Many scientists thereafter ceased to believe in an ether altogether (Ball 2004; Pilkington 2004), although references to it persisted into the early 20th century.

That seemed to leave just space itself, with no additional substance to take over the properties that had previously been assigned to the ether. Yet the reassignment of those properties to space itself as a substance is not commonly identified in a clear manner.

Descartes may have entertained the idea of space being the ether rather than ether being a separate substance filling space, because he sometimes used the terms ether and space synonymously (Pilkington 2004). In 1900, Paul Drude proposed that the physical properties of the electromagnetic field were actually those of space, not of an ether substance within it (Walter 2018).

Einstein eventually developed a similar approach. He had evolving views about the existence of an ether. His special relativity theory made no reference to such a substance and he was widely credited with having destroyed the concept of it. However, 15 years after introducing special relativity and five years after introducing general relativity, he delivered a lecture at the University of Leiden (Einstein, 1920) that included these selected remarks (translated; highlighting added):

> *"…The next position which it was possible to take up in face of this state of things appeared to be the following. The ether does not exist at all. The electromagnetic fields are not states of a medium, and are not bound down to any bearer, but they are*

> *independent realities which are not reducible to anything else, exactly like the atoms of ponderable matter…Certainly, from the standpoint of the special theory of relativity, the ether hypothesis appears at first to be an empty hypothesis… But on the other hand there is a weighty argument to be adduced in favour of the ether hypothesis.* ***To deny the ether is ultimately to assume that empty space has no physical qualities whatever…****Newton objectivizes space. Since he classes his absolute space together with "real" things, for him rotation relative to an absolute space is also something" real."* ***Newton might no less well have called his absolute space ether…****More careful reflection teaches us however, that the special theory of relativity does not compel us to deny ether. We may assume the existence of an ether; only we must give up ascribing a definite state of motion to it…We shall see later that this point of view…is justified by the results of the general theory of relativity…Recapitulating, we may say that according to the general theory of relativity* ***space is endowed with physical qualities; in this sense, therefore, there exists an ether****…"*

Einstein thus acknowledged by 1920 that Newton could have accepted absolute space as the ether medium, and he implied that he could as well. Gene Goodman (1993) also identified space as an ether substance. ***If space and ether are equivalent, the "Waves of Space" model could be considered as a revival of a type ether theory, but with differences. For example, ether theorists did not believe that everything was made of ether.***

2.6 Questioning the Reality of Dimensionless Points, "Singularities," and Infinity

Euclid's geometry is about 2,400 years old, and historically his book "Elements" may be the second most studied reference after the Bible (Norton 2024). Euclidean geometry is extremely useful for mathematical problem-solving, and will shortly be utilized to help explain the inverse square in Newton's gravitation equations (see 5.2).

Although Newton considered Euclidean geometry to be a true description of reality, to the extent of being a branch of mechanics (Jammer 1954), some of the abstractions used in its axioms and postulates seem problematic today. Examples are definitions that imply the existence of points without dimensions, lines with only one dimension and that can extend straight indefinitely, and surfaces with two dimensions but no thickness (Norton 2024). There is no evidence that any of these exist in reality. LaFrenière (2009) preferred to refer to points as granules, *"because a point cannot exist."*

To have "real" existence, a point would have to occupy at least a cubic Planck length in size, and in this model could not be smaller than a "volon," which might be of similar size. Lines and surfaces would have to have at least "volon" thickness. Because "volons" are proposed to be three-dimensional, lines and surfaces would need to occupy three-dimensional space, which violates the Euclidean definitions. A line could not be exactly straight over long distances, because any pathway pointing "straight" ahead would eventually be deflected by space deletions and additions alongside, but that is not the same as saying that space itself is curved, as in general relativity (se 6.1). Waves and quantum uncertainty also require distributions in space and cannot exist in dimensionless points.

Currently, small fundamental entities like electrons, quarks, and neutrinos with no known internal structure are frequently described in physics as being "point particles." In the current model, "point particles" are doubly unreal, as there are no points and waves supplant particles. Hobson (2017) said that Newtonian physics seemed to accept such entities, but he presented the argument that "*…the universe is made of spatially extended fields, not point particles.*" Nevertheless, when size, shape, and extent of location of tiny non-rotating matter waves are negligible and irrelevant to a problem, it is mathematically useful to ignore those properties, and to assign other properties that are known and relevant, such as mass, charge, and momentum, to a junction of spatial coordinates near the center of mass. Such 'point particle" techniques have been widely utilized for decades in various fields of physics, for electrons or sometimes for larger matter entities (Pawl 2009). But characterization of any matter entity as if it actually existed without occupying any space is unrealistic and should not be taken seriously. ***"Point particle" techniques and approaches to calculations in physics need not be renamed, let alone abandoned, but any implications that such dimensionless particles actually exist should be removed from physics theories.***

A "singularity" is the concept of a dimensionless point with a huge amount of energy or mass. The "Big Bang" is supposed to have started in one (see 4.2). The Einstein field equations reportedly all require an initial "singularity," though they provide no information on what came before it and how it came to be (Marsh 2014). However, zero volume is inconsistent with quantum theory (Hobson 2017).

Nevertheless, there is also supposed to be a zero volume “singularity” in the center of every black hole (see 9.5). There is no realistic physical model to account for such a construct. With no volume, a “singularity” should have no capacity to contain, generate, or destroy anything. In addition, below Planck size, physics would break down (Walchover 2018). ***So “singularities” cannot really exist*** (Sutter 2022, February)***, and physics theories should be updated to delete them.***

Mathematics also includes abstractions that do not correspond to reality, which it has every right to do because it is an abstract science and neither a description of nor dependent on reality. A philosophical issue is the concept of infinity, which is accepted in mathematics but can also impact physics. Infinite sets of numbers or points, as developed by Georg Cantor, can be imagined in mathematics as abstractions but should not be applied to the real world (Hilbert 1925). Carl Friedrich Gauss and Jean D’Alembert suggested that even in mathematics, the term infinity was just a way of referring to limits (Waterhouse 1979). In the actual universe, nothing infinitely large or small in space or time has ever been identified.

A century ago, mathematician David Hilbert concluded (1925) that “Our principal result is that the infinite is nowhere to be found in reality. It neither exists in nature nor provides a legitimate basis for rational thought - a remarkable harmony between being and thought.” Yet some physicists and cosmologists apply abstract mathematical concepts and refer to infinities, e.g., when discussing “singularities” (Tegmark 2020), or when discussing certain integration limits. Some variables in calculus equations and physics theories do approach such high values that their limits may seem to be headed for an infinite size, quantity, velocity, or time, but in reality no such limit can ever be achieved. For example, functions may approach infinity as a divisor approaches zero, but actually dividing by zero gives an “indeterminate” rather than an infinite result. Ryan (2016) claimed “infinity is an inherently irrational concept,” and that “currently, physicists reject infinities as meaningless and none of the accepted laws of nature require them.” As noted by Robert Marks (2022), “reasoning with the infinite leads to ludicrous conclusions and is evidence that the infinite does not exist in reality.” In the current model, everything from a “volon” to the universe is finite. **Physics teaching should emphasize that there are no true infinities, and physics theories and literature should avoid characterizing**

infinity as a reality.

Alternative geometrical systems have arisen. One of those, Minkowski's geometry, will be discussed later (see 9.2). ***All geometrical systems to date have been theoretical frameworks or grids to localize objects and events in space, overlying them and involving sets of abstractions and the relationships among them. Such theoretical grids can approximate reality under specific conditions, but none can conform perfectly to it.***

This model suggests a fresh approach. The geometrical grid is physical. Rather than providing abstractions and rules for measurement, every unit of space is an actual distance marker. ***Space itself, rather than a theoretical geometrical system, defines and creates the metrics.***

3. MORE SPACE: EXPANDING OUR THINKING

In Section 2, we reviewed the evidence for space as a substance, with hypothetical units termed as "volons," and dimensions (including three hypothetical extra dimensions). The old ether hypothesis was discussed, and space alone was proposed to replace it as a substance and a medium. The alternative string theory was compared. Geometrical systems were described as theoretical grids that overlie and approximate but do not fully describe reality. Now, we shall move on to how space expands.

3.1 The Hubble Expansion

In 1929, Edwin Hubble made the dramatic discovery that the light from 24 galaxies was exhibiting an increasing wavelength (referred to as a redshift because the red end of the visible spectrum has longer wave lengths than the blue end) that was proportional to their estimated distance. The wave length of light increased with the distance of the source galaxies (Bahcall 2015). Back in 1912, Vesto Slipher had discovered similar red shifts in the wave lengths of nebulae, but had not correlated them with distance (Ott 2025).

Hubble himself did not immediately advocate that the redshifts were due to velocity, and considered an alternative interpretation involving so-called "tired light," which would not imply an expanding universe (Marmet 1989). Some of Hubble's calculations were also in error (Ott 2025). Georges Lemaître, a Belgian priest and physicist, who had predicted an expanding universe from Einstein's equations in 1927, interpreted the results as confirmation of his theory of expansion, and went on to propose what became the "Big Bang" theory in 1931 (Stewart 2017). Nevertheless, the assumption that increasing wave lengths are evidence for expansion of the universe has been credited as the Hubble effect.

There is general acceptance today that the galaxies are receding from us, with apparent velocities that increase the farther they were from us, and therefore that the universe is expanding. The idea is that increases in light wave lengths accrued over billions of years of travel through an expanding space. The increase of recession effects with distance and their lack of limitation by the speed of light are unique in physics. The explanation below will remove some of the mystery by attributing them to cumulative effects of space addition.

The well-known Hubble equation (owing much to Lemaître), using v for velocity of recession H_o for the Hubble constant, and s for the existing distance to the receding galaxy (a physics notation tradition after Latin "spatium," the source of our word space) is listed below for frequent reference as equation (1).

$$v=H_o*s \qquad (1)$$ [2]

The Hubble equation (1) deals with linear distance from an observer anywhere in the "observable universe." Assuming as above that the "volon" units of space are three-dimensional, then not just distance but also the volume of the universe is increasing, but one of those three dimensions is the linear distance included in the Hubble equation (1).

3.2 Addition of New Space, the Likely Mechanism for the Expansion

Over the years since the Hubble discovery, the expansion of the universe has not only become accepted, but is considered to be one of the "arrows" (along with time and the increase in entropy of thermodynamics) that in our common experience proceed in only one direction. However, later, we shall consider the possibility of eventual contraction of the universe (see 4.2). We shall also consider the concept of gravity as a space-reducing force, counteracting the expansion and preventing it entirely in locations near large concentrations of mass (see 5.1).

Two potential mechanisms could be responsible for the expansion of the universe. The expansion of space is sometimes described as a stretching of

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[2] Throughout this article, an asterisk * between letters, numbers, or symbols will be entered to indicate multiplication, in equations where there might otherwise be lack of clarity as to whether two letters or symbols represent single or separate entities.

existing space like a rubber band or balloon (Siegel 2021). The second possible mechanism is the addition of more units of space to existing space (Palma 2024). With either of those alternatives, the apparent speed of recession in every direction should be proportional to distance. The redshift would seem to be consistent with either of the two potential explanations, the stretching of light waves along with the rest of space, or the insertion of more space within the light waves (between the crests) along with everywhere else in space. In either case, the wave lengths would increase.

Either alternative would seem to be an exception to the rest of physics. However, the stretching alternative seems less plausible. Nothing known has unlimited flexibility, and other stretchable objects, such as springs, encounter resistance and require more force the further they are displaced. In Hooke's law, $F=kx$ where F is force to achieve the "stretch,", x is the distance of "stretching" displacement, and k is a constant; the restoring force is $F=-kx$ (M. Williams 2015). Stretching thins a material, and anything continually "stretched" will eventually break.

Regardless of whether space encountered resistance to stretching, it would need an endless capacity to "stretch" without diminishing capacity or breaking down, a capacity not known in physics and for which there is neither theory nor evidence. One rather unusual suggested mechanism for the expansion is the deformation of bosons (Dil 2016), another type of stretching with no explanation of how it could continue without limit.

Ethan Siegel has noted that if there is a type of potential energy that causes the expansion, it does not seem to weaken as the redshift continues. He considers space as a "stage" rather than a substance, and says "It's as though new space is getting created due to the Universe's expansion" (Siegel 2021). The "Waves of Space" model would reverse that concept, i.e., the universe is expanding because new space is being created to push the galaxies further apart from each other.

Thus, the more likely explanation for the redshift, however strange it might seem, is the addition of new space to join every measure of existing space. New space appears everywhere, including within wave lengths, so that they lengthen. That realization by this author over three decades ago inspired the development of this model, because it implied that space must be an actual physical entity (see 2.1).

This means that each unit of distance in space (whether a gamma ray wave length or a light year) is joined by an addition and becomes longer continually over time. The farther away an object is from us, the greater the number of existing units of distance there are between us (whether micrometers or light years), and if each such unit is joined by extra space per time, that extra space increases the distance proportionately to the existing distance.

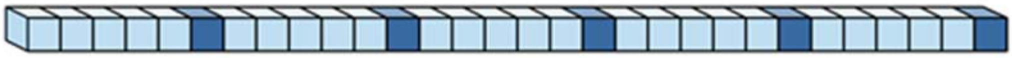

Figure 1: The addition of new space into each expanse of existing space would produce an effect similar to the Hubble expansion.

Figure 1 is offered to help illustrate this. In the figure, there are five expanses of five units each drawn as lighter cubes, representing 25 units of existing space. (The units are drawn as cubes because they are actually three-dimensional, but we are only considering length in one dimension to measure distance.) Each set of five can represent a light wave length. The black cubes represent one additional unit of space added to each set of five per second, a 20% increase in length.

In the Hubble observations, wave length redshift was what was actually observed, but actual distance between objects in space was what was implied. Let us set an imaginary Hubble-like constant H_i at 1/5 or 0.2 wave lengths/second, or one added cube length for every five existing cube lengths, per second. The added space makes objects more distant and creates the recession.

The velocity of this recession at the 25th unit would be $v= H_i*s= H_i*25$ *cube lengths*$=0.2*25$ or five cube lengths added and therefore becoming added distance per second. If the existing (pre-expansion) distance s were n times as long, the new space appearing per second would likewise be n times as great. The increase in distance/second causing apparent recession would be 20 per 100 units per trillion years, still a one to five ratio.as defined in the H_i Hubble-like constant. In other words, n times the baseline distance (the length before addition of new space) would result in n times the total added space/second and therefore n times the recession rate. The velocity of recession would always be proportional to distance, as in the Hubble equation (1).

If new space were added in discrete, constant units like "volons," those units would pop up in between existing similar units, analogously to carbon dioxide bubbles in a carbonated soda or champagne. ***The source of the new space is suggested to be the additional dimensions*** (see 2.4).

The occasional articles in physics literature attributing the expansion to new space being added are usually not followed up by hypothesizing where this new space comes from, and what makes it appear. Other issues generally not typically addressed with respect to added space include its physical reality, what it does, and the potential impact on thermodynamics and time (see 10.3),

The concept proposed here is that units of space are added everywhere, however inside of matter, electromagnetic and strong forces supplement gravity to hold the waves together in relatively stable structures. When material bodies decrease or increase in size it is because of deletions and restorations of "volons," rather than changes in those structures. In space surrounding matter, however, the space deletion effect of gravitation (see 5.1) slows the expansion, or reverses it at short distances from matter with large masses. Because all the stars and other objects with concentrated matter occupy only a small fraction of space in the universe, the expansion of space on a broad scale predominates over the more local deletions by gravity. A net expansion of space occurs in all locations where the gravitational space-deletion effect, divided by the square of distance (the inverse square law), is too weak to exceed the expansion (see 5.2). From an earthly perspective, expansion should overpower the effect of gravitation in the vast expanses between the earth and distant stars, but gravitation should overpower expansion at the much closer distances of the sun, moon, and nearby planets. The Hubble expansion is the net expansion of our dimensions, i.e., total expansion minus gravitational deletions.

The relative homogeneity of the universe permits this expansion predominance to produce the Hubble equation (1). The expansion process accumulates over distance to produce recession velocities that can exceed the speed of light.

Currently, gravity is considered to be one of the four forces of physics, except in general relativity, in which Einstein considered it as an effect of the curvature of space (see 6.1) in the presence of mass (Koberlein 2014). Since the expansion has the capacity to counteract gravity, it could be considered as a candidate for future recognition as a fifth force in physics. Gravity and the expansion are in competition. They both permeate the universe, although gravitational fields are centered locally where there is mass. If space expansion did not exist, gravitational force would presumably be greater, and reflected in a larger gravitational constant *G*. If gravity did not exist, the Hubble constant H_o would presumably be greater.

The term "observable universe" has been used throughout this article, in recognition that many galaxies are today already receding from us more rapidly than the speed of light c. This is not considered mathematically to be a violation of special relativity, but philosophically it seems to be inconsistent with that theory.

The farther we are able to see, the more we are viewing the positions of stars in the distant past. The light we see today from the most distant visible galaxies was emitted billions of years ago. Light being emitted today from those same galaxies will not be expected to reach our solar system, because the galaxies are now receding from it at a speed greater than that of light. According to Siegel (2018), our "observable universe" includes about 2 trillion galaxies, but 96.7% of them are today so far away that the light they emit today will never reach us and light emitted from our sun today will never reach them.

The energy implications of the insertion of new "volons" among existing ones will be discussed later (see 10.3). This could have profound effects on thermodynamics and the evolution of the universe.

In recent years, the expansion of the universe has been found to be accelerating. The term "dark energy" has been applied, because current theories do not explain it. This will be discussed in the next section (see 4.1).

3.3 Thoughts on Isotropy and the Cosmological Principle: How Can We Always Be in the Center?

Modern cosmology accepts the Cosmological Principle, which holds that the distribution of galaxies and inter-galactic stars is relatively homogeneous when looked at over huge distances. This principle moreover implies that universe it is isotropic, i.e., that the density looks roughly the same in all directions, so that no matter your location, it is as though you are in the center of the universe (Durrer 2020). If the universe is isotropic to all observers, it must also be homogeneous, but simply being homogeneous does not require that it be isotropic (Peacock 2012).

Also generally accepted is the Copernican Principle, which holds that the earth is not uniquely located, and has no access to privileged types of observations not available elsewhere (Jones 2019). Specifically, it is highly improbable that the reason for similar density of distribution of celestial bodies in all directions is that the earth happens to be located at the exact location where a "Big Bang" occurred. Our sun in fact lies in a peripheral and undistinguished spiral arm of our unremarkable Milky Way galaxy, which contains an estimated 200 billion other stars (Freudenrich & Bowie 2023).

There is good evidence for homogeneity of the universe from galaxy counts, and from the uniform distribution of the cosmic microwave background (CMB, see 4.2) radiation (Guth 2018). There is strong evidence for isotropy in observations from earth, with some possible exceptions (Mohon 2020). Universal isotropy is consistent with solutions to Einstein's equations as calculated by Aleksandr Friedmann in 1922 (Durrer 2020). A number of physical processes occur in an isotropic manner, including gas kinetics, thermal expansion, permittivity, and permeability. But because we are largely confined to the earth, confirmation has not been available to date from distant locations in the universe that the density of distribution of galaxies looks similar in all directions.

The size of our universe is finite, and all of its contents can be conceptualized to occupy a huge globe-like volume of space, matter, energy, and "dark matter." From our earthly perspective, we are inside the globe and in each direction we are looking outward (with the help of our best telescopes) toward the outer "shell" or spherical surface of the "observable universe." But what we see depends on where we are located. Parallax was discovered by the ancient Greeks, with its first known use by Hipparchus over two millennia ago (Lucas 2022). ***A general rule can be stated, that at any specified time, views of the universe by observers in different locations cannot be the same.***

Light travels through space and cannot travel where there is no space, and neither can anything else. There is no such thing as gazing (or traveling) into non-space. From our current perspective, there is a theoretical outer spherical surface "shell" or periphery of the universe, although we cannot see that far. But if we were able to get closer to that surface, we would see beyond that, and some of the galaxies that would appear to be straight ahead of us would be those that from our previous perspective, we saw as being on the spherical surface. That is because from our current view, there is no space beyond their locations and therefore we cannot view them as being straight ahead. Figure 2 may help in visualizing this concept. Regardless of how counter-intuitive it may seem, nearby locations along what may appear to be an outer sphere of the universe are functionally adjacent, because we can see no space beyond them. To traverse the periphery of a spherical universe, light must follow curved paths. Isotropic appearance of the universe from every location is consistent with such pathways, because it makes the other side of the universe accessible. This may be consistent with the curved space of general relativity (see 6.1), but not with Euclidean geometry.

If we could travel all across the universe, galaxies that now appear to be in separated locations on an outer spherical surface would visually extend out in front of us. As we continued forward, more distant and widely separated locations from what had appeared to be that outer spherical surface, including those that had seemed to be on the other side of the universe, would continue to join together in front of us, and light from them would now come to us. Imagine one of the most distant visible galaxies, near the edge of the "observable universe." The view from that location would not be that it is so located, but instead, it would be isotropic like the view we see from our own initial location. In fact, in the view from that other location, it is we who are at the periphery.

The above conception is consistent with and helps to supply an explanation for a standard but mysterious assumption in cosmology that if we were to travel great distances in a continuous path, we would still see ourselves as being in the center of the universe, which would never have a reachable edge. It is also assumed that other theoretical observers throughout the universe would have the same experience.

If the universe were limited to the surface of a hollow sphere, it would be easy to see in standard Euclidean geometry how an observer at every location of that surface would seem to be at the center (Palma 2024). But as we know, the universe is three (or four)-dimensional and filled with space and stars.

This discussion has been included because it relates to four ideas from the "Waves of Space" model that could provide such mechanisms. The first is that any locations with no space beyond or between them, even if they appear separated to us, are functionally adjacent. The second is that light can only travel where there is space. The third is that light paths are curved by gravity due to space deletion (see 5.1). The fourth (which will be demonstrated by the thought experiment and Figure 2 below) is that motion of matter is accomplished by displacing space from near the front of the moving object to near the rear. How that occurs will be better explained later (see 9.3).

To help visualize the difficult concept of how it is possible to be moving forward from a position with an isotropic view, and continuing to see isotropy from all new positions reached, a thought experiment with an illustration is presented here. Imagine that a girl is grasping several round 'hula" type hoops. Her hands are in the center of the three-dimensional sphere defined by the hoops.

Figure 2: The grasping of hoops is always in the center.

In Figure 2, the global "shell" of the "visible universe" is suggested by the diameters of the hoops shown. Each hoop is painted with markings representing stars (or galaxies) along different portions of it. The place where the girl's hands hold them represents her perspective of being at the center of the volume defined by all the hoops. If she begins to move the grasping spot by hand over hand motion, her hands will remain at the center of this space. The locations on the surface of the hoops, representing the outer sphere of contents of the universe, will be pulled in to new apparent locations as viewed from the center, where they will appear adjacent to one another. They will also appear to be in front of the direction of her hand-over-hand motion and approaching her hands. Meanwhile, the painted stars along each hoop will rise in a curved motion, then lower and pass from in front to behind the location of her hands. Then they would start to rise again.

The movement of portions of the hoops from above the girl's hands to below them is consistent with a possible mechanism of motion suggested by this model. In that mechanism, which is analogous to swimming or travel through water, ***forward motion involves displacement of space and matter in a direction opposite to that of motion*** (see 9.3).

This thought experiment is meant to suggest that if we could travel forward a significant fraction of the radius of the universe, in a very rough analogy to the circumference surfaces of the hoops moving, the outer surface of what appears to us from our current perspective to be the spherical "shell" of the "observable universe" could join together to become a pathway ahead of us, for light and theoretically for extremely long distance travel. The apparent positions of closer galaxies (not represented by these hoops) would also change with motion, so that their locations relative to each other could be preserved. The view from every location in the universe would give the appearance of being in the center (isotropy). Viewing from changing positions would also introduce parallax effects (Lucas 2022).

The thought experiment of the hoops is not suggested as a realistic description of isotropy. It has many flaws, including that the distribution of galaxies would become more concentrated in the direction of motion (as represented by the girl's grip of the hoops), which seems improbable. Also, smaller "hoops" to represent the apparent paths of nearer galaxies are not included. However, its suggestion that light could come to us from around the universe as a body moved through space, and that this could produce isotropic views, is offered for consideration.

This would require curved paths for light where there is no space ahead for a straight path, but it would not require warping of space itself around mass as in general relativity.

There might be a way to examine how the apparent positions of stars in our Milky Way galaxy actually do change with very long-distance travel. Voyager 1 is a satellite that was launched in 1977 and is now over 14.6 billion miles away from earth, beyond our solar system and the most distant object ever sent into space. It is expected to be able to send data and images from its two cameras until at least 2025 (Howell 2022). Although those 14.6 billion miles represent a very small distance galactically, a re-examination of some of those images might have the potential to help produce a more realistic answer to the questions related to isotropy.

4. THE ORIGIN AND FUTURE OF THE UNIVERSE, AND OF ENERGY (LIGHT AND "DARK")

In Section 3, we discussed how the addition of units of space among existing units is the best explanation for the expansion of the universe. Now, we shall move on to consider the implications of overall space expansion, including its acceleration, on the universe as a whole, past present, and future. The nature and possible source of energy will be explored. Three possible contributors to the acceleration of space expansion ("dark energy"), and three possible decelerating factors, will be considered.

4.1..The Acceleration ("Dark Energy"), and Possible Future of the Hubble Expansion

Since the 1990s, the rates of red-shifting, and thus of the expansion, have been found to have increased over time (Rubin & Heitloff 2020). This has been puzzling to many physicists, because it does not seem consistent with the "Big Bang" model in which all energy was imparted to the universe at the very beginning (N. Jackson 2015). The term "dark energy" usually refers to this acceleration of the expansion (Gohd, C. 2024).

The current value of the Hubble constant, measured by various methods, is estimated to be in the range of 72-74 km/second/megaparsec (N. Jackson 2015), or about 22.1-22.7 km/second/million light years (one megaparsec being about 3.26 million light years). However, estimates from the early universe, based in part on the CMB, yield a lower rate of 67 km/second/megaparsec, suggesting about a 9% rise over the course of about 6 billion years (Riess & NASA Hubble Team 2019). This indicates an acceleration of the expansion rate, but not an exponential one. David Tong has expressed wonder why the acceleration of the expansion is not much greater than it is (Strogatz & Tong 2022).

The Hubble constant H_o may not in fact be a constant. This has increasingly been considered, and it is often described as being constant over space but not over time (Siegel 2019, August). That would presumably mean that at any given era, the expansion rate would be homogeneous, but that various factors could alter it over time. However, the redshifts from the more distant galaxies are in light that was emitted billions of years ago, so a sampling from multiple eras is available for Hubble observations. If, as proposed here, there is less space expansion locally in areas with higher density of matter and hence more space deletion, H_o should not be truly constant over space, though an average H_o over vast areas of space might approximate homogeneity.

Six possible factors that could affect the rate of expansion will be reviewed below. Three of the factors should lead to acceleration, and the other three might lead to deceleration. At least one of the three acceleration factors is proposed to be in effect. Any one of the three might produce more rapid acceleration than has been observed, and one could produce exponential acceleration for which there is no evidence. Therefore, at least one possible deceleration factors should also be in effect as a counter-balance, to help reach the current limited rate of acceleration. This agrees with thinking by some cosmologists that multiple factors may be involved (Cho 2023).

Since in the Hubble equation (1), the velocity of recession v depends only on distance s and the Hubble constant H_o, each factor affecting that velocity must be able to change either s or H_o or both. Factor "a" below would change s. The other factors would presumably alter H_o or add additional terms to the equation. Factors "b," "d," and "f" are relatively unique to the "Waves of Space" model, and factor "a" may be underemphasized in current theories. Some factors listed are probably not involved, while other factors not listed could be.

a. The first possible acceleration factor is exponential increase in distance. The first and most prominent possible explanation is that the recession velocity v, which is the momentary added distance per time, keeps increasing the distance *s* between stars or other objects over time. That distance in turn increases velocity (which means that there is acceleration), because in the Hubble equation (1), if H_o is constant, distance *s* is directly proportional to velocity. So with each time interval, each side of the equation increases the other. This assumes that the newly added space has the same ability to increase the velocity of recession as pre-existing space. ***The Hubble equation itself implies not only an accelerating velocity of expansion, but an exponential increase***. The differential form of the Hubble relationship, considering the momentary velocity as ds/dt, is $ds/dt = H_o*s$. This can be rearranged algebraically to equation (2), showing that the ratio of the momentary increase in distance to existing distance increases over time.

$$ds/s=H_o*dt \quad (2)$$

This in turn is related to equation (3), in which the increase in distance with time is exponential and resembles continuous interest compounding. S_o represents the distance to any galaxy at a baseline time. (This baseline time is not meant to represent a "Big Bang" or the beginning of the universe, just the beginning of a measuring period.) S_t represents the distance to the same galaxy after a period of time, and *e* is Euler's number, the base of natural logarithms.

$$S_t=S_o(e^{H_o*t}) \quad (3)$$

b. <u>The second acceleration factor is a hypothetical mid-point at which expansion rate will be maximal.</u> This hypothesis is that the expansion of space could be a harmonic oscillation with an equilibrium position midway to maximal expansion. The velocity of expansion of space would be maximal at the midpoint, analogous to that of a pendulum, and then would steadily decelerate.

By this hypothesis, in dramatic contrast to the "Big Bang" theory, the visible universe could have started to expand very slowly. The expansion phase could have than sped up, but could not do so indefinitely, because it would be drawing its space from a contraction phase in the other dimensions that would eventually be running out of space to transfer to us. This would suggest that expansion, represented by the velocity of recession, should eventually reach a maximum value, then should gradually slow, reaching a stop after several billion more years. At that point, the expansion phase would be complete, and a contraction phase would begin, starting very slowly and increasing gradually in rate till the same midpoint, after which the rate of contraction would gradually decrease. This description of variations in the rate of expansion is similar to a logistic regression curve.

The maximal velocity of recession would be at an unknown mid-location, halfway to maximal potential expansion. The fact that the velocity of recession is still increasing might suggest that our expansion is approaching but has not yet reached that mid-location. The hypothetical mid-location would not necessarily represent an original position of rest, but would be an inflection for both our visible dimensions and the alternate ones, at which maximal rates of expansion in one manifold and of contraction in the other would be reached.

c. The third acceleration factor is gravity reduction due to distance. This possible explanation is that acceleration of expansion is occurring due to the reduction in gravitational force opposing the expansion. The concept of gravity in the "Waves of Space" model will be explained (see 5.1), but in any theory of gravity, including Newtonian and general relativity, the velocity of recession caused by space expansion would be partially counter-balanced by gravity. However, as galaxies become more distant from each other, their gravitational effects should steadily decrease. Gravitational acceleration toward matter with the wave quality of mass is inversely proportional to the square of distance from the center of gravity, as per equation (3) (see 5.2). Therefore, increasing distance should reduce the counter-balance to expansion. This is in contrast to the stretching of a spring or other elastic material, in which resistance to further stretching and restorative force (potential energy) increase with each increment of distance (Hooke's law, see 3.2). The reduced gravitational force, however, might be balanced by the model's gravitational potential energy concept, referred to in factor "d" next below, and to be discussed (see 5.1).

d. The first possible deceleration factor is gravitational force due to spatial pressure, which has not yet been discussed (see 5.1). As per factor "c," gravitation is the main known force to oppose expansion, but it becomes weaker with distance. However, if the spatial pressure, which will be suggested to include the potential energy of gravity, were also increased by new space from the expansion (which will be debated), this might act as a negative feedback or pushback to limit the very expansion that contributed to it. It could help to counteract the reduced strength of gravity of factor "c". However, net spacial pressure should remain stable in order for the gravitational constant *G* to remain a constant, so any increase should be counter-balanced, or neutralized by its effects.

e. The second possible deceleration factor is "dark matter." This is poorly understood (see 5.4), but is thought to pull the universe together gravitationally (Cho 2023) and to oppose expansion. Since "dark matter" is estimated to greatly exceed known types of matter (Betz 2020; Ghosh 2017), there would be plenty of gravitational force to decrease the Hubble constant H_o.

f. The third possible deceleration factor is possible conversion of some of the energy of the acceleration, and of expansion in general, to new mass, adding to gravitation (see 4.4 and 10.3). This might combine with factor "e" to counter-balance the reduction of gravitation due to increasing distances (factor "c").

Another approach that cosmologists and astrophysicists have used to explain the expansion of the universe and its acceleration is to insert a "cosmological constant" into general relativity. Einstein first introduced one in 1915 in order to allow the universe to be static, neither contracting nor expanding. He later withdrew it and considered it to have been his biggest mistake (Mann 2021). However, a revised version with a mysterious anti-gravity effect has more recently been reintroduced by other researchers to fit the accelerating expansion. In the model called Lambda-CDM, which fits the CMB data, lambda is a "cosmological constant" and CDM stands for cold "dark matter" (Cho 2023). This has become a paradigm and a stimulus to research in cosmology and astrophysics, as noted in this journal by Jorge Horvath (2023). However, there is pushback by other physicists, who think that any "cosmological constant" is a "fudge factor" with no real theory or suggested mechanism behind it (Mann 2021). Recent data from the James Webb space telescope is also inconsistent with lambda-CDM (Malewar 2024). Whatever actually happens to the rate of expansion may determine the ultimate fate of the universe.

4.2 "Big Bang" vs. Alternating Expansion and Contraction

The "Big Bang" theory has thrived since discovery of the Hubble expansion (Cho 2023). It has been predominant for several decades as a description of the origin of the universe, to the degree of becoming orthodoxy. This is in spite of the fact that at least two aspects do not conform to any known physical process. First, according to the mathematics of the theory, all of the energy and matter of the universe would have started at some infinitesimal point often referred to as a "singularity." The possibility of such an entity as a "singularity" existing has already been rejected above (see 2.6). Even if there were such a thing, it would lack any content, and thus would have no potential to develop into the entire universe.

The second unrealistic aspect to the "Big Bang" theory, also based on mathematics rather than a physical model, is that the unimaginably small microcosm would have expanded exponentially in an extremely rapid "inflation" for a fraction of a second before slowing to the known Hubble rate of expansion and its modest acceleration (see 4.1). The rate of this momentary expansion would have far exceeded the speed of light (Chown 2024). No known force in physics could have caused such an ultra-brief and powerful "inflation" moment (Wolchover 2018).

The "inflation" aspect of the "Big Bang" theory was developed by Paul Steinhardt and others in the early 1980s, but more recently Steinhardt turned against "inflation" and the entire "Big Bang" theory, and has become an advocate of the "Big Bounce" theory described below, after deciding that inflation could cause a multiverse with an infinite number of solutions. Sabine Hossenfelder (2017) concluded that "inflation" has failed to solve any of the problems for which it was intended, and that it is *"not any simpler and it doesn't explain anything."*

There are two common arguments supporting the "Big Bang," but they are not without challenges:

a. <u>Homogeneity</u>: One argument for the "Big Bang" and "inflation" is that the universe is relatively homogeneous and isotropic (see 3.3). This is credited to the primordial material that became the antecedents of the stars having supposedly been uniformly distributed and contiguous prior to "inflation." The "Waves of Space" model would permit an alternative explanation for the relative homogeneity of the universe. The new space continually appearing everywhere would consist of a uniform distribution of "volon" units of space, and the waves of matter that developed in that space should also be relatively uniform. Other physical processes involve homogeneity and isotropy, so they has limitations as an argument for a "Big Bang."

b. CMB radiation: A second case made for the "Big Bang" model is the cosmic microwave background radiation (CMB), which is relatively uniform everywhere. It is supposedly a residual of radiation from primordial extremely hot temperatures of the "Big Bang" The CMB is assumed to have evolved from electromagnetic waves that were extremely high-frequency (short wave lengths) at that time. The subsequent expansion could have steadily increased these wave lengths until they reached the microwave spectrum. A limitation of this conception is that to some extent it "begs the question" in the true sense of that expression, i.e., it assumes what is to be proven. It depends on those assumptions, so it cannot prove them. If you hypothesize that there was a "Big Bang," with no new energy added since then, and that there were free electromagnetic waves floating around with very short wave lengths at that time that have since steadily experienced elongation of their wave lengths, the CMB radiation is consistent and supportive. However, without such a starting hypothesis, reasoning backward from the CMB can lead to other interpretations than a hot "Big Bang" containing all of the universe's energy. The expansion of space may be a continuing source of energy (see 4.3 and 10.3), and if so, radiation currently found in the microwave range could have been emitted throughout that expansion, at a range of steadily decreasing frequencies over time. Several other alternative causative mechanisms for the CMB, including one by Hoyle, have been proposed that have never been fully developed (Ćirković & Perović 2018).

An alternate theory called the "Big Bounce," now supported by Steinhardt and others, predicts that there could be an endless cycle of expansions and contractions of the universe (Wolchover 2018). Each restart of expansion would presumably start the creation of matter and energy all over again, different than before. It would probably also reset the clock, starting measurable time again from zero. Friedmann- Lemaitre spacetime models are said to allow for alternating expansion and contraction of the universe (Marsh 2014).

The concept of a gradual harmonic oscillation of expansions and contractions is appealing with respect to a "Waves of Space" model. The model could provide an explanation for this alternation different from the "Big Bounce" theory, as space moved back and forth between our observable dimensions and the alternate dimensions. "Inflation" would not be a part of this concept.

1) The current expansion phase in our dimensions would presumably end and start to reverse when there was no more space remaining in the alternate dimensions capable of transfer to ours. That would also be the end of the contraction phase in the alternate dimensions. A contraction phase would then begin in the maximally expanded dimensions. Maximum and minimum sizes of each set of dimensions might be approached gradually, without actual "bangs" or "crunches." In our current expansion phase, electromagnetic wave lengths in light from distant stars are becoming longer. In a contraction phase, the wave lengths would become shorter.

2) In the final stages of a contraction phase, so much space would have been deleted that the waves constituting matter might have broken down and disintegrated. However, the property of mass, deleting the final space and transmitting it to the other dimensions, might have survived through the end of contraction, a dissociation between matter and its mass also proposed to occur in black holes (see 9.5) and possibly in dark matter (see 5.4).

4.3 Energy: What It Is, and Its Association with Waves, Space Deletion, and Mass

Energy has been referred to throughout this paper but not yet clearly described and related to the "Waves of Space" model. In scientific discussion and lessons about energy, there are varied semantics, especially regarding potential energy, and a number of classifications with different numbers of categories ranging from four to twenty, several of which are sub-types of kinetic energy. Generally included as categories and discussed briefly below are mechanical, thermal, electrical, radiant, chemical, and nuclear. Because energy and work can both be classically defined as *force*distance*, each of these forms of energy, either directly or indirectly, should be able to cause motion of matter (Norton 2022, February; Gregersen 2017). Each type of energy should be capable of inter-conversion to others, because of conservation of energy (or of mass-energy), and in some conceptions, every type has a potential form that depends on position or structure. That is compatible with the "Waves of Space" model, which proposes that matter and energy are inter-convertible waves and other processes in space,

Kinetic energy is responsible for the motion of matter (see 9.3). In some classifications, the energies of gravitation, sound, and elasticity are listed as different categories, but they all involve motion of matter and therefore are variations of kinetic energy. What is most different among them is their types of motion, and so they will be considered in the classification of motion, see 9.3. Each version of kinetic energy has an interchangeable form of potential energy. This model provides a new conception of gravitational potential energy (see 5.1). Potential energy does not appear to be transmitted like waves, and some types might be stored in vibrations or pressure instead.

Matter that is considered to be moving, which the model considers to be "real" (see 9.4) has mass and velocity and therefore kinetic energy ($1/2\ mv^2$). If matter is being accelerated, there is a force acting on it over a distance, and its kinetic energy is increasing. If it is moving at a steady velocity (as with inertia in space), its kinetic energy is not increasing. If it is slowing, its kinetic energy may be transforming into potential energy, and/or to friction (usually a conversion to thermal energy).

Kinetic energy is suggested in this model to operate in a wave-like manner. This wave nature is complex, because matter itself is proposed to be made up of standing waves, its gravitation is proposed to generate "gravitational field waves" (see 5.3), and it interacts with electromagnetic waves. A proposal about how this might work will be discussed later (see 9.3)

Thermal energy is essentially the physical motion of molecules (small combinations of matter waves), and therefore is related to kinetic energy, already discussed. The history of concepts of heat is mentioned above in connection with perceptions of reality (see 1.3), and below under the history of thermodynamics (see 10.2). Transfers of molecular motion between substances of different temperatures (different average levels of molecular motion) can drive steam engines and create kinetic energy.

Electrical and magnetic energy (other than in electromagnetic waves, which are classified as radiant) can also be considered to be a form of kinetic energy, in that electrons, which are small matter waves, flow through a conductor as their energy flows around it. Some speculations about its possible wave characteristics and mention of the unique interactive motion of electrical and magnetic charges are included below (see 7.1 and 9.3). Electrostatic energy is the potential energy of electrical charges, thought to be static and stored in the electrical field.

Radiant or electromagnetic energy consists of electromagnetic waves, which have determinants of frequency, amplitude, and concentration, as discussed in detail below with respect to the model (see 7.1). Some frequencies can alter the motion of electrons, while others can produce molecular vibrations and vice versa, producing a close relationship with thermal energy.

Chemical energy involves the conversion of standing waves of matter from one form to another often going through intermediate steps (see 7.3). Its potential energy is considered to exist in its molecular bonds. In a chemical reaction, the end products are at a lower energy level. The wave components that are no longer needed typically convert to thermal energy. There is a minute "mass deficit" meaning that the total mass of the end products is slightly less than of the starting products, and energy is emitted. This can be interpreted as a conversion of mass into energy, although at a much smaller level than in nuclear reactions, and without a decrease in the number of atoms. In the current model, chemical reactions are essentially wave interactions.

Nuclear energy converts matter waves to other wave forms. The number of baryons (see 7.3) is preserved, but some of their mass may be converted to radiant, thermal, and kinetic energy. Because some of the matter waves no longer exist in their original forms, nuclear reactions (fission or fusion) are commonly described as an example of matter converting into energy. In special relativity, matter and energy are inter-convertible, as per Einstein's famous equation $E=mc^2$ (Lamb & Simon 2023), The interpretation of matter conversion to energy in the present model could be that waves with rest or invariant mass (classified as matter) may be converted to other waves lacking that specific property and therefore no longer defined as matter waves. Other than in fission and fusion reactions involving a handful of elements, large-scale conversion of matter to energy has not been achieved.

4.4 The Sources of Matter and Energy

It is intriguing to speculate that all or almost all energy and matter in our dimensions ultimately might have come from space expansion and deletion over the total history of our universe, rather than from a "Big Bang." This possibility is worthy of consideration if "dark energy" is included as an acceleration of the expansion, and if "dark matter" is included as an additional source of space deletion. "Dark energy" is thought to account for about 68% (Horvath 2023) and "dark matter" for about 27% (Sutter 2022, December) of the mass-energy in the universe, or about 95% between the two of them.

Arriving space makes objects with existing matter and energy more distant from each other. Regardless of whether this is a passive process, it produces apparent motion that is considered here to be as "real" as that of gravitation (see 10.3). Space addition might cause groups of volons to spin and become vortices, producing the countervailing space deletion of gravitation. Gravitation could in turn coalesce matter waves into stars and planets, as is believed to be the origin of those celestial bodies and is still occurring (Lamb & Henderson 2023). The vortex concept has resemblances to Descartes' theory (see 2.1), except that it utilizes only space rather than a separate ether substance permeating that space.

All "volons" are presumably engaged to some extent in wave motion within fields or in other energy or matter. All also have the potential to transfer between sets of dimensions, which can be considered as potential energy. ***The total energy in the universe might be a function of the number of "volons" (and hence the volumes) in both sets of dimensions.*** If so, $E=f(V)$ where E is energy and V is volume.

The "Big Bang" theory likewise suggests that it resulted in the formation of the stars and galaxies, and is the ultimate source of energy in the universe. One key difference from that theory is that in the "Waves of Space" model, creation would be an ongoing process rather than constituting the delayed and predetermined results of a single primordial explosive event as with the "Big Bang." Another difference is that the expansion process would add energy along the way (see 10.3).

Day to day, the energy that the earth utilizes predominantly derives directly or indirectly (e.g., by photosynthesis) from thermonuclear fusion on the sun (Lea 2022), despite dilution by the square of the distance from the sun. In the "Waves of Space" model, this energy is transmitted to the earth by waves that ultimately interact with atoms. A very small contribution to the earth's energy comes from nuclear fission on earth.

5. THE GRAVITY OF THE SITUATION

In Section 4, we considered an alternative to the "Big Bang" theory, briefly considered the speculative possibility that space addition might be the ultimate source of the matter and energy in the universe. We also reviewed reasons why an expansion of the universe should accelerate, and possible mechanisms for this "dark energy." Now, we shall move on to an original conception of gravity, in which units of space are deleted by the property of mass rather than being added. Note that throughout this article, the terms gravity and gravitation are used synonymously,

5.1 Space Deletion as the Cause of Gravity

If new space can appear and account for the Hubble expansion of the universe, it has already been suggested that there are processes in nature that can involve space deletion. If the universe experiences alternated expansion and contraction phases, a contraction phase would be a large-scale example of space deletion from our dimensions. This is not something that we are experiencing currently, however.

All matter possesses the property of mass. Gravity is caused by and is proportional to mass, and the cause is proposed to be space deletion. Since mass is hypothesized to consist of waves, it seems reasonable to conclude that mass is a wave property residing in matter, that produces and regulates space deletion. That was the definition of mass provided in the introduction (see 1.6). As will be shown, effects that mass has in classical physics and in relativity theories can be explained by space deletion.

Gravitation results in objects becoming closer together, or else inhibits them from becoming further apart (providing the centripetal force causing curvatures of pathways or orbital motion). The removal of space between material objects by deletion is proposed to be the cause of these effects. Throughout a gravitational field, there would be an in-flow of external "volons" to replace the deleted ones and each other (see 5.3 and 6.4). The deleted space is conjectured to be transferred to the alternate dimensions (see 2.4). An explanation for objects coming closer together will be discussed first.

The gravitation hypothesis of this model is that the actual removal and transfer of "volons" occurs at a rate proportional to the amount of mass. The "volons" that will be deleted are those in immediate contact with matter (which is itself composed of "volons" that are organized into matter waves). ***Gravitational space deletion in this model is continuous, approaching mass from all directions.***

To better understand the mechanisms involved in space deletion, an analogy from hydrodynamics will be utilized. Think of a tank full of water, also containing objects that are dissolved and others that are mixed with the water or floating on it. There is a drain that is open, and a filter in place to assure that only water escapes when the drain is open. The drain is connected to pipes totally separate from the tank, that lead to a sewer. Since water only experiences a minimal space between molecules, every removed molecule would be closely juxtaposed to the surrounding molecules. Any drop of water that went down the drain would be in juxtaposition with its neighboring drops, and would automatically bring surrounding water closer to the drain, but not instantaneously (by which is meant in this article immediately and automatically taking up no time at all), restrained by the limited size of the drain and by viscosity. Small objects in the tub would be carried with the water, and they would collect in the filter. The size of the drain would determine the maximum transfer of water per time, and the water pressure would determine the rate at which water went through the drain.

In this analogy, the water represents space, the drain is the mass property and its size determines the amount of mass, i.e., the rate of space deletion per time, The pipes it connects to represent a transfer system of the space to the alternative dimensions. The filter is the surface of the earth or other matter that absorbs the force of the fallen objects. The objects in the tank represent mass and light being pushed toward the drain and the filter. For all drops of water that go through the drain, others are in close juxtaposition and will take their place.

Like all analogies, this one is imperfect. The decrease in pressure differences with the inverse square of distance cannot be demonstrated because the tub or tank does not extend out in all directions. A better analogy for that aspect might be a vacuum cleaner with a tube held up in the air rather than being pressed against a floor. Ambient air pressure difference would force air into the tube, and the force would decrease with the square of distance (adjusted for air pressure differences with height). Another analogy to demonstrate the decrease of pressure with the square of distance could be a tube applying suction deep in a lake or ocean.

The force of a surviving falling object against the attracting mass, such as the earth, adds its own mass and kinetic energy to the attracting mass, analogous to small matter in the water collecting on the filter. As space is transferred between sets of dimensions, energy and matter waves in an intact form would not be expected to transfer along with it, but they could be reconstructed in the new dimensions (see 4.4 and 10.3). A possible exception might occur in quantum mechanics (see 8.1).

The water is pushed toward the drain by water pressure differences. Water pressure in a tank of water depends on atmospheric pressure plus the height of the water column. Air moves into a vacuum cleaner due to air pressure differences. If space works at all analogously to water and air, there should be an ambient spatial pressure.

Spatial pressure would determine the amount of space moving into the "drain" of mass. Hardly any space would actually be deleted without this pressure, just as hardly any water would drain from a tank unless there were a column of water in the tank creating pressure. A spatial pressure gradient (lower toward the center of gravity than from the external direction) could push space "volons" toward the mass, where they would be deleted. The pressure would push surrounding space to replace the deleted "volons," and then replacing each other, maintaining a cascade of space replacing space, but not as a single body. The in-flow of space toward mass would also carry objects, such as smaller masses or light, that were located in the space being moved. The latter objects would ride along with the space they occupied, as it would move in toward the mass. The propagation of the process of "volon" replacement, in the form of a gravitational wavefront, would extend throughout the universe at the speed of light, but with diminishing force due to the inverse square law.

Spatial pressure has been a silent factor in gravitational equations, which attribute gravitational acceleration only to mass, G (the gravitational constant), and a square of distance from the center of gravity (radius). It has not been necessary mathematically for spatial pressure to be recognized and included as a separate factor in gravitational equations, because its effects are incorporated into the properties of mass. However, in this model, spatial pressure is an essential concept for understanding the actual mechanism of gravitation. Walter Ruh (2022) appeared to recognize this in explaining gravitation by an acceleration throughout space related to spatial pressure, a critical vector being the ratio pressure/acceleration, and that the "*sought-after parameter would have to be the still unknown space pressure.*"

Spatial pressure in a gravitational field should have some similarities to water pressure in a tank with an open drain, but also some differences. Water pressure increases with the weight of the water column; space has no weight and its pressure increases with the reduced inverse square of distance from a mass. Water pressure is the same in any lateral direction at any depth, but is less toward a drain; spatial pressure similarly is the same from any direction within a "shell" of space around a mass, but is lower on the side toward the mass. Water pressure pushes material objects along with it toward the drain; spatial pressure pushes matter and light within it toward the mass. Water pressure does not penetrate material objects and water does not flow out of them; some space moving toward the mass does flow into and out of matter, at different rates (see 6.4).

Advantages of this spatial pressure concept include an explanation for why gravitation produces acceleration, since the continual application of force in the form of pressure has that effect. Force accelerates mass, but without spatial pressure it would not be clear why space deletion on its own would create a force. Also, the spatial pressure mechanism could be a component of balanced forces producing forward inertia, which will be considered (see 6.3). But one of the biggest advantages is the role that that spatial pressure could play as the potential energy of gravitation.

In this hypothesis, gravitation resulting from space deletion does not apply only to individual objects that have been elevated and therefore have supposed individual gravitational potential energy. "Volon" in-flow and deletion by mass occur continually, regardless of whether there is any matter in that space, let alone what the history of that matter has been. The classical concepts of gravitational potential and gravitational potential energy relating to individual objects, which have been lifted upward from mass, permit Lagrangian equations to be applied for calculating trajectories of objects influenced by gravitation (Hirvonen 2025-a). However, such calculations might alternatively be possible with a substitution of spatial pressure for gravitational potential energy.

There are a number of troublesome issues with the conventional concept that gravitation potential energy relates just to specific objects. It is invisible and undetectable when observing an object that supposedly has it, or an area of space in which it supposedly exists. The location, mechanism of storage, and mechanism of conversion back into kinetic energy have been undefined. Gravitational potential energy of individual objects, as traditionally conceived, may be separated from its supposedly related kinetic energy by vast gaps in time and space, or may never be connected.

Once a rocket shot from earth exceeds the escape velocity, its gravitational potential energy to return to earth becomes ineffective, and it may never return. If it approaches another planet, in acquires the potential energy of that planet's gravitational field without ever having previously encountered and been lifted off that planet. Galaxies that interact gravitationally were never lifted from one another to create potential energy, except going back billions of years to the beginning of the expansion of the universe.

The alternative concept presented here, which resolves those problems without violating conservation of energy, is that all gravitational potential energy joins a large pool of spatial pressure rather than being held somehow in reserve for individual objects. As kinetic energy opposing gravitation slows and finally stops, the energy is added to that ambient spatial pressure, and when objects fall, they are propelled by spatial pressure toward the mass where space is being deleted. Since spatial pressure exists throughout the universe, it is not measurably reduced when an individual object's gravitational kinetic energy increases. Pressure is defined as force per area, but in air or water, it acts on volume and converts to kinetic energy, and that is proposed for space as well.

The constancy of spatial pressure and possible additional sources deserve consideration. Constancy would help prevent this pressure from slowing the accelerating rate of expansion (see 4.1). On the other hand, the kinetic effects of additional "volons" being added between existing ones might be expected to have a pressure effect on existing space, suggesting that spatial expansion could be an additional source of ambient spatial pressure (see 10.3). The accelerating rate of expansion might potentially tend to increase spatial pressure (see 4.4), if it were not counter-balanced. If the universe were to encounter some partial barrier to expansion, as from the elastic surface of a balloon, an increase in volume would increase pressure, but the universe is presumably unbounded. As the universe expands, the pressure just within the pre-existing gases like hydrogen and helium that fill the universe, should be diluted and thereby should decrease as per Boyle's Law (*pressure*volume=constant)*. That could be a counter-balance to any spatial pressure increase so that the pressure could remain stable.

The discussion so far has involved the removal of space by deletion and in-flow in-between material objects. However, a small but significant amount of space is also hypothesized to be removed by gravitation from matter, also replaced (but incompletely) by spatial pressure, which can cause a limited penetration of "volons" into matter. This will be discussed in connection with general relativity, to help explain the shrinkage of matter under the influence of gravitation (see 6.4).

Newton assumed that gravitational information about a moving mass was transmitted through space instantaneously, but for the past century, physicists have instead presumed that the adjustment of gravitational fields occurs at the speed of light, and that is accepted in the "Waves of Space" model. The replacement of deleted space, which is the key to gravitational effects including field adjustments, cannot be instantaneous. Since at the speed of light, $c=s/t$ (distance divided by time), $t=s/c$, indicating that the time needed for gravitational field adjustments should be proportional to the ratio of distance s to the speed of light c. An explanation of this and how waves and gravitational field adjustments could progress in an oscillatory, wave-like manner through space, will be provided later (see 5.3).

The total system of coordinated mechanisms described above could provide an explanation for the effects of gravity. In contrast, Newton's gravitational equations merely provide the mathematical relationships. The space deletion explanation of gravity would be mathematically simpler than general relativity and its tensors. It could also satisfy the criteria for elegance, defined as "*the adequate representation of a physical problem in mathematical formulae which bestow unity, symmetry, and harmony among the elements of the problem*" (Tsilikis 1959).

The mechanism of space deletion is not precisely explained in this model, but the matter waves that carry the space-deleting property of mass might act as vortices that flush units of space to the invisible dimensions. The spatial distribution of the wave forms of matter will be discussed later (see 8.3).

According to this model, the reason why matter and light passing by (moving horizontally past, not toward) the earth follow curved paths in a gravitational field is not that mass causes local curvature of space (or spacetime) as per general relativity. Instead, the inertia of the passing matter (producing a fictitious centrifugal force) interacts with the earth's gravitation (creating a centripetal force). This is just as in classical Newtonian theory, except that in this model, the gravitation is due to space deletion and in-flow. The inertia of matter, and the pathway of light (which has no rest or invariant mass but of course does have energy) both attempt to progress in a straight line, while the inward motion of space is proposed to carry the matter and light travelling in that space in the direction of the earth's center of gravity.. The otherwise straight path of matter and light moving through a gravitational field past the earth or another body with mass becomes a curved path.

If the inertial motion of the passing matter is strong enough to avoid falling into the earth or entering an orbit around it, the matter may continue past the earth but have its pathway deflected toward it. If the passing matter's velocity were less, it could go into orbit, and if still less it could fall into the earth. Light pathways will be similarly deflected, but light travels so fast that the deflections by earth's gravity are extremely small, and light traveling horizontally to the earth does not go into orbit or become bent so much that it strikes the earth (however, a black hole deletes enough space to cause both).

Gravitation is often described as an attraction toward mass, however spatial pressure differences would actually push units of space in toward where other units of space were deleted. So gravitation would probably really involve a "push," rather than a "pull" or attraction. Galileo Galilei showed that all objects subject to the gravitation of the earth accelerate the same if differences in air resistance can be disregarded or are negligible (Mittal 2019). The model would explain this on the basis of all such objects being subject to the same spatial pressure.

5.2 Deriving Newton's Inverse Square Law from Geometry and Space Deletion

Newton's equations from the 17^{th} century provided the dominant description of gravity for about 250 years, until Einstein's general relativity was developed. The

Newtonian formulation still gives calculations that are sufficiently accurate for most common situations (Siegel 2019, October). The inverse square law, by which acceleration is reduced with the square of distance, is still a dominant concept, and applies to electromagnetism as well as gravity. Corrections to Newton's concepts that have been provided by general relativity, such as that gravitational information is transmitted at the speed of light rather than instantaneously, are also consistent with the model and will be discussed below (see 6.1 and 6.2).

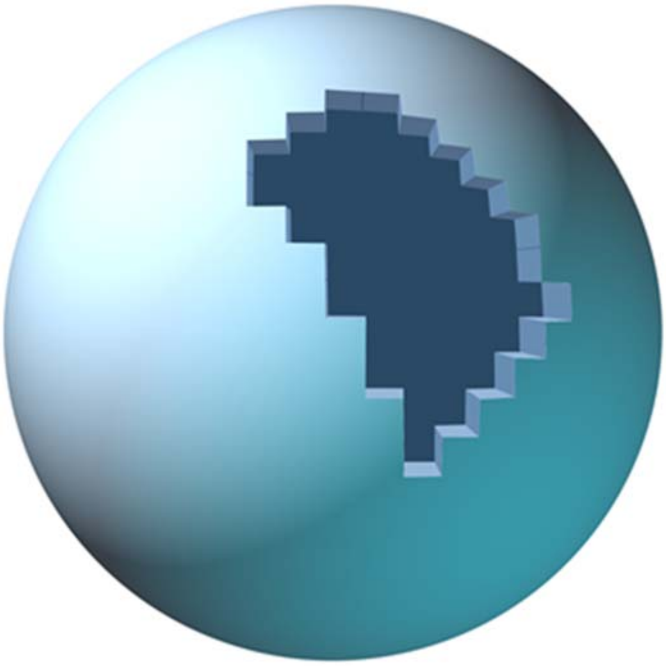

Figure 3: A cutaway of a sphere, hollow to show one "shell" of surface area

The geometrical derivation presented here is not original, however combining it with the concept of space deletion is, and this adds a mechanism to explain gravity. Classical gravitational equations are included in this article for convenient reference, and to show their consistency with the "Waves of Space" model. Consider the gravitational field of an object at theoretical rest (that term will be used since there is no absolute rest) to consist of concentric spherical "shells" of space at different radii, one of which is simulated in Figure 3 above, which is not to scale. Unlike the appearance in the figure, each "shell" is conceived as only one "volon" thick. The figure shows that each concentric spherical "shell" of surface area occupies three dimensions, with thickness *dr* due to being constructed from minimal but finite "volon" units of space. In Euclidean geometry, the equation for the surface of a sphere (and thus of each "shell" of space around a mass object) is $4\pi r^2$. The volume of each "shell" should therefore be $4\pi r^2 dr$.

The amount of mass determines the quantity of units of space ("volons") per second pulled inward from the "shell," to replace the units deleted by the mass. Since the mass does not change, the same number of units of space moves inward per second from every "shell" (and therefore at every radius) toward the center of gravity. However, the removal of the same number of space units has different effects at different distances, because every radius from the center of gravity defines a spherical "shell" with volume $4\pi r^2\, dr$. As the radius increases, that fixed number of units becomes a smaller and smaller fraction of the total units in the "shell."

The strength of the effect of loss of space units (i.e., the strength of the gravitation, and hence of gravitational acceleration) depends on the ratio consisting of the number of units to be removed divided by the total units in the shell. ***Since the "shell" volume includes the square of the radius, the gravitational acceleration is divided by r^2 just as in Newton's equation*** (3). As an example, if 20% of the space units in the "shell" at radius *r* were to flow inward each second to replace space deletion, the same number of space units would be only 5% of the "shell" at a radius of $2r$, because the 20% would be divided by 2^2 or 4. The $4\pi\, dr$ in the equation for the volume of each "shell" is a constant (assuming "volon" width *dr* is always the same), and is simply absorbed as a component of *G*, the gravitational constant.

In order to derive Newtonian equations, it is helpful to temporarily veer away from the concept as discussed above of mass as a wave property, and to think instead of mass *m* as a property of matter that can attract other units of matter. Newton's equation for the force between two such masses is $F= Gm_1*m_2/r^2$. In this equation, mass m_1 attracts mass m_2, and they are multiplied by a gravitational constant *G* (big G) and divided by the square of the radius (distance between their centers of gravity). The gravitational acceleration *g* (small g) can be derived from this and Newton's second law of motion equation (Helmenstine 2013) for *F*, mechanical force ($F = ma$, or in this case mg, a moving mass multiplied by its acceleration). Combining these two equations, $F=mg = Gm_1*m_2/r^2$. One mass cancels out, and we are left with the well-known Newtonian equation (3) in which the acceleration toward a single mass is due to that mass alone, let us say m_1. Since each mass attracts the other, the equation applies reciprocally for the acceleration toward mass m_2, by substituting that mass into the equation.

$$\boldsymbol{g=Gm/r^2} \qquad (3)$$

This is an unusual equation for acceleration, because time is not included, even in the units for the gravitational constant, G. Acceleration is traditionally defined as *velocity/time* or *distance/time squared.* The mass in $F=ma$ is inertial, whereas the masses in Gm_1*m_2/r^2 are gravitational, so this algebraic cancellation implies a degree of acceptance of Einstein's Principle of Equivalence that the two are equivalent. Later on, the association of inertial and gravitational effects will be explained (see 6.3). Equation (3) is included here with the perspective that this acceleration is due to space deletion by the attracting mass m, and that the mass quality or lack of it in the falling entity is mathematically irrelevant when we are calculating the attraction toward only a single mass. On the other hand, each mass will fall toward the other, and they should meet somewhere in-between.

As the radius increases, moving away from the center of gravity of the mass object, the volume of each concentric "shell" away from the attracting mass object is successively larger (due to the increasing surface area), and the fixed amount of space to be removed from each "shell" becomes a successively smaller proportion of the "shell" volume. The strength of the effect of the space in-flow decreases with the square of the radius, and the gravitational force and acceleration decrease similarly. Conversely, as the object with the mass is approached and the radius decreases, the volume of each concentric shell is successively smaller in each concentric "shell" closer to the attracting mass. The fixed amount of space flowing in from the "shells" becomes a greater proportion of the total shell volume, and dividing by the square of the smaller radius causes less of a reduction, So gravitational force and acceleration are weaker when the mass object is farther and stronger when it is closer. How "volons" leave "shells" to flow inward toward a mass will be discussed in the next subsection.

5.3 Space as a Medium; "Gravitational Field Waves" and how They May Oscillate, and "Free Volons"

Volons" can be involved in group action that has been termed "volon mechanics," including participation in waves. Space composed of "volons" has also been described as the medium for waves to move through space, including those that express the properties of matter and energy. Waves involve oscillation, so the question arises, how do "volons" oscillate and how do such oscillations act as waves? Other questions that have not yet been answered include what happens and how gaps, compression, or enlargement of "volons" are avoided when "volons" are deleted or pulled in to replace deletions, why a column of "volons" reaching throughout the gravitational field does not instantaneously move in as a single body when one is deleted or pulled inward, why the replacement process propagates outward through the universe at the speed of light?

"Volons" are conceived of as being incompressible, because compression would change the amount of space they occupy, which would alter their identity as the units of space. They should likewise not be expandable. There should not be empty gaps between "volons," since with no space between them there could be nothing to fill such a gap. However, it may be possible for "volons" to be pushed momentarily into different shapes and configurations with the same volumes, and there might be elasticity bringing them back to a usual form and causing a shape oscillation.

A hypothesis is offered here as one possible way to answer all these questions, including how gravitational effects could disseminate in a wave-like manner at the speed of light. "Volons" surrounding matter (which is composed of other "volons" organized into matter waves) are proposed to act as components of "shells" surrounding masses, one "volon" thick, as has already been suggested (see 5.2). As mentioned in the last subsection, each "shell" has the volume of the spherical surface multiplied by the thickness of one "volon" ($4 \pi r^2 dr$).

When some "volons" are deleted or pulled inward from a gravitational "shell," the circumference of the "shell" losing "volons" becomes momentarily smaller and therefore the "shell" moves closer to the mass causing the gravitation, at a smaller radius, replacing the next inner "shell." At the same time, that next inner "shell" it replaces has also lost "volons" and is moving further closer to the mass. As the "volons" of each "shell" are replenished by "volons" moving inward from the next external "shell," the circumference size of replenished "shells" is restored and they all move back toward their previous radii.

Each of the various steps in this process is presumed to take time: “volons” moving from ”shell” to “shell,” “volons” within a “shell” closing in or separating to adjust as other “volons” move in and out, and “shells” moving closer or further from a mass. If “volons” have some sort of elasticity, any shape bending and shape restoration that might be needed for a “shell” to alternately lose and absorb “volons” would also require time. These processes could not exceed the speed of light, which as mentioned earlier (see 2.2) is an inherent property of space.

The continual inward-outward fluctuation of “shells” could involve all of the concentric “shells” and could produce an oscillation of the entire gravitational field, which we shall call a “gravitational field wave,” inward and outward in an undulation. This would function like a longitudinal traveling wave, however when “volons” oscillated between two “shells,” there would be no midway equilibrium position, unlike other types of waves. The oscillation would propagate outward into the universe as the gravitational field, at the speed of light, carrying with it any new gravitational information if the object is changing orientation and direction, and forming new functional “shells” as it went.

Electromagnetism and gravitation are the two main phenomena believed to propagate at the speed of light in space with negligible matter content, it should not be surprising for both to include within their waves much slower processes. Electromagnetic waves have finite and variable wave frequencies. Similarly, in waves involving “volon” oscillation, individual “volons” are presumed to travel at finite rates, and waves constituting matter and moving past other “volons” (see 9.3) in mechanical motion cannot reach the speed of light (see 6.1). Mass in a gravitational process is quantified by the rate of matter-associated space deletion and of drawing in of replacement “volons.”

The propagation of a gravitational field from a mass outward through space is somewhat analogous to a ripple effect in water disseminating outward from the location of a dive or a pebble drop. A difference from most classical waves is that nothing would radiate outward except the propagation itself, which could change directions if the mass moved to a new location. The field would involve space units moving inward toward the mass rather than outward away from it. These adjustments will be called “gravitational field waves,” to avoid confusion.

The hypothetical “gravitational field waves” are totally different from what physicists currently call gravitational waves, which are thought to be ripples in spacetime generated by movements of extremely massive bodies like binary pulsars, neutron stars, and black holes (Kulkarni & Thwaites 2023). The hypothetical "graviton," which is supposed to be the boson particle for such waves (see 7.3), is the only particle predicted by the "standard model" that has not been found. It is missing along with a workable quantum theory of gravity (Elert 2023, Sutton 2024). That might be because the graviton does not exist, and gravity operates instead by the mechanisms proposed in this model and described above.

If the mass generating a "gravitational field wave" changes its direction of motion, the direction of the-movement of "volons" will keep adjusting, toward the new front position of the mass. The direction of propagation of the "shell" oscillations and the shape and orientation of the gravitational field will also change accordingly. Every independently moving object with the space-deleting quality of mass, even an insect, would produce a progression of space moving inward, and oscillation of "shells," however miniscule the effect.

The actual deletion of space by matter occurs where "volons" encounter the associated mass. Mathematically, all the locations of deletion will average out so that the center of gravity can represent the source, just as in Newtonian gravity.

Space units that are not incorporated in standing waves of matter or energy (though they are likely part of extended gravitational and/or electromagnetic fields) can be considered as "free volons." "Free volons" make up the vast majority of the universe, the space between bodies of matter, through which the standing waves of matter can travel without friction. According to this concept, some "free volons" are also found in matter, where they serve several important roles. They are pushed into matter by spatial pressure or by impact from the motion of matter. They fill gaps between (and possibly within) the matter structures formed by standing waves. "Free volons" are the ones most susceptible to deletion by mass, or to out-flow toward bodies with greater amounts of mass. They are also the raw material of space restoration to replace the "volons" that were deleted or that flowed out. When "volons" were removed from standing waves, the restoration process involves incorporation of "free volons" to repair or reconstruct those waves (see 6.4). "Volons" that are incorporated into standing matter or mass waves might be preferentially though not totally spared from deletion and transfer to the other dimensions, compared with "free volons." If so, that would help to maintain the structural integrity of matter in gravitational fields. When matter waves come into contact with each other, friction and other well-known interactions of mechanics occur.

5.4 Alternative Theories of Gravity, and "Dark Matter"

A number of scientists have proposed similar ideas on gravity in the past. According to Swedish physicist Ove Tedenstig (1990) in a self-published book: *"It turns out that the gravitation is actuated by an inflow process of matter from the environmental space."* He did not, however, specify whether there is an inflow of space itself.

At least three additional scientists have proposed that gravitation results from space flowing into matter, but their models differ from each other and from that presented in this article. Yevgeniy Kutanov (2014) offered a thought experiment in which space is made up of compressible cells. He proposed that elementary particles of ordinary matter act like "small black holes," absorbing space and making it disappear. The absorbed space converts to energy and matter and is an endless source of both, but does not apparently affect the size of the particles. It is not clear in that model how that influx of space affects objects with the mass property and light, which are attracted by ordinary black holes. He suggested that in contrast to ordinary matter, antimatter particles could act as "small white holes" that emit space. Kutanov attempted to draw implications for particle repulsion and strong and weak interactions. He provided considerable mathematics as well as diagrams in support of his model. An apparent weakness in this theory is the lack of evidence for the increased matter and energy to which the absorbed space converts.

Lindner proposed in this journal (2015) that gravity is due to the absorption of space by matter. He had previously (2012) provided a theory of space and had described gravity as a fluid-like flow of space into matter. He did not suggest a mechanism of absorption or an explanation of what becomes of the space. Reginald Cahill (2017) claimed that experimental data going back to the 1933 work of Dayton Miller, an ether supporter, showed an inflow of space into the sun, where it was presumably absorbed. He implied that such space absorption was the cause of gravity.

"Dark matter," the currently unexplained source of extra gravitation that cannot be associated with visible mass, was first reported by Jacobus Kapteyn in

1922 and has been an enigma for more than a century (Lieu 2024). It is estimated to produce over five times as much gravity as ordinary matter (Betz 2020; Ghosh 2017), and is thought to keep galaxies from flying apart (Clavin 2020), but does not emit, reflect, or absorb light, or respond to electromagnetism, and interacts with the rest of the universe only by gravity. Marmet (1989) proposed that "dark matter" could be explained by hydrogen molecules in space, but there has not been confirmation of association with particular particles or wave forms. It does seem to be concentrated in localized areas of space.

There is no essential or inherent requirement in the "Waves of Space" model for the deletions of space that define gravitation to be caused only by mass associated with matter as we know it. ***"Dark matter" might better be termed "dark gravity," because it does not seem to exhibit other properties of matter such as charge, or to be associated with coherent bodies of matter, i.e. "volon" wave clusters.*** No known type of matter has been definitely associated with it. Richard Lieu (2014) has proposed that no matter may be involved at all, and that the gravitation may be produced by spherical "shells" of mass, also described as topological defects in space. Additional causes of space deletion, such as vortices generated by the space expansion that are not concentrated into stars or planets and may not be constructed of matter, could be proposed.

The "Waves of Space" model recognizes a parallel between "dark matter" and other phenomena in which mass may be dissociated from its matter, involving breakdowns of matter waves (see 9.5). This dissociation seems mysterious to us because it is not known to occur in our ordinary experience, but the destruction of matter with retention of mass by black holes (see 9.5) seems not to be an uncommon assumption by physicists (Impey 2021; Sutter 2022). Although mass has been defined here as a wave property associated with matter that involves space deletion (see 1.6), there is no prohibition by the model against its also existing separately from matter. In special relativity, mass is also associated with energy, e.g., $E=mc^2$. Other theories of "dark matter" could be compatible with the model, but the concept of mass waves separated from matter seems to be a plausible contender (see 9.5). Mass that is not derived from an association with matter is theorized in general relativity to instead be associated with energy (see 6.1).

6. RELATIVITY, SPACE DELETION IN MOVING BODIES, AND NON-UNIFORM GRAVITATIONAL FIELDS

In Section 5, we presented a new hypothesis for the nature of gravity, based on deletion of space by matter with the wave property of mass, and showed that this would cause the same diminution of gravitational acceleration with the square of distance as in Newton's equations. We considered the effects of space deletion on moving bodies. Now, we shall further consider those effects and how they may interact with the predictions of special and general relativity. Of particularly interest are proposed alternative mechanisms, for the Lorentz transformations and for the increase in inertia of a rapidly moving body. We shall also look at just how equivalent inertial and gravitational mass really are.

6.1 Relativity Theories: Geometry, Gravity, and What Space Deletion May Offer

Both special and general relativity were brilliantly conceived by Albert Einstein and further developed by other prominent physicists in the 20th century. The experimentally confirmed findings consistent with relativity theories will not be challenged, and some will be reviewed to show how the present model is also consistent with them (see 6.5). Instead, the "Waves of Space" model will provide an alternative way of thinking about the same findings. It is modestly suggested that they might be explainable by a different, simpler, yet comprehensive model, one more easily united with quantum theory.

Both special and general relativity theories describe geometric representations of space and time, combined into spacetime. In special relativity, linear measurements and time vary with velocity. In general relativity, they also vary with gravitation. In special relativity, rapid velocity also produces an increase in mass. These features will be discussed later (see 6.2).

Special relativity, introduced by Einstein in 1905, applies to inertial motion but not to gravity. The theory requires that the laws of physics be the same in all inertial frames of reference (Principle of Relativity), and that the speed of light also be the same in all inertial frames of reference (Light Postulate). The Principle of Relativity requires that all linear steady motion be relative (Einstein 1921). Spacetime in special relativity is "flat," whereas it is curved in general relativity. Therefore, special relativity only is valid locally, where the curvature is inconsequential and can be ignored. Special relativity is considered to be an incomplete theory, since every object with mass does have gravitation.

The requirement that the speed of light be equal "in all inertial frames of reference" causes light to always be faster by the same velocity, *c*, than a moving body that the light passes or from which light is emitted, as judged from that moving body's frame of reference (Einstein 1921; Norton 1924, January). Not only can no material body reach the speed of light, but observers in its frame of reference will not even be able to tell if they have reached a fraction of that speed, The Lorentz transformations that produce these changes will be discussed in the next sub-section (see 6.2). The "Waves of Space" model accepts the Light Postulate but sees it as an effect of these transformations rather than vice versa, with the transformations having been caused by space deletion.

General relativity, introduced by Einstein a decade later, is predominantly a complex geometrical theory of gravitation (Einstein 1921). In that theory, which is mathematically challenging and involves ten tensors, four-dimensional spacetime (which is considered essential to the theory) is warped by mass and energy, creating curved geodesic lines. Gravity is not a true force, but rather is the curvature or warping of spacetime produced by mass or energy. A number of predictions of the theory and confirmatory tests will be discussed later (see 6.5). Norma Sanchez (2019) considered general relativity, because it is non-quantum, to also be an incomplete theory, "*a particular approximation from a more complete theory yet to be achieved*."

In relativity theories, energy should have its own gravitational effects, since mass is equivalent to energy. However, that is not a significant consideration in the "Waves of Space" model, because gravitation-like effects would be caused by different mechanisms. For example, light could be bent by gravitation not because of mass or gravitational potential energy of its own, but because the space through which it travels is moving in toward a mass, carrying both mass and energy along with it. Heating a material object supposedly causes a slight increase in weight because the heat energy increases gravitation. However, that may be a mass-like effect of increased space deletion, caused because increased molecular motion brings more space in contact with the molecules, allowing more "volons" to be deleted (as with "relativistic mass," see 6.3). Besides, objects do not need to have their own gravitational mass in order to fall in a gravitational field, as falling is due to the gravitation of only the mass toward which the falling occurs (see 5.2).

In general relativity, there are geodesics in the curved space describing the paths of objects moving due to gravity. These paths are curved due to the space curvature. ***It seems to be less clear what in general relativity actually causes objects to fall, i.e., how the curved space causes objects to move along those geodesics, since gravity is not a force in that theory.***

Relativity theories also seem to accept almost unlimited reductions in sizes or shapes of matter, e.g., shortening of lengths with velocities approaching that of light (see 6.2), and reductions in overall size to the extent of a "singularity" at a "Big Bang" (see 4.2) or in a black hole (see 9.5). In those theories, there is little concern about, or mechanisms offered for, how the components of matter (be they waves or hypothetical particles) could exist and maintain any functions under such extreme conditions (Marmet 2001). Even if the assumption is that the "standard model" would not yet exist in a "Big Bang's" "singularity" or would break down in a black hole's "singularity," those do not seem to be adequate excuses for failure to deal with these problems. One would think that general relativity should at least include descriptions of what happens to matter as it emerges from or approaches such a state. These are among the continuing objections to relativity theories (see 6.6), in spite of experimental evidence consistent with them (see 6.5).

The current model rejects "singularities" and particles altogether (see 2.6 and 7.1). It attributes reductions in size to deletion of "volons," and accepts that there can be a limit at which waves have lost too many of them to retain the functions of matter (see 9.5).

General relativity shares with Newtonian theory the limitation that they both describe mathematical relationships but not why all of those relationships exist. They thus both fail to fulfill Aristotle's criteria for high science, i.e., that it explain both facts and causes (Bouchier 1901).

The "Waves of Space" model applies to frames of reference with or without significant gravity, both locally and throughout the universe, in our familiar three dimensions (though with additional, unseen dimensions for space transfer). This may turn out to be a more comprehensive yet mathematically simpler concept of space, time, gravity, and the effects of rapid velocities. ***A future adaptation might have a potential to contribute to substitution of one new theory for two current relativity theories, and to permit a better correlation with quantum theory.***

6.2 Effects of Space Deletion on Moving Bodies, a Mechanism for the Lorentz Transformations and Non-uniformity

Figure 4 below can assist in visualization of the effects of space deletion in a body in motion, including effects on the body's gravitational field. The body is pictured as a spaceship. The figure is hypothetical and not to scale but illustrates some key concepts about the gravitation of moving bodies. It represents a snapshot at a given instant in time, as a spaceship moved at close to the speed of light. The concentric but off-center circles represent three-dimensional spheres. Each shows the outer margin of the gravitational field (which can be thought of as the wave front of a "gravitational field wave" front) that was initiated at six separate consecutive (but not continuous) times T1 through T6. The consecutive positions where the spaceship was when it initiated the gravitational signals are shown more faintly, each in the center of its circle and likewise labeled T1 through T6. The spaceship is depicted as shortened by the Lorentz transformations as viewed from a separate frame of reference. Gravitational attraction toward a moving body would be toward the location where the body was when it emitted the gravitational information, and not toward the body's current location.

Circles initiated earlier are shown as larger because the wave front has had more time to propagate outward. The circles have different colors, to represent a reduction in the concentration of gravitation with the square of the distance from the center of where the body was when the gravitational. Because larger circles have larger radii, they have reduced gravitational intensity.

The gravitational wave fronts are moving at the speed of light, while the spaceship is moving at a slightly slower speed, so all of the circles reach space in front of the ship. The forward portions of the circles are closer together, because the ship is traveling almost as fast. Behind the moving body, the circles are farther apart, because the gravitational effects have been left behind, in addition to being reduced by the square of the radius. Each wave front was delayed en route by the speed of light, but the figure is meant as a sort of snapshot view, to show where the wave fronts have reached as of "now" as perceived from the current position of the spaceship. So regardless of those delays, and despite the weaker gravitation in the waves originating from posterior positions, it is evident that the concentration of "gravitational field waves" (and hence of gravitation itself) is greater in front and less in back of the spaceship. Note that all processes that this figure represents in two dimensions actually extend out into three dimensions.

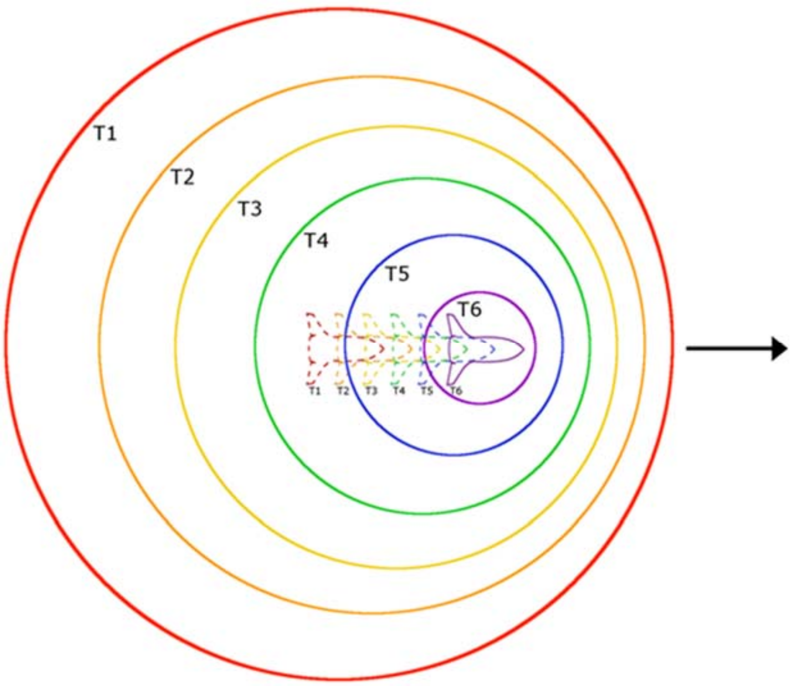

Figure 4: The concept of a rapidly moving object developing a non-uniform gravitational field as it approaches the speed of light; not to any scale. (Assisted by Dennis Polis; interpretation by the author)

In this model, the deletion of space is produced by mass, and therefore in the figure it is taking place within the spaceship location at each time (and the quantum distributions of its own matter waves), rather than in the circles themselves, however in-motion of "volons" to replace the deletions and each other will take place within the circles, and that will be more concentrated in front of the spaceship. As with a drain or a jet engine, at a rapid velocity the mass encounters more space to delete (see 5.1 and 6.3), but the only available space moving in to restore the deletion is that within the concentrated portion of the gravitational field represented by the circles. That field is conceptualized as the volume of space in which inward motion of units of space would be replacing deletion, as the body progressed to successive positions.

Although Figure 4 only represents the object's own gravity, and not that of an extremely massive external object or a black hole, the concentration of gravitational effects should have physical effects on the moving object itself. Because a moving object's gravitation has effects on itself, this could be considered as a type of self-interaction.

The impact of space against mass can occur from opposite directions. Spatial pressure can force space toward an object. However, an object can also move against space, and if so will encounter more space in front of it, analogous to the breeze a motorcyclist feels by driving through the air. This will lead to more deletions of that space, analogous to more air entering the engines of a rapidly moving jet airplane, but also to more in-flow of external "volons" to replace the deletions and each other. The "Waves of Space" model suggests that the effects of the increased space deletion and restoration processes in moving objects should cause three main concurrent and inter related effects, which can be distinguished by where the space is being deleted. These effects will be referred to in the remainder of this subsection and the next.

a. <u>General increased space deletion and restoration, related to inertia and mass</u>: As described above, as a result of increased space deletion, concentration of the in-motion of space to replace deletions will be greater in front of the object and less behind it. The resulting spatial pressure difference will push the moving object forward, but should be balanced by effect "c," cancelling some of the forward motion. Those balanced forces are suggested to result in inertia, preserving steady, non-accelerating motion. Inertia will be discussed in the next subsection (see 6.3). Since space deletion is proposed to be the main effect of mass, increased space deletion should mimic an increase in mass with velocity, a complex issue that will also be discussed in the next subsection (see 6.3). :
b. <u>Space deletion and delayed restoration within the moving object, related to Lorentz length shortening:</u> Deletion of space within the length of objects in the axis of front to back is proposed as the mechanism for these transformations. This must be combined with space restoration within matter that is slower than the pace of deletion but should maintain an equilibrium in the percentage of lag. Shortening in the Lorentz contractions will be explained below in this sub-section; three-dimensional size reduction in intense gravitation will be addressed later (see 6.4).

c. <u>Deletion and in-flow of space that is being or has been traversed, related to inertia and time dilation:</u> The least intuitive effect is that space deletion and inward movement of "volons" in the replacement process can involve distances that an object is traveling or has already travelled. This is somewhat analogous to being on a treadmill, in which the backward motion of the belt cancels forward motion. This effect is considered to be crucial in maintaining balanced forces in inertia, and in preventing the velocity of matter from reaching the speed of light. It also is the proposed mechanism for time dilation with velocity. Both will be discussed in the next subsection (see 6.3).

The Lorentz transformation of length (effect "b") permits the speed of light relative to a moving body to be measured as constant when observed from the frame of reference of the moving object. The transformations also include slowing of clock speed, effect "c" (see 6.3). Both transformations utilize a "gamma factor" (Koks 2012) that occurs ubiquitously in special relativity: $\gamma=1/(1-v^2/c^2)^{1/2}$.

This factor can be derived in several different ways, and mainly depends on an observer in a separate reference frame from a moving object, and on *c* being a constant (Kataru 2019). Those conditions are easily met by the "Waves of Space" model (*c* being a property of the space substance, the limiting speed through space), so calculations based on the model should yield the same "gamma factor" and the same results as in special relativity. For both gravity and rapid velocity, the changes would not be apparent to the traveler and would need to be judged from a separate frame of reference (Einstein 1921).

The Lorentz transformations are negligible at slow velocities, but become significant when traveling at great velocity approaching *c*. The dilation of time with velocity (also discussed in the next subsection) has been experimentally confirmed, but confirmation of length contraction may be lacking in experimental evidence (Zyga 2012).

The model provides a mechanism to explain the Lorentz shortening of length (effect "b"). The moving object would encounter more space to be deleted at its front, and the rest of the body would continually move into this anterior region of increased deletion. At any speed, but becoming significant as a moving object approached the speed of light, some "volons" of space would be deleted within the moving object, mostly in the axis from front to back. In that axis, the increased number of "volons" encountered by the moving object due to its motion would be consumed by increased deletion of space, and restoration of the deletion. The latter would be slowed by the need for reconstruction of waves depleted by the increased deletion,

Length restoration within a moving body of matter should require some reconstruction of waves that lost "volons" during deletion, and therefore is likely to be a slower process than space deletion, dependent in part on the volume of matter needing reconstruction. Since volume is $4/3\ \pi\ r^3$, that portion of the process should be inversely proportion to the cube rather than the square of the radius of the matter (see 6.4). Upon reaching a steady rate of velocity, there would be a percentage of length reduction because of the lag of restoration behind deletion of length along the axis. An equilibrium in the proportion of shortened length should develop. A somewhat similar lag could occur in connection with gravitational size reduction (see 6.4).

Length would be restored with deceleration, presumably due to reduced space deletion and a concurrent decrease in the in-flow of external space for restoration. Since matter is represented as consisting of three-dimensional waves, shortening of a moving body in only the axis of motion implies that one-dimension changes in deletion and restoration can occur.

Although the measured changes occurring in a body approaching the speed of light should be the same in the "Waves of Space" model as in the Lorentz transformation of special relativity, there would be a difference. In special relativity theory, if the relative motion of two frames of reference were close to the speed of light, an observer on either frame would detect the transformations in the other frame and could consider him/herself to be at rest, with both observations equally valid. That part of the theory has never been experimentally confirmed.

In the current model, motion is "real" (see 9.4). ***The transformations would be "real" as well, only occurring in bodies that were "really" moving, although both the motion and the transformations could only be detected and measured relative to other frames of reference.*** Two bodies moving toward one another could each exhibit "real" changes in length and size that would be additive. The changes would be reversible with deceleration to slower velocities, which would permit increased space restoration.

In addition to shortening the moving object itself, this effect would cause concentric gravitational wave fronts immediately in front of it to become closer together than those behind it, as illustrated in Figure 4, because some of the space between them would be deleted. As with other velocity-related changes, the distances should be restored with deceleration.

Deletion and restoration are both theoretically proportional to the object's mass as well as to its velocity. Mass in both the numerator and denominator would cancel out (and therefore mass does not appear as a factor in the equations of the Lorentz transformations), leaving the velocity in relation to the speed of light as the main determinant regarding the proportion of length reduction.

The time slowing (dilation) of the Lorentz transformations would be due to effect "c" of space deletion in a moving body, deletion of space being traversed or that had already been traversed. The dilation of time can be conceptualized by imagining an analog clock attached to the moving object. If space were removed from the distance that the clock hands were in the process of moving or had already moved, it would slow the forward progression of measured time. Space deleted in front of the motion of clock would merely maintain the current velocity of the clock (inertia), and would be unrelated to shortening. A similar deletion and consequent slowing would occur in any other type of time device within the moving body, including the movement of electrons in atomic clocks, and there would also be slower aging within a living organism as has been experimentally confirmed (Marder 1971). Upon deceleration, time passage would speed up and the rate of further aging would increase, but the reduced aging during the period at higher velocity could not be changed.

6.3 Inertia and Gravitation in Moving Bodies

Newton in the late 17^{th} century made inertia his first law of motion, stating that every object at rest remains at rest, and every object in motion remains in motion at the same speed and direction, until acted on by external forces (Helmenstine 2013). The physics pioneers of that era borrowed from one another. This law and the concept of inertia had actually been stated earlier in that century by Johannes Kepler and by others before him. Newton also established that mass objects approach one another through gravitation, but that had previously been proposed by Kepler (McMullin 2002).

These concepts of inertia and gravitation might seem to be separate phenomena, but Einstein made the universal association of gravitational and inertial mass his Principle of Equivalence. This is an underlying assumption in general relativity, also referred to by Einstein as the law of the equality of inertial and gravitational mass (Einstein 1921; Gundlach & Ross 2023). This equivalence has agreed with all scientific observations, but none of the writings of Newton, Kepler, or Einstein actually explain why inertia should be in lock-step with gravitation.

The Waves of Space model suggests a common origin for gravitation and inertia related to space deletion. The proposal here is that the essential link between gravitation and inertia is that they both result from the space deletion, however minimal, from an object's own mass. Inertia and gravitation are the two properties associated with mass in physics equations. They should always be related, because they both are effects of the same space deletion caused by the same mass.

Newton's first law of motion is all about inertia, but in his second law, $F=ma$ or $a=F/m$, an interesting feature is that it allows the continued application of a steady, non-accelerating force to produce acceleration (Helmenstine 2013). The suggested explanation here is that during every increment of time, the continued force adds to the inertial velocity already achieved.

Alternative concepts related to inertia and gravitation have been proposed by others. Amrit Sorli also concluded that inertial and gravitational mass have the same origin, but rather than speaking of space deletion, his concept was diminished energy density in a three-dimensional "quantum" space (Zyga 2012). Paul Marmet (2001) claimed differences between inertial and gravitational acceleration, among them that inertial but not gravitational acceleration creates stresses inside the accelerating body.

In Newton's first law, inertia does not require any forces whatsoever, but the conception in this model is that instead there are forces, but they are balanced. Non-uniform space deletion, greater in the front of a moving object than in the rear (see Figure 4), could result in greater spatial pressure behind the object than in front of it, and produce a force toward the front of the moving object. If this were not balanced in some way, there would be acceleration rather than inertia. It could be balanced, however, by the deletion of space traversed by the object (effect "c" in the previous subsection). If that effect is not sufficient to produce a precise balance consistent with inertia, additional deletion effects may supplement. The inertia of theoretical rest would be preserved by symmetry of space deletions in all directions, a special circumstance applying the same physical model.

Mathematically, the "gamma factor" prevents velocity from ever reaching c because $1-v^2/c^2$ would be zero and dividing by zero gives an "undefined" quotient. The "Waves of Space" model suggests a possible mechanism. ***As a body would accelerate to approach the speed of light, more and more of the "volons" of space it had already traversed would be deleted within the body (the same distribution as the shortening in the Lorentz transformation).*** Further acceleration would become more and more difficult, because more of the forward motion would be cancelled, setting forward progress back (effect "c" in the previous subsection). Inertia would increase with each increment in velocity, because of balanced increases in both the forward and backward forces producing it (effect "a").

Increased velocity would make it more and more difficult to either accelerate or decelerate the body. Everyone knows that it is harder to stop a rapidly moving ball than a slow one. The closer a body comes to the speed of light, the more its increase in inertia should resist changing its velocity. Space in front of the body would also be deleted, but that would merely maintain current velocity. As with the Lorentz transformations, at each velocity, an equilibrium would be reached between deletion and restoration of space, maintaining the current velocity and inertia.

If an object were nevertheless somehow able to reach the speed of light (impossible as far as we know), it would lose so many of its "volons" due to space deletion that it would no longer be able to maintain its wave structure as matter. Despite this, it might theoretically retain its inertia and therefore presumably its mass, requiring a dissociation between matter and its mass as discussed elsewhere (see 5.4 and 9.5).

The total energy of the moving object increases (due to the increase in the kinetic component) as acceleration increases velocity, and is called relativistic energy. It is also sometimes referred to as "relativistic mass." Since in this model, mass deletes space, increased space deletion suggests an increased mass-like function, also associated with an increase in inertia as has just been discussed. However, in the equation for relativistic energy, $E=\gamma 1/2mv^{2}$', there is no indication that the mass must increase if the velocity increases, and if energy remains constant, an increase in velocity should require a decrease in mass. On the other hand, in the equation $E=mc^2$, if energy increases, so must mass. One argument for relativistic mass is that the masses of neutrons and protons are thought to come mostly from the kinetic energy of its constituent quarks and gluons (see 7.3), because the estimated rest masses of the quarks would be much too small and gluons are supposedly massless (Sundermier 2016).

If mass increases with velocity, it is not rest or invariant mass. Rest or invariant mass can be considered as "real" mass, because it is the mass function that is inherent in the quantity of matter, whether it moves or not. In the water drain analogy, it represents the size of the hypothetical "drain" for space deletion, which does not increase if more water goes down the drain. Applying that perspective, the mass effects of increased velocity could be considered as an artifact (Roche 2004). However, that distinction is partly semantic (Fowler 2024), because that artifact can be defined as a type of mass, as it is in special relativity.

The term and concept of "relativistic mass" seems to be falling out of favor. Many physics students are no longer taught it. Some particle physicists reportedly dislike the idea of variable mass, questioning where that mass could be stored as the moving object actually gets shorter (Koks 2012; Fowler 2024). Physics historian John Roche said (2004) that it is impossible to properly measure mass during rapid motion, and that by the early 21st century, modern nuclear and particle physics made no reference to "relativistic mass" and about 60% of recent authors writing on special relativity did not introduce it. He added that Einstein in his later years no longer referred to it, and said in 1948 that "*no clear definition can be given…It is better to introduce no other mass than the 'rest mass'…*"

Eli Manor (2015), another physician interested in the philosophy of physics, proposed that inertia and gravitation but not mass increase with velocity, and that there is a relativistic increase in the gravitational "constant," giving a false impression of mass increase. According to particle physicist Don Lincoln (2023), "*relativistic mass" is a pedagogical invention that does not conform to reality*." Roche (2004) concluded that "*Clearly, relativistic mass,* $m = mo\ \ 1-v2/c2$ *, or* $m = \gamma\ mo$*, is not a well-defined concept, and seems to be no more than a mathematical artefact*."

If mass actually did increase with velocity, an increased gravitational field effect would be expected, which would be difficult to test and has not apparently been experimentally observed. Lincoln said that velocity should not increase the gravitational field. If a gravitational effect does exist toward a moving body, it might cause an unevenly distributed gravitational effect on other objects and light. This should be greater toward the front of the moving body where more concentrated space deletion and therefore more inward flow of "volons" to replace the deletions and each other was expected, and less toward the rear where more diluted space deletion was expected (see Figure 4). In contrast, a body at theoretical rest should produce uniform gravitational "pull," the same from all directions. This is suggested as an area for further research to help resolve the issue.

One star in our Milky Way galaxy, S4714, is estimated to be moving at 8% of the speed of light (Gohd 2020). A review of observations of light bending and gravitational lensing might reveal whether there are differences in gravitational strength in in front vs. behind such a star. Another possible test would be to observe the rates of acceleration toward such a star of any nearby objects approaching from different directions.

6.4 Size and Time Changes Due to Gravity

In general relativity, gravity produces size reduction of matter, and dilation of time in material clocks, at theoretical rest on the surface or at any elevation in a gravitational field, if observed from another frame of reference. The greater the mass, and the closer a body of matter is to the mass generating the gravitational field, the stronger these effects should be, inversely proportional to a function of the radius from the center of gravity. What that function should be is about to be discussed. Both the size and time effects would reach an extreme when approaching a black hole (see 9.5).

Although gravitational time dilation has been experimentally confirmed (Gharat 2019; Redmond 2022), there appears to have been little experimental research on size reduction. Assuming that both effects really occur, the "Waves of Space" model permits a possible mechanism. For this subsection the following definitions should be helpful:

- In-flow means "volons" pushed into matter by external spatial pressure.
- Out-flow means "volons" pushed all the way through matter and out of it, toward another (usually larger) material object with mass. Many would

be "free volons," including those that flowed in, plus some from depletion of "free volons" in matter waves.

- Deletion means the removal of "volons" by mass.
- Restoration means all replacement of "volons" removed by out-flow and deletion, including both replenishment and reconstruction, using "volons" being supplied by in-flow.
- Reconstruction means repair or correction of depletion of matter waves, from which "volons" were removed by out-flow or deletion.
- Replenishment means restoration of lost "volons" that does not require reconstruction, e.g., the use of "free volons" from the in-flow to replace those in the out-flow.
- Shrinkage means a decrease in volume of a material object due to the inability of restoration to keep up with the combined effects of deletion and outflow.

Although most of the volume defined by any material object is proposed to be occupied by standing matter waves, the model allows a limited but important penetrability of matter by "free volons." In the solid and liquid states, there are gaps within and between molecules, particularly organic ones which can have intricate shapes, that are occupied by "free volons." In the gas state, molecules are separated by variable distances that depend on pressure, and the gaps between them are occupied by "free volons." Some of the space deletion caused by mass probably occurs in the interior of matter rather than on its surface.

In a small material object, not moving rapidly, in a gravitational field around a larger object with much more mass, spatial pressure would push some "volons" into the matter. An almost equal number would flow out of the object and toward the large mass, where a large majority of the deletions of "volons" would occur. The "volons" flowing out of the small object would not necessarily all be the same ones that had just been pushed into it. A small amount of space deletion would occur within the small object due to its own gravitation. This in-flow and out-flow would be part of the cascade in which "volons" replace each other en route to replacing deletions. In-flows and out-flows might also oscillate in what has been proposed as gravitational field waves (see 5.3).

Although the "out-flow" would mostly consist of "free volons," some "volons" would be pushed out of the matter waves. Some matter waves should be depleted of their full complement. Some of the in-flowing “volons” would therefore be utilized for reconstruction of those waves. As mentioned in connection with the Lorentz transformations (see 6.2), wave reconstruction should be a more complex and slower process than out-flow, deletion, or ordinary restoration of “volons.”

Because of the slowness of the reconstruction component, there would be a lag in the overall rate of “volon” restoration in matter, behind the combined rates of “volon” deletion and of out-flow from the matter. In weak gravitation, such as that produced by a small amount of matter or at great distances, this lag would be inconsequential. However, in very strong gravitation at short distances, the significance of the lag would be increased, causing shrinkage, and also time dilation as will be explained below.

The basic rationale for the difference in rates is that it takes less time to pull things apart than to reconstruct them. The same in-flow of “volons” into matter is used for four processes: the out-flow, the limited deletion within the mass, the replenishment of “free volons” pushed out of the small body, and the reconstruction of depleted matter waves. The time lag would imply that an increased proportion of the in-flowing “volons” would be consumed than replaced, resulting in shrinkage. If for each 100 “volons” leaving a material body or deleted by its mass, only 95 were fully restored, there would be a 5% shrinkage in volume, and a corresponding dilation of time.

Within a three-dimensional material object, the rates of out-flow, deletion of “volons,” and replenishment would resemble deletions from “shells” of space. Each “shell” volume consists of a spherical surface $4\pi r^2$ multiplied by the single-“volon” thickness of the “shell,” dr, so division by the volume of each “shell” would include division by r^2, following the inverse square law similar to gravity. However, whatever proportion of “volon” replacement required reconstruction would be dependent on the volume of the matter waves for which this is needed.

Equation (4) shows how integration (calculus definition) of multiple shells (left side), produces a volume that includes the cube of the radius (right side). In this case, rather than referring to “shells” of space surrounding a body of matter, on the left side we are imagining theoretical concentric “shells” inside of a spherical body of matter, with the integration limits being from zero at the center of gravity out to the radius at the surface.

$$V= \int 4\pi r^2 * dr = 4/3 \pi * r^3 \quad (4)$$

The volume of a sphere shown on the right side of equation (4) is proportional to the cube of the radius ($4/3\ \pi\ r^3$), rather than the square. Matter wave reconstruction should involve "volons" per volume of matter needing the reconstruction, and therefore might include a factor of division by r^3. This could explain why reconstruction in matter would be slower than the rates of out-flow, deletion, or replenishment of "volons." The percentage of total space restoration (replenishment plus reconstruction) that is made up of reconstruction should depend on the strength of gravitation, and therefore on the amount of mass and the distance from the center of gravity. There should be an equilibrium of the percentage of volume reduction between deletion and restoration, a stable proportion of shrinkage. This reduction should be partially restored if a material object were lifted to a higher radius from the center of gravity, because deletion and out-flow would be decreased, and so would the "volon" depletion of matter waves needing reconstruction.

There are two main differences between the size reduction of a material object in a gravitational field, and the shortening caused by velocity. The former would be three-dimensional rather than along only one axis. Also, more out-flow of "volons" would be occurring than space deletion.

Time dilation by gravitation would be due to deletion of time already traversed by clock hands or any other timing mechanism used. This would be analogous to time dilation (effect "c") of the Lorentz transformations (see 6.3). Like size shrinkage, dilation of time would become significant only in powerful gravitation at short distances. At any degree of gravitation, the equilibrium between space deletion and restoration would determine the percentage of slowing of time and hence of aging. If a material object were lifted to a higher radius from the center of gravity, an increased rate of space restoration would reduce time dilation and increase the rate of further aging, but could not change the reduced aging that had already elapsed during the time in stronger gravitation (Marder 1971).

6.5 Some Confirmed General Relativity Predictions Might Be Explained by the "Waves of Space" Model, or by Others

General relativity makes a number of predictions that have been verified experimentally, although some have required decades for technology to catch up with theory. As summarized in an editorial in Nature Physics (2019), general relativity attributes these changes to curvature or warping of space around masses. The "Waves of Space" model proposes similar effects, but on the basis of space deletion by gravitational masses.

In 1907, eight years before he released general relativity, Einstein concluded that light under the influence of a gravity "well" would experience a gravitational blueshift or shortening of wave length, and a gravitational redshift or lengthening of wave length after leaving that strong gravity. His explanation was based on gravitational time dilation affecting light frequency. Gravitational redshift and blueshift were confirmed by experiments in the 1950s and 1960s (Siegel 2022). Others have mistakenly attributed these shifts to a Doppler effect, which is understandable because the blueshift is often experienced while approaching a mass and the redshift while leaving it (Okun, Selivanov, &Telegdi 2019). However, the Doppler and gravitational wave length shifts are separate and additive effects (Siegel 2022). There have been a variety of additional explanations for gravitational blueshifts, including energy gain caused by gravity.

The present model can explain the gravitational blueshift by space between the wave crests being pulled in toward the center of gravity as part of the replacement of space deletion by the gravitational mass. This is in equilibrium with external space restoration, which however does not quite catch up with the in-pulling (see 5.1). By this rationale, the gravitational redshift is caused by weakened gravitational strength and a new equilibrium between in-pulling and restoration of space from the wavelengths at every increased radius.

The first proof for general relativity offered by Einstein was issued in 1915, the same year that he issued the theory, and was confirmed in 1919 (Editors, Nature Physics 2019). That was an explanation for an anomaly in the precession of the orbit of Mercury. The perihelion of an orbit is the location where the radius is smallest. Precession (slow change in rotational axis) of an elliptical orbit can be expected to occur if the body is not perfectly spherical, if there are any deviations from the inverse square law (Wells 2016), or if there are any gravitational distortions, e.g., due to other planets, mainly Jupiter and Saturn. But even accounting for all of these (though assuming instantaneous transmission of Jupiter's and Saturn's gravity), there was a tiny anomaly of 43 arc seconds per century to the precession in the perihelion of Mercury, which puzzled astronomers until 1915, when Einstein accounted for it and claimed this as the first successful test of general relativity (Wells 2016).

However, there appear to be alternative ways to explain that precession without dependence on either special or general relativity, because the same result has been claimed in at least three other ways. Paul Gerber in 1898 was the first to obtain the correct result, which was praised by prominent physicist and philosopher Ernst Mach and drew considerable attention at the time. However, his calculations were based on ad hoc assumptions, most notably that gravitational effects were propagated at the speed of light, and they were criticized for having no basis in then-current theory and no proof (Wells 2016). Interest in the Gerber derivation evaporated after Einstein's theory was released, but might be worth re-evaluation. Marmet (1999) also derived the same result as Einstein, using matter-energy conservation, but otherwise claiming to have based everything on Newtonian physics with no other aspects of relativity theories. He did calculate changes in length and clock speed, but attributed them to the changes in mass rather than the Lorentz transformations. More recently, Sorli with Davide Fiscaletti claim to have attained the same result using a three-dimensional quantum space model (Zyga 2012).

The "Waves of Space" model would expect Mercury to be shortened and its motion to take less clock time as it passed its perihelion, and meanwhile to be receiving gravitational effects from Jupiter and Saturn delayed by the speed of light. These effects might give Mercury's precession a tiny boost with each revolution.

Time dilation increases in stronger and decreases in weaker gravity, as predicted by general relativity, and as also explained by this model (see 6.1 and 6.4). This was first confirmed experimentally in 1971, by flying atomic clocks around the world and comparing with clocks left on earth (Hafele & Keating 1972). This experiment also confirmed Lorentz time dilation with velocity. A more recent experiment has confirmed differences in time dilation even with minute changes in height (Redmond 2022). The "Waves of Space" model would expect the same dilation on the basis of deletion of space already traversed by the parts of any clock or other timing device, similar to the time dilation of the Lorentz transformations (see 6.3 and 6.4).

General relativity also predicts gravitational bending of light, following "null geodesics" (Hirvonen 2025-b). The current model predicts a similar bending effect, on the basis of space deletion (see 5.1). Newton himself had predicted the attraction of light by gravity similarly to mass, in 1704 in a brief note without elaboration (Shapiro & Shapiro 2010).

The bending of light wave fronts moving horizontally past a planet or star is analogous to refraction. The closer portions of that wave front move slower than the farther portions, as if it had entered a material medium with an index of refraction greater than one. Unlike refraction in physical media, in which there is variation of indices of refraction for different frequencies, there is no separation of colors as light is bent by gravity in space.

6.6 Challenges to Relativity Theories

Although there was vigorous opposition and debate when each of the relativity theories came out, they have since achieved widespread acceptance among physicists. Some are now saying, though, that general relativity has lasted over a century, but will not be our final theory of gravity, in part because it is not compatible with quantum theory (Wolfram 2015). There are still small bastions of dissent, including the journal Galilean Electrodynamics (https://www.galilean-electrodynamics.com/home), and supporters of the Absolute Theory of Relativity (ATR). As described by ATR's apparent chief theorist, Florentin Smarandache (2012):

> *"While Einstein considered a relative space and relative time but the ultimate speed of light, we did the opposite: we considered an absolute time and absolute space but no ultimate speed, and we called it the Absolute Theory of Relativity (ATR). ATR has no time dilation, no length contraction, no relativistic simultaneities, and no relativistic paradoxes…We don't use Minkowski spacetime since we consider it as artificial, imaginary…Einstein did not prove that the speed of light cannot be surpassed, he only postulated it. Therefore we have the right to question this."*

Marmet (2001) identified a fundamental limitation of relativity theories, posing an obstacle in uniting relativity theories with quantum mechanics:

> "*There exists no physical rationalization explaining why and how matter can dilate or contract as claimed in relativity. That physics theory is impenetrable, because it is not compatible with the existence of an absolute physical reality, independent of the observer. Einstein's theory has never been able to provide a logical description of the*

> *physical meaning of relativity. Unfortunately, just as during the Middle Ages, most scientists claim that nature is not compatible with conventional logic. Magic is required in the interpretation of Einstein's relativity."*

The "Waves of Space" model, in contrast, accepts many essential findings of special relativity, including length contraction and time dilation at rapid speeds as well as in powerful gravitational fields, and expects the same results. However, it attributes both to different mechanisms, each resulting in increased space deletion (see 6.2 and 6.4). Gravitational bending of light and slowing of clocks are similarly accepted as logical results of space deletion by gravity. Space expansion is attributed to space addition, not a "cosmological constant" (see 3.2 and 4.4).

The model is inconsistent with relativity theories in several respects. These include arguments that shrinkage of matter in size or length should have mechanisms explaining what happens to the units and function of the matter, and that singularities cannot exist (see 2.6 and 6.1). Also, that motion and variations in size are "real," even though detected and measured relatively (see 9.4). Further, that the gravitational field of a moving body should be unevenly distributed (see 6.3), greater toward the front where more concentrated space deletion is expected, and less toward the rear. If the latter is true, it might be an exception to the equivalence of gravitational and inertial mass. Four-dimensional spacetime becomes optional in the model (see 9.2).

7. DO WE NEED PARTICLES WHEN WE HAVE WAVES?

In Section 6, we considered some implications of the "Waves of Space" model for special and general relativity, looking especially at how the local gravitational field of a rapidly moving body with the wave quality of mass might cause the Lorentz transformations and the increase in inertia. Now, we shall move on to consider the question of whether particles exist or are actually waves, first for light and then for matter. A major cause of complexity and confusion in physics is the intuitive and philosophical belief in particles, with empty space between them. This ancient concept of "atoms and the void" has persisted since the age of Democritus (Berryman 2022). John Dalton reinforced it with his atomic theory over two centuries ago (Barlow 2017). Modern humans retain the concept of particles, probably because it corresponds to our every-day subjective experience of solid physical matter.

7.1 Light Is Made of Waves and Does Not Require Particles; Hypothesis on Electromagnetism

This subsection takes on the issue of whether light requires particles. The term light will apply to all frequencies of electromagnetic radiation. The next subsection will question whether matter requires particles.

Newton and Einstein preferred to think of light as made up of particles, but the wave theory of light, first expressed by Christiaan Huygens in 1690, has more evidence. Thomas Young in 1803 showed that when a beam of light is fired such that it goes through two slits, the photographic images show interference that can only be explained by wave interaction (Ananthaswamy 2023).

None of the particle-like properties of light rule out causation by waves in space. John D. Norton (2022, February) explained particle-like properties in terms of "wave packets" rather than particulate photons. An allegedly particle-like property of light is that the energy levels of electron orbits around atomic nuclei occur in roughly discrete quantities, emitting a photon of light energy at an appropriate frequency when an electron drops to a lower orbital, and absorbing one photon (at the cost of its annihilation) at an appropriate frequency when the electron enters a higher orbital. However, this property too is based on the energy levels of the electrons, and not on particle-like properties of light.

There is no discrete segment of a light wave (such as a certain number of wave lengths) that defines a photon. A light wave is a continuum. This is a powerful indication that light itself as it travels freely through space is not inherently quantized or otherwise defined into units. ***Photons instead are determined and defined by the absorption and emission of quantized amounts of light energy by atoms.*** This contradicts a 1905 article by Einstein, claiming that the total energy of a beam of light was quantized (Styer 1999), When a light wave of an appropriate frequency encounters an atom, the atom can utilize "just enough" of its energy to raise an electron to a standing wave in a higher orbital, or to let it escape altogether from the atom. The "just enough" quantity of light energy is called a photon, which remains a wave throughout and has no need to be considered as a particle.

Conversely, an electron can drop to a standing wave in a lower orbital, and emit "just enough" light at an appropriate frequency to account for the energy difference, as in blackbody radiation (Nelaturu & Wooding 2023). The fact that a photon is not really a unit of light, let alone a particle, but rather a measure of the use of light energy to move electrons between orbitals is not often discussed in physics literature.

An atom contains a hierarchy of electron "shells" and orbitals, each with a greater and discrete energy level. In physics as in astronomy, more distant orbits require higher energy than closer ones, and this is true for electrons around nuclei as well as for satellites around the earth. Only certain energy levels are permitted, and the number of electrons in each "shell" is known to be $2n^2$, with *n* being the "shell" number counting from closest to the nucleus. Orbitals labelled *s, p, d,* and *f* are added to accommodate the permitted electron energy levels within a "shell" that has multiple electrons (Vitz et al. 2024).

The suggestion here is that this may be because all electrons in orbitals are situated where each electron within them can form such a standing wave, with the shapes of these waves varying by orbital (e.g., circular vs. dumbbell or clover-leaf shaped), but all connected end-to-end (Vitz et al. 2024, LaFreniére 2009). In standing waves on circular or equivalent paths with connected ends, the initial and final points are coincident, and the path's circumference must be a multiple of the wave length, so that nodes remain undisturbed (Riggs 2021). This can only be achieved by specific wave lengths in orbitals with specific circumferences. Higher-frequency light waves with short wave lengths provide the extra energy to form standing waves at higher-energy orbitals, and lower-frequency light waves do the same for lower-energy orbitals. Black bodies also emit more high-frequency waves at higher temperatures, although not exclusively.

With respect to interactions with electrons, higher-frequency light can therefore be considered to be associated with higher energy, but this has more to do with resonating frequencies than with the total energy of the light. Certain near-infrared frequencies are not energetic enough to move electrons, but they resonate with the frequencies of chemical bonds and can thereby vibrate molecules. The energy of individual light waves is mostly determined by their amplitude. **Both frequency and amplitude, and in beams of light also concentration of waves, determine energy density.** The relationships among these factors will be further discussed in connection with entropy (see 10.3).

Electrical and magnetic fields are uniquely different from anything else in physics, and rather mystifying in terms of mechanisms. This is not a treatise on electromagnetism, but a few key aspects will be reviewed as examples of this uniqueness. James Maxwell summarized equations that describe most electrical and magnetic phenomena effectively, and apply to all frequencies of electromagnetic radiation, but neither he nor anyone since has supplied an explanation as to why they work (Paschos 2007).

Electromagnetic waves are often described as transverse, with oscillating electrical and magnetic fields perpendicular to each other, propagating at the speed of light. This makes them electromagnetic even though the waves themselves do not carry a charge (Bhattacharjee 2022). In the present model, the fields are volumes of space that conduct the waves but do not create them.

Unique aspects of electromagnetism include that currents of electrons are induced when magnets are moved, and that magnetism is induced by moving charges. Electrical charges can be unipolar, but only dipoles occur with magnetism. For both electrical and magnetic charges, there is attraction, but also repulsion and polarity, and both extend out into space, decreasing with the square of distance from the center of the electrical or magnetic charge (Elert 2024). The attraction and the inverse square relationship of concentration with distance are similar to gravity, but other features including repulsion and polarity are not. Space deletion, proposed to be the cause of gravity in the current model, does not appear to be involved, because these fields have no effect on gravitational fields and vice versa.

All of the features of electromagnetism are rooted in the electrical charges of electrons and protons, which in the current model are properties of matter waves. In three metals considered ferromagnetic (iron, nickel, and cobalt), atoms can directionally align their positive and negative charges, which makes them magnetic, always with two poles (Ghalayini & Vaupel 2017). The impossibility of magnetic monopoles is not surprising, because the atoms thus aligned always have both types of charges due to their electrons and protons. Magnetic phenomena would be due to the wave interactions of the charges issuing from the positive and negative sides of the ferromagnetic materials with aligned atoms.

In a common lab exercise, iron filings scattered near a magnet form lines as they stimulate each other to align atoms and pass on temporary magnetism, while also curving toward the opposite pole. This does not mean that there are actual lines of force. If the waves that influence atomic alignments are self-duplicating, each temporarily magnetized iron filing should in turn temporarily magnetize the next.

An unsupported speculation related to attraction, repulsion, and polarity is that the matter waves (not the electromagnetic waves) associated with electrical charges occur in two opposing wave configurations, with opposite phases. One configuration could theoretically be associated with positive charge, the other with negative charge. Superposition of two waves with the same frequencies and amplitudes but completely out of phase should cause perfect destructive interference. If cancelled waves could allow the next adjacent waves to approach each other, there could be less space between the adjacent waves and hence electromagnetic attraction would occur. Superposition of wave configurations of the same charge (in phase) would produce constructive interference with enhancement of amplitude. If this could increase the space between the next adjacent waves, electromagnetic repulsion could occur. Unfortunately for that speculation, known wave superpositions involve destructive or constructive wave interference of amplitude but not of distance (Bryant 2006). ***The interaction of matter waves in relation to electrical charges is suggested as an area for research.***

7.2 Matter is also Made of Waves and Does Not Require Particles

The concept of particles is intuitive but misleading. The impression that there are solid objects is difficult for humans to think beyond. It may be the most difficult conceptual barrier in getting past the concept of particles. Gaseous and liquid states of matter are less difficult to associate with the concept of waves (even though they can have impacts on our bodies from their momentum), but the solid state is different. When we hit a vehicle, a wall, or a floor, there is a sudden hard sensation from the impact, and damage can be done.

In physics, solidity is consistent with some of the phenomena in mechanics theory, but it is more difficult to reconcile with atomic and subatomic physics theory, in which particles are not really solid or compact at all. If an atom had particles, they would not take up much of its volume, because an estimated 99.9999999% is thought to space not occupied by particles (Sundermier 2016). In quantum theory, wave functions would fill much of the space, and the interpretation of the model would be that "volons" would fill the entire volume, Not only light, but also particles are said to have wave properties as well as particle properties. Louis De Broglie in 1923-24 proposed a wave form for each particle of matter, similar to light, with the relationship of *momentum=(Planck's constant)/wavelength.* Since experiments in 1925-27, it has been known that interference patterns through slits, similar to those with light, occur with beams of electrons (Hosch 2006), and have also been found with protons, neutrons, and helium nuclei (College Sidekick 2024). Thus, both light and matter act as waves.

According to Gabriel LaFreniére (2009), De Broglie proposed that matter mechanics be renamed as "wave mechanics." LaFreniére declared that matter and energy are entirely made of waves, and attempted to characterize some of these waves graphically.

Two or more waves impacting upon one another can produce new waves. It seems considerably more difficult to conceive of how particles can break apart in such a way that their components have exactly the right contents to recombine into other known types of particles. Mechanisms for such particle reconstruction seem to be lacking. In contrast, as noted by Norton (2022, February), waves can break apart and re-combine, and their energy can be modified by changes in amplitude or increased emission. Norton further stated that *"quantum theory demands that we get some of the properties of classical particles back into the waves."* Waves in general have more capabilities than particles, including degrees of freedom, and therefore more potential to explain all the properties of matter and energy. ***The breaking and recombination of waves probably involves tiny fractions of a second for transitional wave forms, which if they resonate can be mistaken for separate particles.***

Hobson has understood this, though he has described the wave medium as fields rather than space. He published an article (2013) entitled "*There are no particles, there are only fields.*" In a follow-up book (2017), he declared that "Reality is made of waves in unseen fields. Quanta such as photons, electrons, atoms, and molecules are not "things. They are, instead, waves in fields, much as water ripples on a pond are waves in water." He noted that at high energies, most quantum field theorists (see 8.2) agree that relativistic quantum physics is about fields, and that electrons, photos, etc. are merely waves (excitations) in the fundamental fields. Nevertheless, he noted, at low energy levels, "*both non-relativistic quantum physics education and popular talk is about particles.*"

When Natalie Wolchover (2020, November) asked 12 particle physicists to define a particle, she got a different answer from each. Some of the interesting responses were "a quantum excitation of a field" or a "bit of energy in a field." Such an excitation or energy in a field could be a wave in the medium of space. Another definition was "a point-like collapsed quantum wave function," but waves should not need to totally collapse for discrete properties to occur, and as we have discussed, there are no dimensionless points and hence no point particles (see 2.6). Still another answer was that particles might be vibrating strings (see 2.3). This small survey suggests two things. First, physicists who work with particle physics do not have an entirely uniform concept of what a particle is. Second, particle physicists are able to transcend the intuitive sense of particles as small compact chunks of matter, which is encouraging.

Regardless of this flexibility, continued use of the particle terminology may have the potential to perpetuate inaccurate impressions in the general public, confusion among students, and perpetuation of a subconscious attitude even among physicists, that they are the "real stuff," and the space that they occupy and that lies between them is not. This can be a psychological barrier to considering the possibility that the opposite is true, and that physical reality is entirely based on waves and other processes in the medium of space. Avoiding this duality and concentrating on that more useful concept could potentially introduce some helpful simplicity to physics.

In order to fully identify matter particles as waves, a method for notation and calculation can be useful. In 1925, not long after De Broglie's proposal and thesis, Edwin Schrödinger developed a wave equation that included all of the variables needed to fulfill the quantum mechanics properties of any particle, and most others except for spin. Schrödinger's equation is widely used through the present time (Johnson 2020). The same year it was proposed, Werner Heisenberg and colleagues developed a matrix mechanics formulation for quantum theory (Heisenberg 1933), an alternate system that is less utilized.

The qualities of the relevant entities considered as particles today can be described both mathematically and physically independently of any particulate nature. Particles are already considered to have wave equivalents. The evolution of conceptualization would be to think of them as waves that sometimes behave in a particle-like manner (rather than the reverse) but do not require a dual nature. Over the coming years, it would be encouraging to see a gradual phase-out of references to particles and increasing characterization of quarks, electrons, photons, and neutrinos in terms of resonating waves and other processes in space, except in historical contexts.

In the "Waves of Space" model, the basic structure of matter is considered to be standing waves. Every subatomic unit of matter (proton, neutron, and electron, or quark and electron) is thought to consist of such a wave form, and every object made of matter is a vast complex of such standing waves.

Despite the basic standing wave structure of matter, the gravitational effects of its space-deleting mass property are proposed to disseminate out as traveling waves through space in "gravitational field waves" (see 5.3). A hypothesis will be considered later that kinetic energy from moving matter acts as a traveling wave (see 9.3).

7.3 The "Standard Model": More Particles than Relevance

Although this manuscript is not enthusiastic about particle physics, it does not mean to denigrate its practitioners. Particle physicists include some of our most brilliant scientists, and their motivations are of the highest order. Howard Georgi has described particle theorists like himself as a *"fortunate breed"* of players in *"the most interesting game,"* to *"determine the rules according to which the world works."* They carry around in their heads "bits and pieces of a majestic jigsaw puzzle," and it is *"rare and wonderful"* when the pieces fit together in a *"surprising and beautiful way"* (Georgi 1989). The years of diligent work by these brilliant scientists have not been in vain. In defining the properties of particles, they have in the process defined the properties of the associated matter waves, and of matter itself.

Nevertheless, some of the particles seem to have been specifically sought in particle colliders partly to test predictions, and to fill in cells and create symmetry in particle tables. There was a motivation to complete the pre-existing "standard model" (Elert 2023; Wolchover et al. 2020), and regardless of the instability of the resonances found, they were given credit for fulfilling the task. This raises questions about whether physicists at the colliders should have been looking primarily for more sustainable entities and been open to other theories. It suggests to skeptics that the "standard model" might be partly an intellectual exercise rather than entirely an essential tool for studying the truly significant building blocks of the universe.

The "standard model" of modern particle physics was developed in the 1970s and continually expanded since. According to this model at present, there are at least 17 different types of so-called "fundamental particles," plus the anti-particle (reversed charge) versions of nine particles with electrical charges. In addition, there are a multitude of combination particles.

Of the "fundamental particles," 12 are called fermions and have "spins" of 1/2, of which six are types of quarks that make up the hadron combinations like protons and neutrons. Only two types of quarks, called "up" and "down," are stable. These are the components of the protons and neutrons that are in the nuclei of natural atoms. The other four only exist for extremely tiny fractions of a second and must be produced by high energy colliders. Quarks are never detected individually; they are confined by the strong force, usually in twos or threes (Elert 2023; Wolchover et al. 2020, October). All six quarks have charges, so they have anti-quarks with reversed charges.

The other six fermions are leptons, the most familiar and stable of which is the common electron. The lepton group includes two other and much heavier types of electrons (muon and tau) that last for extremely tiny fractions of a second, and three types of neutrinos, of which only the lightest, the electron neutrino, is stable (Strassler 2011). The three electrons have electrical charges, so they have anti-electrons with reversed charges. (The neutrinos are also considered to have anti-neutrinos with opposite properties, even though they are not charged particles.)

That leaves five other particles called bosons, which have integer or zero "spins." and are thought to be "gauge" or force-carrying particles. Of those bosons, photons and gluons are massless, while the Z and two oppositely charged W particles are more massive. These particles supposedly carry three of the four fundamental forces, the strong and weak nuclear and the electromagnetic (Wolchover et al. 2020, October). Except for the photon, they cannot be isolated, and hence are considered as "virtual" particles (some photons also being "virtual"). W and Z particles decay. The only familiar member of this group is the photon in its non-"virtual" form. The "standard model" claims that the exchange of virtual bosons back and forth between other particles somehow produces those forces, which may have a good mathematical explanation but is not easy to conceptualize psychologically, or to explain in physical terms.

Virtual bosons are not observable in isolation, so there is only circumstantial evidence for their existence. They can possess and exchange energy and resonate, but so can waves. In the case of quarks, their apparent inability to exist alone could mean that they are components of composite waves that cannot be separated out. Domino Valdano (2022), a theoretical physicist, has produced three definitions for a virtual particle, of which he describes the first as mostly a "mathematical trick," and the third as the quantum version of an "evanescent (very short-lived) wave." In his second definition, a virtual particle might ironically be slightly more real and physical than a real particle, but the latter is "just an idealized mathematical abstraction nobody has ever actually measured in a lab." Taking all of this into account, there would seem to be an argument that virtual bosons, if they exist at all, are waves.

The most recently supposedly detected particle is the Higgs boson, sometimes jokingly referred to as the "God particle." It is credited with imparting all of the mass that other particles have. This supposedly occurred after the "Big Bang," via a universal "Higgs field" (Letzer 2020). That might satisfy some equations, but it seems less appealing logically and philosophically. The resonance at a very high energy level at the Large Hadron Collider, that led physicists to announce its discovery, decayed after $1.56*10^{-22}$ second. It is reasonable to ask how such an elusive entity could have played its alleged role, particularly if the "Big Bang" itself is questioned? As mentioned above (see 2.3), a theoretical additional particle, a "graviton" to carry the gravitational force, has been postulated but not found (Elert 2023, Sutton 2025).

Only five of the so-called "fundamental particles" (up and down quarks, electrons, photons, and electron neutrinos) last long enough to be common constituents of our universe. The anti-particles of the quarks, electrons (the positrons), and electron neutrino (the anti-neutrinos) could be added, because they could be sustainable, but in usual conditions they rapidly collide with their ordinary versions and are annihilated. Wave collapse is easier to visualize than particle disappearance. The five stable types of ordinary elementary particles are commonly found, because for an unknown reason they predominate numerically (Sutton 2024). Perhaps anti-particles might be more common and predominate in the alternate dimensions.

In addition to the "fundamental particles," there are hundreds of combination particles. The hadrons are made up of quarks, including the baryons like the proton and neutron that are made of 3 quarks, and the mesons, each made up of a quark and an anti-quark. Of over 200 hadrons, only the proton is stable on its own over long periods. Isolated neutrons decay after about 15 minutes, but they last much longer inside atomic nuclei, perhaps because protons and neutrons inter-convert there (Strassler 2011). Other hadrons last only for extremely tiny fractions of a second and must be produced by high-energy colliders (Elert 2023; Sutton 2025). None of the mesons are stable.

The unstable entities mentioned above appear in Feynman diagrams depicting particle interactions. *However, they are likely to be unsustainable, ultra-brief, transitional wave forms in the rapid process of converting from one more stable wave form to another.*

Particle physicists could follow the example of chemists, who make a distinction between intermediates and transition states in chemical reactions. An intermediate is an actual molecular form midway between the initial reactants and the products of a chemical reaction. It may last a few seconds or longer, and in some cases can be isolated. A transition state is like a higher-energy vibration (in this model presumably an unstable transitional wave form) that cannot be isolated and lasts for only a tiny fraction of a second (Gonzales 2025). Chemists do not make the mistake of reifying these states into being actual substances, let alone fundamental ones.

Oscar Gomez (2018) identified five important physics phenomena that the "standard model" cannot explain. These are neutrino mass, "dark matter," gravity, the paucity of antimatter, and the acceleration of expansion of the universe ("dark energy"). Wolchover, et al. (2020) noted that it omits the "color" property. Others have mentioned the mystery of proton mass, which cannot be explained by the much smaller masses of its constituent quarks. While most of the physics community currently accepts the "standard model," there are dissenters who consider it as "*totally wrong*" (Cahill 2017).

It is reasonable to question the relevance of any proposed particles that last only an extremely tiny fraction of a second, except as momentary components of transitions between more stable wave forms. In the "Standard Model," some of these particles have supposed importance in the structure of the universe, but those functions cannot be proven. For such particles to continue to be present, they would need to be re-created billions of times per second, and there is no clear way that this could be possible.

The unstable particles are sometimes thought to have had relevance and more stability at the beginning of the "Big Bang" (Green 2004), but that of course is even more speculative than the "Big Bang" itself. Philosophers of science can debate how relevant such entities are to science and whether they are worth the amount of study and investment they are receiving. Even the few stable particles have wave equivalents, and can be thought of as wave forms with resonance, so referring to them as particles at all is unnecessary.

7.4 *Mechanical Waves*

Not all waves are transmitted through "empty" space, i.e., space that lacks a substantial presence of matter. Mechanical waves require matter as a medium (Gregerson 2016; Kaylegian-Starkey & Howard 2023). They include both traveling waves, such as sound and those in oceans, and standing waves such as those in musical instruments. Mechanical waves occur only in the locations in which matter exists. There they constitute the wave form of motion, utilizing kinetic energy (see 9.3). Familiarity with common mechanical waves and the past belief that "matter cannot act where it is not" (McMullin 2002) likely convinced Descartes and other early scientists to believe that all waves required a material medium, and thereby contributed to the ether theory.

Since the "Waves of Space" model characterizes matter as a complex cluster of wavelets representing all of the subatomic components within it (e.g., within molecules), mechanical waves would be waves within waves. That is, the waves that constitute matter would be oscillating in waves, all of this occurring within the medium of space.

8. *QUANTUM QUERIES*

In Section 7, we reviewed the "standard model" of supposedly fundamental particles, considered whether the ones that are not stable or sustainable are relevant, and pondered whether they could all be considered as waves. Quantum considerations were frequently mentioned, but when space was described as consisting of quantized units, the meaning was not explained. Now, we shall take a brief look at a few possible interactions of the "Waves of Space" model with quantum mechanics.

8.1 Quantization, and Hypothetical Small-scale to-and fro Transfers of "Volons"

Quantum theory developed incrementally, starting with discoveries by Max Planck in 1900, three years after discovery of the electron and five years before special relativity (Styer 1999). Like relativity, it has been developed by a series of brilliant physicists.

However, Hobson noted continuing problems with the theory (2017):

> *"It's surprising that, more than a century after the quantum's birth, quantum fundamentals are still in dispute. At the 2011 "Quantum Physics and the Nature of Reality" conference organized by Anton Zeilinger, 27 physicists, 5 philosophers, and 3 mathematicians responded to a prepared questionnaire with 16 multiple- choice questions covering major issues in quantum foundations. Conference participants disagreed widely about several fundamental principles. Meeting organizers summed up the poll by saying, "There is still no consensus in the scientific community regarding the interpretation of the theory's foundational building blocks...The problem is, it's not easy to figure out what the equations and words of quantum theory actually mean. The formal mathematical theory is more abstract, and more difficult to interpret concretely, than other physical theories. Many scientists even question whether the theory describes the real world at all or is instead, simply a useful mathematical prescription for predicting experimental outcomes…"*

Quantum mechanics applies to entities that are very small (quantum actions cannot be identified on a macroscopic scale), and occur in units with discrete mass and charge. At the same time, their location and momentum cannot both be simultaneously known (see 8.3) due to the uncertainty principle (Heisenberg 1933). "Volons" are proposed to be in a size range affected by quantum mechanics. They also act by wave action, and their ability to be deleted or added could explain some of the features of uncertainty and probability.

So far in this discussion, the addition of space has been associated with the Hubble expansion, and its acceleration due to "dark energy," while the deletion of space has been associated with gravity. The space being added or deleted has not included the transfer of complete matter or energy waves. But those might be just predominant directions of the transfer of space under specific conditions, and there might be exceptions. On the Planck or smallest functional scale, movement of individual "volons" of space might be in both directions, back and forth, with one direction predominating but not exclusively. This would be similar to chemical reactions, which proceed in both directions, with one direction usually predominating during reactions but with equilibrium often the end result. The movement of "volons" is likely to be similarly reversible on a small scale. "Free volons" would be most likely to transfer between dimensions in this manner, rather than those incorporated into matter or energy waves.

If a single "volon" of space were to move from our dimensions to the other set, the replacement "volon" transferred back would not necessarily be the same one or restored to exactly the same location. The determination of which "volons" would move, and the new location, would currently be unpredictable and best dealt with as a matter of probability. This phenomenon might be involved in quantum uncertainty. Back and forth oscillations of "volons" between the two sets of dimensions could in themselves be thought of as waves.

Within a single set of dimensions, because waves by their very nature involve oscillation, there is sometimes an alternation of a property, with uncertainty about which version of the property exists at a particular time and place until a measurement is made. The process of measurement (which may require ultra-short wave gamma waves) can alter the wave function, permitting only one version of the property and no further fluctuation. All of these phenomena are consistent with what we know of quantum mechanics.

8.2 Fields and Quantum Field Theories

Recent physics theories rely heavily on a concept of fields, in which values are assigned to locations. Although those locations are points in space, apparently identified by geometrical coordinates, the role of space itself seems to be limited to being a grid for the fields rather than their basic material. If fields were more clearly conceptualized as being areas of space rather than collections of points, it might encourage development of a model such as the current one. Ernan McMullin (2002) has written a history of the concept of fields in physics, tracing centuries of debate among philosophers and scientists about how actions could take place at a distance.

In this article, the term "field" for purposes of this article was previously defined (see 1.6 and 5.3). However, there are different concepts of fields in quantum field theory or QFT. According to one interpretation, every type of elementary particle has a field, and the particles are localized vibrations in those fields (Lincoln 2013). Another interpretation is that fields create particles, and that they are therefore more fundamental than those particles (Strogatz & Tong 2022). In the pre-quantum version of fields, they were associated with forces; in the quantum version, they are associated with particles (Taylor 1989). Various characterizations of how particles relate to fields were included in some of the definitions of particles that Wolchover received in her small survey (see 7.2).

Some physicists consider QFT as a negation of fundamental particles, and that the fields totally replace them (Hobson 2013). Others consider QFT to be essential to particle physics and a way to calculate particle interactions (Wolchover 2020, November).

The wave nature of the "Waves of Space" model may be somewhat compatible with quantum mechanics and QFT. It is less clear whether the concept of discrete "volons" of space is compatible, because of unresolved issues in quantum theory. On the one hand, there are calls to "discretize" space (conceptualize it in terms of discrete units). However, there is a Nielsen-Ninomiya Theorem in quantum mechanics, which some physicists believe may prohibit breaking down space into discrete units (Strogatz & Tong 2022).

Components of QFT include quantum electrodynamics, which unifies electromagnetism with the weak nuclear force into an "electroweak" force, and quantum chromodynamics, which theoretically explains the strong nuclear force by means of gluons (Paschos 2007; Elert 2023). QFT is considered by some physicists to have been a remarkably successful theory, which seems somewhat ironic since there are differences of opinion about its essence and conclusions. However, some physicists also think that its math is incomplete and that it will never impress mathematicians as being rigorous enough (Strogatz & Tong 2022).

Sheng Qin (2022) has claimed that there is a basic flaw in the common conception that fields contain energy. If in every new position of an object it sends out a new field, and especially if the object accelerates, he asked, what happens to the energy in the field from its last location? Is it mysteriously reabsorbed by the mass or charge? He has argued that there is no generally accepted theory for such a process. In the present model, the fields are areas of space in which waves or other processes are active, and in contrast to some current conceptions of fields, they do not contain energy independent of those waves or processes.

8.3 What and Where is a Quantum Wave Function?

The waves of space include quantum wave forms, so what and where those are deserves some brief attention. The equations of quantum wave forms are often described as the probabilities of finding an electron or other small mass entity at certain locations, a view often referred to as the Copenhagen interpretation. That would be reasonable if those entities were really particles and had specific locations. However, the alternative concept is that each mass entity is actually a wave, and that a quantum equation describes the range of locations among which the wave is distributed. The latter concept is favored here, and is considered to be a majority opinion (Norton 2022, February), which will be utilized for this discussion.

The uncertainty principle in quantum mechanics, *(indeterminacy in position)* (indeterminacy in momentum)* $\geq$ h/2π, was derived by Heisenberg from De Broglie's equation *momentum = (Planck's constant)/wavelength.* It requires that if we precisely localize a wave, its momentum must be entirely undefined and must include every possible value; and that if we precisely identify the momentum, the location is similarly undefined, and either the wave is spread out throughout the universe or the probability of finding it is. But those are the extreme solutions. Wave packets are usually considered to be in an intermediate situation, where both location and momentum are partially known.

The vast majority of the location probabilities would be within a small volume, because rapid reduction as the wave would spread would make further extension negligible. Therefore, an electron may be a wave that includes minute portions extending out into space, but its location is predominantly within the volume of its atom (Norton 2022, February). Our senses of vision and touch assign definite borders as to where matter in its solid and liquid phases is macroscopically. That could be partly because beyond those borders, the diffuse extension of matter waves becomes inconsequential.

9 TIME AND MOTION

In Section 8, we examined possible implications of our model on quantum mechanics and quantum field theories. Now, we shall move on again to consider some miscellaneous topics (a potpourri) directly and indirectly related to time and motion. In the course of the discussion, we shall touch on time itself, a classification of motion, electromagnetism, and the “arrows” of the universe. The latter may be less universally unidirectional than sometimes thought.

9.1 Time as a Function of Repetitive Motion in Space

The question of what time really is deserves some special consideration. No other dimension extends in only one direction. In our experience, we can go forward or backward in space but only forward in time. In this discussion, known concepts used in the definition and measurement of units of time will be referenced, to point out that it is convenient but not necessary to consider time as a dimension, let alone as a component of a four-dimensional spacetime. Space, made up of “volons,” is primary, and time describes displacements within space that recur.

As reviewed in this journal by Varanasi Ramabrahman (2018), there have been many different philosophical approaches to the nature of time, from thinkers in ancient India, China, and Greece, to modern physicists. Aristotle defined time in terms of motion, and motion can occur without the need to conceive of time as a dimension (Rassi 2014). Regardless of different philosophical concepts of time, there has been remarkable uniformity at a practical level in how units of time are measured. ***Units of time have always been determined by comparison of the events to be timed with selected repetitive movements.*** Historically, the selected repetitive movements have been astronomical, such as rotations of the earth (days), revolutions around the sun (years), lunar cycles (months), and movement of the sun across the sky (days and hours). Other repetitive motions used for time measurement more recently include pendulum swings, balance wheel oscillations, quartz crystal vibrations, and electron jumps up and down among energy levels around atomic nuclei in atomic clocks (Hadhazy 2010).

The repetitive motions used as measures of time must occur at regular intervals. Our common understanding of “regular” is that the interval between each repetition takes the same amount of time, thus seeming to produce a circular definition that defines time in terms of itself. But that does not turn out to be a problem. Instead, we can compare one type of repetitive motion with another, for example, how many rotations of the earth per revolution around the sun (how many days in a year), or how many such rotations from one full moon to another (how many days in a lunar month). ***A constant or almost constant ratio of two or more types of repetitive motion implies regularity of both***

(although they could both be changing at the same rate).

Mach seems to have had a similar concept of time and regularity. In discussing time, he said it was an "*abstraction*," and that "*A motion is termed uniform in which equal increments of space described correspond to equal increments of space described by some motion with which we form a comparison, as the rotation of the earth. A motion may, with respect to another motion, be uniform*" (Mach 1883). Sorli and Fiscaletti viewed time as a "*numerical order in space*" (Zyga 2012).

An event is the measured entity in the numerator that is to be timed by comparison with the selected repetitive motion. The event to be timed will usually also be a motion, but it could be any process involving "volon mechanics" or additions or deletions of space (see 8.1) A single event can be assigned a time, based on how many fractions of a repetition have occurred between them.

Thus time can be defined just in terms of recurring motions in space. We accept a day and a year as units of time, but to be more aware of the dependence of time on space, we can be reminded that a day is a rotation of the earth in space, and the interval between successive solar high noons. A year is a revolution of the earth around the sun. The number of units into which some such repetitive motions are divided, such as hours in a day, minutes in an hour, and seconds in a minute, is arbitrary, and is set by convention so that people can agree on when events have occurred or are planned to occur.

It is possible to delete the familiar symbols for time from any physics equation, by substituting fractions of repeating astronomical motions in space. Time in an equation is usually in the denominator. e.g., we want to know the number of events per unit of time.

To express the unit of time such as the second in terms of a repeating astronomical motions in space, we can use a fraction in the denominator made up of two variables. One is the selected astronomical event, such as a rotation of the earth or a revolution around the sun (which will be called E_r, for events that repeat or recur). The other is the number of equal parts into which we wish to divide up E_r to derive a shorter interval to compare with the numerator (which will be called P_{er}, for portions of the event recurrence). An hour is one 24th of a day, so . A second is one 86,440th of a day (calculated by division of a day into 24 hours * 60 minutes * 60 seconds or 86,440 seconds). If *E_r is a day,* P_{er} could be 24 for an hour (a 24th of a day). or 86,440 for a second. E_r / P_{er} would be a day divided by 24 for an hour, or a day divided by 86,440 for a second. So the equation v =

s/t (velocity = distance/time) could be written as in equation (5). The speed of an automobile traveling at 50 kilometers per hour could be stated as 50 kilometers per (earth rotation/24) or 50 kilometers*24 per earth rotation, and the speed of light as 300,000 kilometers per (earth rotation/86,440) or 300,000 kilometers*86,440 per earth rotation.

$$v = s/(E_r/P_{er}) = s^*P_{er}/E_r \qquad (5)$$

This exercise was included just to help emphasize that time is recognized and measured only in relation to regularly repeating motions in space. Space provides the real dimensions of the universe. However useful they may be, time and particularly spacetime are merely functions of events that take place in space, and it is optional to consider them as dimensions. In the remainder of this article, time will be referred to in the usual manner, to avoid confusion. Time as we understand it in common usage is a helpful concept, to which humans are strongly bound, and there is no need to eliminate it in order to apply the "Waves of Space" model. However, it is important to realize that time depends on space and is ultimately a function of motions through space, just as Aristotle recognized.

In 1967 the General Conference on Weights and Measures redefined the second as the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom, at a temperature of as close as possible to 0° K. (Betts and Hosch 2007; Scharping 2020). This too can be considered as a repetitive motion (occurring in this case in a very minute amount of space), just like any other criterion for a unit of time.

In our common experience, time is one of the "arrows" (along with space expansion and the entropy increase of thermodynamics) that only proceed in one direction. There is a relationship between space expansion and time passage, as repetitive motions in space continue in our expanding dimensions. However, backward-moving time under other conditions is a theoretical possibility. Gerald Marsh (2014) wrote that the expansion of the universe, entropy increase, and time are inextricably linked. He referred to the arrow of time as "thermodynamic time." However, he also said that in "Friedmann-Lemaître spacetimes," even in a universe that was contracting and entropy was reversing, time would still flow in the same direction as it does in our currently expanding universe. Hypothetical backward-moving time will be discussed in relation to black holes (see 9.5).

9.2 Doing without Spacetime

The concept of spacetime was proposed by Hermann Minkowski in 1908 (Marsh 2014, Galison 1979). This was three years after the publication of special relativity, so it had no influence on the initial formulation of that theory. Einstein is said to have not initially been comfortable with Minkowski's idea of spacetime. Although special relativity made adjustments to both space and time (see 6.2), its conception did not apparently require or incorporate a four-dimensional manifold. However, a decade after the release of special relativity, Einstein incorporated four-dimensional spacetime as an essential part of the mathematics of general relativity.

Minkowski made the following bold prediction (Minkowski 1908):

> *"The views of space and time which I wish to lay before you have spring (sic) from the soul of experimental physics, and therein lies (sic) its strength. They are radical. Henceforth space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality."*

That prediction has turned out to have been an overstatement. The term spacetime is widely used by physical scientists, but as in many of the citations in this article, they often are referring to space over the course of time, rather than to a single combined manifold. Spacetime has been integrated mathematically into many areas of physics, and in those applications, it is useful. But even physicists who specialize in relativity check the time on their watches or phones, and use rulers and tape measures for distance, like the rest of us. There are no instruments in practical use that measure distance or time in terms of spacetime, and no one can actually visualize four dimensions.

Three-dimensional calculations were used for many centuries. In the "Waves of Space" model, three-dimensional explanations have been offered for the curved paths produced by gravity (see 5.1), for the Lorentz transformations (see 6.2), and for conditions related to black holes, so four-dimensional relativistic calculations may not be needed. The model does include a set of three extra theoretical dimensions, but no more than one set of three needs to be considered for calculations at any one time (see 2.4. Although calculations within either set of three dimensions are complicated by continual localized deletions and additions of space, the mathematics should be simpler with a three-dimension than a four-dimensional manifold (Wolfram 2015).

Some theoretical physicists apparently think that unifying relativity with quantum mechanics will require an overthrow of the concept of spacetime (Wood 2024). Some working with string theory think that spacetime is "emergent" from a more fundamental reality. Others specializing in loop quantum gravity believe that spacetime is broken down into units, a concept with similarities (see 2.3) to the present model (Becker 2022). Sorli and Fiscaletti supported a return to three-dimensional space separate from time, and said that there is no experimental support for considering time as a fourth dimension (Zyga 2012).

9.3 What is Motion? Several Types, Including the Mechanics of Matter through Space

Motion has been mentioned but not yet been defined, classified, or related to mechanisms of the "Waves of Space" model. Motion is a change of position of matter over time, relative to a separate frame of reference. The energy for all motion is kinetic.

Material objects maintain their structural integrity as they move through space at normal speeds and gravitation (well below that the speed of light and the gravity of a black hole). The wave nature of material objects consists of very complex and organized combinations of smaller standing waves that stay intact as they change in location. Each material object must move through space as a unit, as it is inconceivable for something as complex as matter to be continually reconstituted, at every Planck length or any other distance interval.

Not everything in the universe can be simplified and unified. It appears that there may be several different types of motion. Motion is traditionally classified (Shah 2024) as linear or translational (rectilinear or curvilinear, changing the location along a path), rotational (changing the orientation of the body or spinning), periodic (following a repetitive path), oscillatory (to and fro), or "random" (pattern of the path not predictable). While these distinctions are important descriptively, the additional classification presented below relates each type of motion to such things as its mechanism of generation, its relation to units of space, and its relation to waves. This is a classification that can be applied to kinematics, and includes both uniform (steady) and accelerating motion.

a. Space addition: This is the motion of recession in the Hubble expansion, already discussed (see 3.1 and 3.2). It is likely that as new space appears, its effect on the recession is not instantaneous throughout the universe, but rather that it propagates outward at a finite rate, either the speed of light or the velocity of recession, which can be slower or faster than light depending on distance. The expansion is three-dimensional rather than linear, which helps to create homogeneity. New "volons" are expected to join in the motions of existing "volons" (see 3.1). When new space joins existing space, it can be expected to set off a wave of displacement of other "volons," including those in matter waves such as astronomical bodies.
b. Space deletion and its replacement: This is the motion of gravitation, also previously discussed in detail (see 5.1). It is not out of keeping with accepted physics for gravity to be considered as a separate type of motion, considering that general relativity is a separate theory devoted to explaining gravity. In the present model, the deletion of "volons" by mass and the in-flow of other "volons" for replacement, are continuous in every gravitational field, regardless of whether there happen to be zero or millions of material objects items or light waves close enough to be pushed in toward the mass by spatial pressure. Gravitational deletion of space occurs within matter, and the cascade of "volons" extends throughout the field, replacing the deletions and then each other. The deletion of space, the gravitational potential energy stored as spatial pressure, and the wave-like replacement process have been discussed (see 5.1 and 5.3).
c. Mechanical wave motion: This includes the motion of mechanical waves like sound that require matter as a medium and travel relatively slowly. More controversial to include in this category are waves like electromagnetic in which nothing with rest mass or defined as matter moves. The oscillating material substance (e.g., molecules or electrons) moves in repeated small to-and-fro paths determined by the wave amplitude (which varies in standing

waves and is zero at nodes). Typically, the units of this substance do not move forward, but the wave action itself propagates forward in linear traveling waves (though not in standing waves).

d. Elastic displacement: Matter that can be stretched or compressed encounters more resistance and builds up more potential energy, the greater the displacement (see 3.2) within tolerated limits, as per Hooke's law (M. Williams 2015). This has been contrasted with the weakening of gravity with space expansion (see 4.1). The rebound caused by that potential energy is part of an oscillation that can generate waves in media and space. In the model, when a substance made of standing matter waves stretched, "free volons" would be pushed in by spatial pressure to fill any extra space, and when it contracted, they would be pushed out.

e. Electromagnetic motion (repulsion, attraction, and induction): This has been previously reviewed, including speculation on wave interactions (see 7.1). Charges and magnetic poles would not delete or add "volons" but would become closer or farther away from each other. These interactions can be blocked or shielded by opposing charges. Motion of an electrical charge produces magnetism (magnetic induction), and motion of a magnet produces an electrical current in a conductor (electrical induction). The model does not provide a complete explanation.

f. Mechanical motion associated with force and space displacement: This is the common motion of matter, both uniform and accelerated, generated by mechanical force (then decelerated to a steady velocity if uniform). It is difficult to define in a way that distinguishes it clearly from the other types of motion, but it can be considered as "none of the above." "The "Waves of Space" hypothesis is that when a material object moves in this manner, many "free volons" within the water and air are displaced, just as the air and water are. ***The space in front of an object in linear motion is transferred toward the rear in a set of concurrent "volon" exchanges, via a route around its sides, top, and bottom , so that a similar number of other "volons" end up behind the object.*** The process described below is suggested as one possible way in which this could occur in a wave-like manner. Analogies are swimming and flying through air. The location of a swimmer or boat advances in a forward direction, while water that is displaced moves backward. Similarly, the location of a bird advances in a forward direction, while air moves backward. Similarly, a group of "free volons" in the same locations as the water and air should move backward with respect to a moving body, making way for the body to move forward. This is another way of conceptualizing Newton's third law of motion, because the motion forward would be creating an "equal and opposite reaction" backward (Helmenstine 2024).

To help conceptualize this process, imagine a boat moving through a lake. Part is above the water, in contact with air, and part below, in contact with water. For each unit of distance encountered and passed by the boat, it pushes molecules of air and water out of the way, making room for itself. Anyone who has traveled on a boat knows that its motion creates waves, including a wake, and also a breeze as air is encountered. It is reasonable to suppose that "free volons" will be part of wave motion similar to that in air and water, as the boat or other object moves through space in addition to moving through the air and water.

Oscillations should be produced by reciprocal motions of "volons." The "volons" pushed out of the way should soon follow curved pathways, first toward each side and the top and bottom of the boat or other moving object, and then continuing to curve toward the rear. The shape of this movement should be similar to that of magnetic flux (and of mythical lines of force) between the north and south poles of a magnet. Individual "volons" starting on those pathways cannot jump all the way to the back of the moving object. Instead, there should be a flow from front to back that can be conceptualized as "volons" pushing other "volons," which push still other "volons" until an appropriate number reach the back to fill the gap created by the movement of the moving object. These "volon" movements have been described above as

> if they occur sequentially, but they are actually concurrent (though not instantaneous).

Continuing the example of a boat, a more detailed hypothetical conception that could explain wave-like transmission is that the "volons" displaced by the boat join and expand the nearest local arrangements of "free volons" along each pathway. ("Volon" arrangements conceptually would not have fixed borders but would act as groups when additional "volons" joined or left,) This expansion is rapidly alternated with contraction, as "volons" (not necessarily the same ones) leave the arrangement they are in and impact and join the next local arrangement of "volons" in the same manner. Meanwhile, that next local arrangement will have expanded from the "volons" joining it and contracted due to passing "volons" on further to the next local arrangement. The oscillating expansions and contractions might extend on and on, toward the rear of the moving object, where a gap must be prevented. Since the front and the rear of the boar move together, concurrently to the "volon" displacements at the front of the boat, near the rear, "volons" would leave the local arrangement of "free volons" nearest to the rear location vacated by the boat, and would be replaced by "volons" from the next arrangement further forward. The "volon" displacement from front to back would thus be continuous and concurrent, rather than sequential.

The oscillating expansions and contractions of all the local arrangements of "volons," due to their synchronized out-flows and replacement in-flows, would act as a wave. Such waves will tentatively be called "space displacement waves," because they are generated by displaced "volons." There might be more than one type of wave with separate distributions and speeds. Those portions of the "space displacement waves" that impact the surroundings might disseminate out surrounding space (within the water or air) at a slower rate, their amplitudes diminishing with distance.

In addition, there might theoretically be a separate and much slower wake of turbulence in space (separate from that in matter) following behind any moving object in a cone shape. Wakes following vessels have long been identified in water and air and are a hazard to other vehicles. Such a phenomenon has not been identified in space alone, but may be worth researching, because it could impact the flight of missiles fired into space at rapid velocities and in parallel paths. Wakes in water behind boats were found by Lord Kelvin to travel at 81.6% of the speed of the boat (Jennings 2022), while wake vortices created by large aircraft produce vortices and have been clocked at only 1.5-3.5 meters/second (Khoury 2023). Either of these can be detected for hundreds of meters.

The boat, like any other moving object, has mass, which will gravitationally delete some "volons," particularly those it encounters head-on (see 5.1 and 6.2). A boat or any other object moving through matter like a liquid or gas in addition to space will of course also experience friction, not discussed above.

All types of motion can interact on a macro level. As examples, a moving ball can strike a body falling due to gravity, and knock it back up or change its trajectory. Gravity can limit the rate of the Hubble expansion. If an object has an electrical charge, its path can be modified by another charge or magnet, and because it also has the other properties of matter, alternatively by a missile, a spring, or gravity. In other classification systems, some of the types of motion just reviewed are considered instead to be categories of energy (e.g., gravitational, sound, elastic, electromagnetic). That categorization was not adopted because they all use variations of kinetic energy.

9.4 Motion is Relatively "Real"

Since matter waves are hypothesized to be capable of motion through space, as just discussed, it seems relevant to consider how we know if something is moving. Whether non-accelerating motion can be absolute has been the subject of philosophical and mathematical discussion since antiquity (Huggett & Hoefer 2021). The concept of absolute motion implies that there is some absolute frame of reference to compare to that is at rest or in a constant state, but the consensus for the last hundred years or so is that there is no such absolute frame of reference with which to compare motion and position, and a state of absolute rest does not actually exist (Norton 2022, January).

Real motion, in contrast, implies a displacement of an object from one location to another, but does not require any absolute frame. The "Waves of Space" model would propose that constant, non-accelerating motion is "real," but not absolute. This could be considered as a clarification of the Principle of Relativity, specifying that it is possible to distinguish motion that is "real," i.e., which of two bodies is "really" moving at a greater velocity than another. However, the detection and measurement of the motion must be relative to that of other reference bodies in a designated frame of reference.

In the model, there are real "volons," through which waves and other processes in space move. Motion by a body would change the distances to other bodies or sources of light situated in space, and would involve an exchange in position of a wave made up of multiple "volons" with respect to other "volons." We can only detect motion by changes in position of one entity relative to those of others, so for detection and measurement, motion is relative.

We can assume that everything is in motion, and that changes in relative positions between two bodies can be detected from either one. It is therefore admittedly difficult to analyze the motion of different objects, except by comparison with other objects subject to similar conditions. Gravitation (not dealt with in special relativity) and rapid velocity also complicate the measurement of motion. In the current model, that is because they both delete some of the space traversed and slow clock speed.

Although special relativity rejects absolute motion (Einstein 1921; Norton 2022, January), it accepts the absolute local detection of acceleration. As summarized by Gibbs (1996), in special relativity "Velocities are relative but acceleration is treated as absolute." In Minkowski spacetime there is a background structure, and there could be absolute motion without acceleration, in relation to that structure (Huggett & Hoefer 2021). However, the current model argues only for distinguishable and not absolute motion.

When two objects pass each other, if neither is currently accelerating, according to common interpretations of the Principle of Relativity, there is supposedly no way for an observer to tell by mechanical experiments which of the two is moving and thereby has more kinetic energy (Gregerson 2019). However, that applies to a local comparison of only two objects, without access to the history of the objects or to the positions of multiple distant bodies for comparison. Actually, there are at least five ways to distinguish which of two objects in steady, non-accelerating motion in the same frame of reference is "really" moving through space more than the other, because of added motion that was imparted more to one than to the other.

a. Difference in time elapsed, i.e., aging: The first difference (and an argument ironically from special relativity itself) is that less time should elapse on clocks (and in aging of living things) on the body to which more "real" motion has been imparted. This time dilation in a "real" traveller whose twin remains on earth is the basis of the famous "twin paradox" (Marder 1971). Information could be exchanged between the twins along the way about clock and aging measurements as the traveling twin continued in a linear path, so differences in elapsed time would not depend on decelerations and reaccelerations as is sometimes claimed. The difference of time elapsed on moving vs. hypothetically stationary clocks has been experimentally confirmed, and debate as to why it occurs have been going on for well over a century. But it is a paradox only if "real" motion is not distinguishable. The twins have different histories as per "b" below. Clearly recognizing that the traveling twin has been in "real" motion should eliminate the paradox.
b. Contextual history: The second difference is that in many real-world comparisons in which one body passes by another, one of them is and the other is not in a situation where it could have been moving. For example, one may have been in a vehicle, while the other has been in a stationary building. In the twin example of "a" above, the traveler has been in a space ship and has undergone a long, confined journey, while the non-traveler has had a normal life on earth and no equivalent means of moving through space.
c. Dynamic history: The third difference between a body with more "real" motion and one with less is that they have different dynamic histories of kinetic energy having been imparted to them by temporary acceleration. Thus, observers on each of two bodies in relative motion to one another could reasonably believe that they were at rest and that the other body was moving, if historical records of past acceleration were unavailable, but not if it is known that one was first accelerated and then decelerated to a steady velocity to achieve its state of motion and the other was not. In Einstein's thought experiments about relative motion, there is no access to such historical information (Einstein 1905, 1921).

d. Change of relative position: A fourth difference (utilizing relative motion as consistent with both relativity theories to distinguish "real" motion) is that movement can also be judged by changes of position relative to landmarks in other frames of reference, on earth or in space, taking into account those bodies' own relative motions. The limitations in distinguishing which of only two bodies is moving, if they can only be compared with one another, no longer apply when comparisons with additional external and independent bodies in different frames of reference are added. One body but not the other may be identified as moving by a global positioning system (GPS, which itself uses relative methods of evaluating positions), or by passing landmarks such as mountains or lakes whose only possible movement is that of the earth as a whole, or by changing its orientation to a geosynchronous satellite. Not only will the environment look different and continuously change as viewed from the moving body, but if it moves from the northern hemisphere toward the southern or vice versa, the positions of the stars will look different as well. In terms of statistical probability, the more frames of reference relative to which an isolated and relatively small object of interest changes its position in a similar direction, and the fewer frames to which a comparison object does so, the more likely it is that the object of interest is "really" moving, or moving more than the comparison object. It is much less likely that the object of interest is at relative rest and that the comparison object and all those frames of reference are moving past it instead.

e. Gravitational field adjustment: A fifth difference, which depends on the "Waves in Space" model, is that the body with more "real" motion should have greater spatial adjustments, including non-uniformity, of its gravitational field (see 6.3). Gravitation as we know is not included in special relativity. In the case of a massive body such as a star or a galaxy, the non-uniformity might be detectable by comparing the gravitational bending of light in front of vs. behind the direction of motion, as measured from a separate and neutral frame of reference.

The conclusion is that uniform motion is can be distinguished as "real" though not as absolute, and that apparent motion by a body that does not fulfill any of the criteria above is illusory and not "real." However, motion can only be detected and measured relative to other objects, so even "real" motion is relative. Because everything in the universe is in various combinations of motion (gravitational, expansion, electromagnetic, etc.), a specific motion added to this complex can be difficult to separate out and study. Quantum effects should also apply at subatomic distances, so that motion can be considered quantum compatible.

Because of these factors, it is useful to consider the baseline pre-motion state for an object whose motion is to be studied, as being at rest relative to various other objects in the same frame of reference. Items whose positions are used for reference should either be relatively stable in relation to the object's frame of reference, or else their own motions should be well understood and taken into account. In those respects, landmarks that are non-moving with respect to a frame of reference can be ideal for the relative measurement of "real" motion.

9.5 Time, Mass, and Matter in a Black Hole

There are at least three possibilities of what happens to objects falling into a black hole.

a. The first possibility, and a common conception, is that matter passing the event horizon (the Schwarzschild radius, $r_s=2GM/c^2$), with its mass property intact, would continue inward to some sort of a "singularity" at the center, as proposed by Roger Penrose and Stephen Hawking (Hawking 1988; UCSB Science Line 2008; Hamilton 2006). It should either disintegrate there, or the laws of physics would break down there. This is consistent with general relativity, in which indefinite shrinkage in size can occur without consideration of what happens to the constituents of matter and how they maintain their function, whether waves or hypothetical particles (see 6.1 and 7.2). As already discussed, however (see 2.6), a "singularity" is an abstraction that cannot exist in reality (Sutter 2022, February). Speaking of the theoretical "singularity" at the center of a black hole, astrophysicist Paul Sutter recognized (2022, February) that "… it doesn't really exist. Something has to replace the "singularity," but we're not exactly sure what." He also suggested that what happens inside a black hole is not only unknown but may never be knowable.

Another consideration is that gravitation decreases within the interior of a mass, for example becoming zero at the center of the earth, because there are equal forces in every direction, cancelling each other out. At the center of a black hole, there might analogously be no gravitational force.

b. A second possibility is that objects might fall no further than the event horizon, and would disintegrate there. One reason to suspect the possibility of the event horizon as the limit is that time would supposedly stop there, at least as judged from outside of the black hole. Falling objects would not progress further because they could no longer move at all due to the time stoppage.

If there is disintegration of matter, whether at the center of a black hole or at the event horizon, the current model would suggest that would be due to in-motion of so many more "volons" than could be replenished that the matter wave structures would not survive. If replacement of deleted "volons" in a black hole were possible, it might take a very long time (see 6.1), and there might be no adequate source of "free volons" for such replacement.

As an object approached very near to a black hole, three-dimensional shrinkage would be expected (see 6.4). However, according to Hawking (1988), shortening of the object in the axis toward the center of gravity would be disproportionally great and would produce stretching "like spaghetti," because a gradient of gravitational strength would be evident at very short distances, and the portion of an object closer to the event horizon would be subject to greater gravitational "pull." The object would then be torn apart. The interpretation in the present model would be that extreme "volon" deletions would disrupt and destroy matter waves. Ironically, this effect should be less in a more powerful black hole, such as a "supermassive" one at the center of a galaxy, because it would be larger and the gradient of force would extend over a longer range of radius (Lin 2024).

c. A third possibility is that matter would accumulate at the event horizon, becoming smaller and smaller, but would not disintegrate or dissociate

> from mass, and that both matter and mass would survive in some form. Any such surviving object would have near-zero size. The Schwarzschild radius increases gradually as the amount of ingested mass grows, and might be able to encompass a myriad of such tiny objects.

A problem with either of the first two possibilities is how mass but not matter waves would survive. Many physicists believe that matter cannot survive in a black hole, which has been described as a "tomb of matter" (Impey 2021). Yet a black hole is expected to accumulate mass as it swallows up more and more matter. There may therefore be a dissociation between matter and its mass waves, the same process proposed for "dark matter" (see 5.4). There seems to be little discussion in physics literature of the relationship between matter and mass, and how it is affected when matter breaks down. Mass waves alone, if they are standing waves like those in matter, might require much less space (fewer "volons") than matter waves, and hence might be able to exist in an extremely contracted black hole. On the other hand, they could be spread out over volumes of space where "dark matter" is believed to exist. The persistence of mass when matter shrinks (see 6.4) is an additional indication that the two are not always proportional.

The deletion of "volons" from matter can be thought of as having three levels of susceptibility. "Free volons" filling the many gaps in the matter waves but not essential to their structure could presumably be deleted most readily. "Volons" that are actually part of standing matter waves but are involved in non-mass properties such as electrical charge might be the next most susceptible to deletion. The most resistant would be those "volons" involved in the space-deleting property of mass. Those could end up on their own as the last remnants of matter.

Why mass does not break down when matter presumably does is unknown, but any such breakdown would presumably be due to "volon" deletion, and mass waves are thought in this model to be the cause of that. The destruction of mass would require the breakdown of the very mechanism of breakdown, and might therefore tend to shut itself off. Perhaps mass waves can break down, but only over a vast amount of time.

The speed of light and an event horizon are both limitations for matter, but they differ. There is only one speed of light in all reference frames, but there can be black holes of different strengths. Also, matter cannot reach the speed of light but can actually reach an event horizon (though that might be the end of it).

Time in the usual direction is believed to slow to a stop at the event horizon, as viewed from a distant frame of reference (Impey 2021). If so, penetration further inside a black hole would be problematic. In the absence of forward-moving time, if objects could still exist at the event horizon (at extremely small size) and continued to fall, that might only be possible in time that began very slowly to flow backward,

Time reversal is not a concept foreign to physics, and might theoretically occur in a black hole. Ernst Stuekelberg and later Richard Feynman proposed an interpretation of the positron (an antimatter electron) as an electron moving backward in time (Schwartz 2015). If so, the small amount of antimatter in the universe could be accounted for by the rarity of negative time. Gravitational acceleration is $G*m/r^2$, as per equation (3). If time were flowing in a negative direction, that acceleration would be in a negative spatial direction as in equation (6).

$$- \ g=Gm/r^2) \tag{6}$$

That would mean that if an object could maintain its existence and could cross the event horizon toward the center, it might thereupon actually move backward rather than forward, in other words back to the event horizon. Therefore, everything would collect at the event horizon rather than continuing on to the center of the black hole, the same result as the second possibility above .

As Chrisy Impey said (2021), we cannot really understand what happens in the interior of a black hole, because physics breaks down. And off course, no traveler can return from a visit inside a black hole to report to us. However, the current model would find the second possibility, disintegration of matter waves at the event horizon, with dissociation and survival of very small mass waves, to be philosophically appealing.

10. THERMODYNAMICS: HOW REVERSIBLE?

In the last section, we reviewed a mix of topics related to time and motion, including the direction of time, which is commonly experienced to only proceed in one direction but might be capable of reversing under special circumstances (see 9.5). We have also previously reviewed the expansion of the universe (see 3.2) and the suggestion that it too might reverse both in an eventual contraction phase and locally under the influence of gravity. The flow of time and the expansion of the universe are thought of as two of the "arrows" of physics. Another "arrow" is the second law of thermodynamics in which entropy (a tendency toward increasing disorder) has been assumed to continually increase. The "arrows" are considered to be linked (Marsh 2014). It therefore seems appropriate to review the "arrow" of the second law of thermodynamics.

10.1 The "Arrow" of Entropy

The second law of thermodynamics requires in general terms that the overall tendency of a system will be toward increased disorder (or at least thermal disorder), and many understand this to mean and greater distances among component parts. Part of a system may acquire increased order only if it imports energy from another part that is becoming much more disordered. At one time, this law was considered as sacrosanct territory in physics. Einstein is said to have written that the second law *"is the only universal physical theory that will never be refuted."* Arthur Eddington said in the 1920s that "*The law that entropy always increases—the Second Law of thermodynamics—holds, I think, the supreme position among the Laws of Nature*" (Kostic 2020). However, in more recent times, attitudes of some scientists toward this law have become more nuanced.

The second law of thermodynamics is based on work by Sadi Carnot and William Thomson (Lord Kelvin), and was stated as a law of physics by Rudolf Clausius in 1850 as: *"It is impossible for a self-acting machine, unaided by any external agency, to convey heat from one body to another at a higher temperature"* (Wolfram 2023). At the time, heat was thought to be a substance called caloric (see 10.2), so the law said that the caloric moved from hot to cold but not in reverse (Siegfried 2024). That is understood by today's mechanical theory of heat as saying more or less that a collection of molecules with more vigorous motion will increase the motion of less vigorous molecules. The second law has generally been understood to require that entropy will tend to increase unless energy is applied to force things together and to be more organized (Micu 2023). But even some true believers in the second law admit problems with definitions and ambiguous meanings (Kostic 2020). Scientists have reportedly not been able to agree on how to state the second law precisely, and efforts to prove it mathematically have been inconsistent (Siegfried 2024). We shall explore it a bit historically and philosophically in relation to the current model.

10.2 Cold Comfort

The ancient Greeks, including Aristotle, considered fire to be one of four basic substances (along with earth, water, and air). During the last few centuries, heat and cold went through other stages of reification prior to the rise of our current concept. Three phantom substances were postulated, sometimes with competing proponents. The popular theory of phlogiston, a substance of combustion (possibly modeled on the ancient Greek concept of fire as an element), was developed in the early 1700s. In the 1800s, cold was thought by some scientists including Count Rumford to be a substance called frigoric (Chang 2002). Those theories were succeeded by caloric theory introduced by Antoine Lavoisier (Morris 1972). Once heat was discovered to cause the kinetic effect of molecular motion, it gradually became understood as *being* molecular motion (Siegfried 2024).

Even the formulation about the flow of molecular motion can be reversed to some extent by changing one's philosophical and semantic perspective. The conception can be inverted to give the power to cold over heat, i.e., to say that cold bodies always dilute the temperature of hotter ones. While it is true as Clausius declared that a warm body cannot transfer heat at a higher temperature than its own, neither can a cold body transfer chilling at a lower temperature than its own.

When a cup of hot water (with greater molecular motion) is mixed with a cup of cold water (with less molecular motion), after a brief period of molecular collisions, the average molecular motion will determine an intermediate temperature. Physicists and most of the general public of course prefer to think of this as a flow of heat energy to the colder object, but it can alternatively be thought of as a flow of coldness to chill the hotter water. In a steam engine, the condensation of steam back into liquid water is just as vital a step as the production of steam from the water. We think of the latter as requiring heat energy, but we could instead conceptualize cooling energy to slow down molecular motion. Assuming that the second law is correct, it could be interpreted as meaning that cold is ultimately more powerful than heat, because in the long run things will become colder.

This exercise in conceptual reversal can be carried only so far, because the universe appears to be powered primarily by thermonuclear energy in the stars (including our sun), which of course produces extreme heat. Also, in the example of a steam engine, or in any engine, heating precedes cooling, suggesting that heating is primary and drives the process. But it is a good example of flexibility of perspective, and of how ***the human mind is capable of multiple interpretations of existence and causation***. Past beliefs in false entities like fire as an elementary substance, phlogiston, frigoric, and caloric, and earlier attribution of physical phenomena to gods and demons (Siegfried 2024), are examples.

10.3 New Space, New Energy, Less Entropy?

Of the four recognized forces in physics, gravity and the strong force are attractive forces that can "pull" things into greater order (reduced entropy), but the strong force only functions at very small distances. The weak force is involved in radioactive decay (Taylor 1989), so it is the only one of the four that can be considered entirely to increase entropy, but it is also very short-ranged. Electromagnetism can both attract and repel, so it has a mixed or neutral effect on entropy. ***Overall, the mixture of forces that can increase or decrease entropy suggests that we should consider a nuanced approach to whether the dynamics of the universe (perhaps including two sets of dimensions) favor an increase, a decrease, or relative stability of entropy.***

One might expect the expansion of the universe to increase entropy. As the volume of our dimensions of the universe increases, existing matter and energy waves can disseminate among the "volons" in that increased space, and become slightly more diluted over time. That would provide a theoretical mechanistic link among the "arrows" of expansion, time, and thermodynamics, assuming that the expansion is associated with the passage of time.

It is commonly believed that the expansion is making the universe colder and that its ultimate fate will be a "Big Freeze," sometimes referred to as a "heat death" (Bets 2023). ***However, the common conception that high light frequency always indicates higher energy is oversimplified.*** There appears to be a lack of consistent evidence for a steady decrease in temperature throughout time.

The energy of any type of wave is indeed proportional to its frequency.

Frequency is particularly important in interactions with atoms (see 7.1). Even some physicists tend to focus only on frequency when they discuss the CMB. However light energy is also proportional to the square of the amplitude, and therefore amplitude has more impact. For example, you can have a bright red light with more energy than a dim blue light, or a hot infra-red light and a cool ultraviolet bulb. The CMB is very cold because it is spread out thinly throughout space, but your microwave oven produces concentrated, high-amplitude, low-frequency microwaves and can heat up your lunch.

Light wave concentration is another determinant of light energy, that is particularly relevant to the expansion of the universe. The energy density of beams of light in lumens depends in part on the concentration of light and is reduced by the square of distance from the source, an inverse square law similar to that of gravity. The sun's rays are much hotter because of greater concentration as they leave its surface than after they have spatially dispersed with distance, including that due to expansion, by the inverse square law.

The implication that things have been getting steadily colder would seem reasonable, if one could assume that all the energy that the universe has ever contained had come from a hot "Big Bang," with no additional energy being added ever since (see 4.2). Under those conditions, energy density should have indeed been diluted by increased wave lengths as well as distance.

However, this model suggests that space addition ~~may~~ adds energy to our dimensions. If space expansion has provided an energy boost, there could be one or more entropy-reducing effects. There should be little objection to the idea that if the light from existing stars becomes more intense, and if new stars are created that pour more heat into our dimensions, those phenomena should tend to decrease entropy or reduce its increase. The model suggests that those very things could result from space expansion.

As existing light waves travelled toward us from distant galaxies, space expansion could do more than just increase wave lengths. The expansion could ~~also~~ produce kinetic energy. The recession of matter and hence of masses from each other at the Hubble velocity (see 3.2) would involve the new "volons" impacting and displacing existing ones. ***In this model, recession due to space expansion is "real" motion.*** Since that recession of masses accelerates as its velocity increases with distance (let alone that the expansion itself is accelerating), it would seem to fulfill the classical Newtonian definition of a force, *mass*acceleration*. Applying that force over distance would fulfill the classical definition of energy and work, *force*distance*. It may have been assumed that when material objects are being pushed outward and away from each other in all directions, they will not impact one another, but since the "volons" being inserted would impact other "volons," they could indirectly affect matter motion.

The force of expansion could be a factor in the creation of spatial pressure (see 5.1), which in turn could produce mechanical (e.g., gravitational) and thermal energy. However, if spatial pressure increases, it is apparently counter-balanced so that net pressure can remain stable. As already suggested (see 4.4), the impact of "volons" on one another might also speculatively produce vortices capable of generating new matter.

Atoms excited by the kinetic energy could experience electrons jumping to higher orbitals. When those electrons returned to lower orbitals, they would give off new light waves (see 7.1), some of which might have higher amplitude than ambient light. New waves would increase energy density via wave concentration, adding to light from extremely distant sources. As in black body radiation, however, the wave lengths would likely be longer than visible light, because atoms in space that were not in stars would not be expected to reach high temperatures. With further space expansion, some of these new electromagnetic waves might reach the microwave frequency range, and be interpreted as part of the CMB (see 4.2).

During our current expansion of the universe, there is some evidence suggesting that its thermal content may be increasing, not decreasing. Chiang, et al. (2020) reported that the temperature of galaxy clusters has actually risen about tenfold over the past 10 billion years of expansion. The authors suggested that this might be due to the gravitational collapse of "dark matter" and gases to create new galaxies (M. Williams 2020), perhaps an example of energy redistribution and conservation.

Astronomers working with the James Webb Space Telescope have also discovered that light from the most distant galaxies is much brighter than expected. This is the light that has had the most travel time through expanding space. That finding has been such a surprise that it has raised doubts about the lambda-CDM model (see 4.1) and even about the "Big Bang" (Catanzaro 2023;

Malewar 2024). The presumption has been that the earliest galaxies were more massive than thought possible, but the suggestion here is that some of the brightness might be generated by space expansion.

There is also evidence that many new stars are being created in some regions, which should produce significant amounts of new heat and other energy. This is occurring particularly within nebulae referred to as "stellar nurseries," including the Orion and Eagle nebulae within our galaxy, in which gravity is presumably coalescing gases (Lamb & Henderson 2023). ***Over recent decades, much research has been done one the lifecycles of stars, but it is suggested that more work be done to estimate the ratio of star deaths to new star births.***

Such kinetic and electromagnetic effects could limit the cooling effect of the expansion. Outer space is currently very cold, but the beginning of expansion in our dimensions was not necessarily as hot as is assumed in the "Big Bang" theory.

The idea that space expansion could introduce new energy raises questions about conservation of energy. There is already recognition among physicists that ~~controversy about whether~~ "dark energy" is an exception to conservation of energy (Cartlidge 2017). The energy conservation question is neither unique to nor created by this model, which only seeks to help explain it. ***In this model, total energy (sum of kinetic and potential) would be conserved within the total closed system of the visible and alternate invisible dimensions combined.*** This could be considered analogous to a Hamiltonian (Hirvonen 2024-a). Energy could be moved in the form of "volon" exchanges from one set of dimensions to the other. Once in a given set of dimensions, energy would be conserved there except for further inter-dimensional exchanges. General relativity is claimed by some to only require local energy conservation (Hossenfelder 2019).

10.4 Probably So

In any localized area, statistical probability can determine whether entropy increases or decreases, as Maxwell insightfully recognized (Siegfried 2024). The second law may be basically a manifestation of that probability, which is in turn dependent on a number of factors, including initial states of order and their disturbances, the volume of space available for dispersal, ambient conditions affecting entropy including gravitation and expansion, and the attractive and repulsive properties of materials present. We are located in a highly ordered environment to start with, due to entropy having been decreased, mostly by gravity, when our earth and solar system were formed. There is a lot of space around us, full of "volons" but with fewer waves, for redistribution of matter, and there are many ways and potential states in which things that are already assembled here can break apart, separate, or cool down. As a result, it is not surprising if our common experience is of entropy increasing.

If we were to take a box with plenty of available space, containing an organized structure made of matter such as a tower of blocks, as our initial state, and were to shake it so that it broke apart, entropy would increase. A box full of electrons repelling one another would likewise tend toward maximum separation and entropy.

On the other hand, if we were to start with tiny floating magnetized specks of iron, in a box of similar size, and were to use the same amount of energy to shake the box, the units would tend to clump to some extent due to their attraction for one another, negating any expectation of increased entropy. And if there were a strong bipolar magnet in the box, alignment and attachment of the small magnets to the large one and to each other would likely be greater and there would be stronger evidence that entropy had decreased. Similarly, if we were to have a box with some naked protons and allowed a stream of electrons to flow in (both part of a closed though initially polarized system), they would join together into hydrogen molecules, likewise reducing entropy. Once they were both in the box, no additional energy would have needed to be applied.

In summary, in the entire experience of our lives, time has been unidirectional. Astronomical evidence suggests that the expansion of the universe has likewise been consistently unidirectional for a long duration. Unidirectional thermodynamics with a statistical tendency toward an increase in entropy is also common (though not ubiquitous) in our experience. ***However, these "arrows" do not necessarily apply to all localities and conditions, or to the extreme long term future of the universe.***

11. CONCLUSIONS

Starting with the logical train of thought introduced at the start of this article, and following through step by step in the subsequent sections, a new "Waves of Space" model of the universe has been developed. ***The aim has been to***

propose an alternative way of conceptualizing the physical world, with a more seamless system in which the basic composition of the universe is responsible for its processes, and each phenomenon explains others in a way that can be followed by human reasoning. This model should help make some phenomena more comprehensible, which have been previously described and incorporated into equations, but have never been adequately explained before in terms of mechanisms or in relation to other known phenomena. Everyone is invited to explore this conceptualization, including those theoretical physicists, astronomers, mathematicians, philosophers of science, students in all those fields, and lay persons from other occupations who dare to think slightly "outside the box."

The following conclusions are some but not all of the hypotheses presented in this article. For those that seem difficult to accept or do not resonate, referral to the appropriate sections of the article is recommended, using the contents list for reference or searching for key words.

1. The "Fundamental Principle": Space is the ultimate material of the universe, and is the medium of fields and of the transmission of gravity and of electromagnetic waves. This is the underlying cause of the remaining conclusions. Postulating any additional fundamental substances complicates theoretical physics unnecessarily. Space is proposed to be quantized and made up of discrete, "real," universal units, which nevertheless can be added and deleted. The name "volons" has been tentatively assigned to such units of space, and group action by "volons" to create waves has been termed "volon mechanics." This concept is also important with respect to motion, in which groups of "volons" pass by and displace other "volons." Motion of matter is "real," and faster motion should be distinguishable from slower. Nevertheless, any motion is also relative in that it must be detected and measured relative to other objects.
2. The Hubble expansion of the universe is best explained by the addition of tiny units of space in-between those of existing space, which supports space being a substance. This occurs everywhere but is opposed by the local space deletions of gravity. The expansion exceeds those deletions except in locations close to high concentrations of matter, where more units of space are being deleted than added. When new space is added

to existing space, objects appear to recede from one another. Because matter occupies only a small amount of the universe, gravity does not prevent the expansion from being predominant and relatively homogeneous. When units of space are added to one set of dimensions, they are suggested to be coming from deletions in the hidden set of other dimensions. In this model, three dimensions in each set are considered to be adequate for computations, because time is considered as a function of space rather than as a fourth dimension.

3. Gravitation is explained by the deletion of units of space ("volons") by mass. Only units that actually come in contact with mass can be deleted. When units of space are deleted, they are thought to be transferred from our dimensions to the alternate set. This deletion results in an in-flow of surrounding units of space toward the mass to replace the deleted units, propelled by external spatial pressure, which is higher than the pressure around the mass where space has been deleted. The mechanism involves a cascade in which the "volons" closest to the mass are pushed into it, while other "volons" are pushed in to replace those "volons," the next adjacent "volons" replace those "volons," and so on. Deletion of space and in-flow of replacement space toward mass reduces the distances to other masses or light, or serves as a centripetal force for orbits or bent pathways. Although the term mass is often used as a synonym for matter, for purposes of this model, mass can alternatively be thought of as one of the main wave properties of matter, which either causes or regulates space deletion, and therefore is the key to gravity and also to inertia.

4. Matter at theoretical rest (a term used because there is no absolute rest) can be thought of as having a spherical "shell" at each radius, a single "volon" thick. The volume of each shell is the surface area of its sphere*one volon of radius thickness. The amount of space removed per time from each "shell" is the same, but as the effects propagate out to greater distances, the spheres' surfaces become larger and the deleted space becomes a smaller fraction of the total volume of each successive shell. Because the area of a sphere is $4*\pi r^2$, which includes the square of the radius, gravitation is diluted by the square of distance from the center of gravity, an explanation for the inverse square law of gravity.

5. The gravitational field around every mass produces size reduction and time dilation in matter by a mechanism different from general relativity. In small bodies of matter in the gravitational field of a larger body, some

external "volons" flow into the small body and "volons" also flow out toward the attracting mass. Some of the "volons" that flow in are deleted by the mass of the small body itself, and some are used to reconstruct matter waves depleted of "volons." The rate of restoration of space in the small body is slower than the rate of out-flow, at least partly because the restoration incorporates an element of wave reconstruction that should be proportional to the volume of matter needing reconstruction. That should be inversely proportional to the cube of the radius because volume is $4/3 \pi r^3$, whereas the space outflow should be related to the inverse square. These effects are negligible except in very high gravitation at short distances, at which they cause a three-dimensional reduction in the size of matter in the "shells" around the mass. Deletion of space already traversed by clock hands would set the hands back and result in dilation of time, as well as being a balancing force in inertia. Explanations by the model for size reduction and time dilation by gravity are consistent with general relativity, and supply mechanisms missing from both relativity theories.

6. It has been assumed for over 100 years that gravitational information travels at the speed of light, but this model develops mechanisms and proposes that gravitational fields propagate outward from mass in a wave-like manner. Each "shell" of space around a mass would alternately lose and regain units of space, an oscillation of "shell" volume that would be transmitted throughout the gravitational field, limited by the speed of light. The traveling oscillations would constitute waves of gravitational effects, labelled here as "gravitational field waves." These are not currently recognized in physics, but would explain known phenomena and are worthy of study.

7. There are factors tending to accelerate the expansion of space, currently thought of as "dark energy." The most obvious is that the more new space is added, the more that new space increases the velocity of recession, in accordance with the Hubble equation ($v=H_o*s$) which itself implies exponential acceleration. Currently, there is a net acceleration, but it is not exponential. Several other factors have been identified that could accelerate and decelerate the expansion, and the current acceleration may represent a balance of these.

8. The properties of matter and of most energy may be accounted for by oscillating disturbances within the space medium. These include the wave functions (the "Waves of Space," quantum and other) associated with so-called sub-atomic particles, complemented by effects of space addition and deletion, vibration, and other processes in space.

9. The gravitational field of a moving object would be redistributed, causing gravitational "pull" toward the object to be greatest immediately in front, weakest behind, and "normal" and intermediate from the sides, above, and below. Experiments should test whether overall gravitational "pull" increases with motion, which is relevant to the issue of "relativistic mass." Non-uniformity of the gravitational field might also be testable by comparisons of gravitational bending of light in front of and behind rapidly moving stars. There are several types of motion of matter, generated differently, e.g., by space addition, space deletion, mechanical wave oscillation, elastic displacement, electromagnetism, and common mechanics. In all types, at ordinary velocities and gravity, matter in motion retains its structural integrity. Linear motion requires the transfer of "volons" in front of the moving material object to the rear, to make room for the transfer of location of the object. This transfer sets off "space displacement waves," just as motion in air or water creates wakes.

10. The inertia of uniform linear motion (Newton's first law) at normal velocities could result from a balance of space deletions. The moving object should experience more concentrated space deletion from its own gravitation in front in the direction of the motion than behind it. Because of this minute difference in space deletion, spatial pressure would be greater from behind, tending to accelerate the forward motion of the object. However, this should be balanced by deletions of space already traversed, leaving forward motion unchanged. In the inertia of rest, space deletion and spatial pressure would be balanced from all directions.

11. Bodies of matter in linear motion would encounter more space in a forward direction that would be available for deletion and for in-flow to replace deletions. The rate of increase in space deletion in the front-to-back axis should exceed the restoration of space within matter. The latter might depend at least in part on the volume of matter in which waves needed to be reconstructed, the same mechanism for slowing as in #5 above.. Those effects, explaining the Lorentz transformations of

special relativity, would be negligible except at velocities close to the speed of light, at which unrestored space deletion within the moving object would cause length shortening in the axis of motion. Deletion of space already traversed would reduce the forward movement of clock hands or any other device used to measure time. These actions only occur with "real" motion.

12. The concepts of time as a geometrical fourth dimension, and of four-dimensional spacetime (whether flat as in special relativity or curved as in general relativity), can be a barrier to new conceptualizations. All waves and other processes travel through the three-dimensional space medium, as it expands overall by addition of more units or contracts locally due to their gravitational deletion. Time itself is a helpful concept, both mathematically and intuitively for common usage. However, it is just a ratio of events in space to selected repetitive motions or fractions thereof, also in space (such as a year, day, hour, minute, or second). In other words, time is a ratio of changes of positions in space to repetitions of other changes of positions in space, and thus is totally a function of space. By applying to all frames of reference regardless of gravity, throughout the universe without restrictions of locality, the model with adaptations could provide new conceptions that might ultimately permit substitution of a single new theory for both relativity theories.

13. The traditional concept of particles is intuitively appealing but misleading. It lacks relevance in the large majority of proposed subatomic particles that have no stability or sustainability whatsoever. It creates the problem of particle/wave duality, and serves as an intellectual barrier to understanding the present model as well as the wave-like nature of the quantum world. Entities of matter and most energy are accounted for solely by waves and other processes in space. Particles might eventually be considered as a historical mischaracterization of those waves and other processes.

14. Light (electromagnetic waves) is made up of continuous waves, and in contrast with some common conceptions, it is not inherently quantized or made up of particle-like units. Photons are determined by the interaction of light with atoms. A photon is not a little identifiable segment of a light wave, but rather a quantity of light energy at the appropriate frequency, that an atom absorbs or gives off, to bump an

electron up or down, from a standing wave state at one radius from the nucleus, to a standing wave state at the next higher or lower available energy level, i.e., from one electron orbital to the next higher or lower one, or to leave the atom entirely. That energy is what is quantized. Light can only travel where there is space in our familiar dimensions; and the speed of light is one of the properties of space as a substance.

15. Geometric systems offer theoretical grids for space, but those that have been developed do not match reality perfectly. Although Euclid's system has been used in this article to explain the inverse square law, the physical existence of dimensionless points, and of lines and surfaces without thickness, is not evidence-based. In this model, the geometrical grid is physical and made up of the "volons" of space themselves, rather than being a theoretical and abstract one overlain on the physical world. Physics would be a more realistic science if "singularities" and "point particles" were eliminated from physics theories, and if teaching and literature emphasized that these do not really exist (although "point particle" techniques in problem solving have wide applications, and should be retained though possibly renamed).

16. Mathematics is a necessary tool in physics, but involves some abstractions that also do not necessarily exist. There has never been evidence for the physical existence of anything infinitely large or small in size or in any other characteristic, and physics breaks down for anything smaller than a Planck length. Both scientific observations and theory indicate a finite age as well as size of the universe. Although in calculus, some variables seem to approach unimagineably large values, physics teaching should always emphasize that actual infinities are non-existent abstractions.

17. The continuous addition of new space within existing space, and the acceleration of that process, should add energy to our dimensions. The energy of light waves is directly proportional to their frequencies (decreasing during expansion), but also directly proportional to the square of their amplitude and the concentration of light beams (reduced by the inverse square law but increased if new light is generated by the expansion). Despite not possessing mass in itself, the expansion accelerates receding galaxies and therefore can be considered to be a force. It is known to produce apparent movement of masses by separating them, and therefore could be considered as a source of kinetic energy. The impact of old and new "volons" against each other

might also cause vortices that could theoretically generate new mass, which in turn could create more gravitational kinetic energy. New electromagnet waves might also be generated. By these mechanisms, entropy increase and a decrease in temperature as the expansion progresses might be slowed. More speculatively, overall expansion and local deletions of space throughout the history of expansion could conceivably be the ultimate source of all or most of the energy and matter in our dimensions, an alternative origin theory to the "Big Bang."

18. Our "observable universe" and the three additional unseen dimensions proposed above could be in gradual harmonic oscillation, similar to the "Big Bounce" theory. The hidden dimensions may be currently contracting as our dimensions expand, and might eventually expand while ours contract. There would be an alternation of expansion and contraction phases, each starting and ending slowly as one set of dimensions gradually ran out of space to transfer to the other. This would be a dramatic contrast to a "Big Bang," and would lack the implausible "singularity" and "inflation" features of that theory.
19. In a black hole, everything would likely collect at the event horizon and would not progress beyond it. Matter might disintegrate there due to extreme deletion of its "volons," yet mass accumulates in a black hole. This is an example of hypothetical dissociation of matter and mass when waves of the former break down, which may also be associated with "dark matter."
20. Individual "volons" of space might constantly be exchanged back and forth between the two sets of dimensions, with restorations not necessarily in the exact locations of deletions, possibly explaining some quantum effects.
21. The "arrows" of time, space expansion, and second law of thermodynamics, though one-directional in our experience, might theoretically be reversible under other special conditions. Of these, the universality of the once-revered second law depends primarily on probability, and varies by location and time.

Some of these theoretical proposals have been suggested previously by others, or take only a small leap from those that have been proposed before by others. However, they have either not previously been incorporated into a model, or they have not been widely extrapolated to consider their full implications for other aspects of physics and astronomy. All are implied by the "Fundamental Principle" or are consistent with it. Some aspects of the model may seem counter-intuitive, but no more so than relativity or quantum mechanics, and they are based on scientific data and reasoning. ***Getting past barriers imposed by human intuition about what is "real" may be the key to a breakthrough in scientific thinking that will help us to resolve problems in physics and to better understand the nature of the physical world.***

A model constructed as an alternative to current physics concepts should not be castigated for succeeding, and for thereby being inconsistent with those very concepts. "Overall, dissent has served the lofty principles and ideals of scientific enterprise" (Ćirković & Perović 2018). Those who might wish to excommunicate the model from the science of physics should at least consider it as an important contribution to the philosophy of science, and specifically of space and time.

More details of this new model for the universe will of course need to be developed with the help of experts in each facet. In particular, the mathematics implied by the model needs to be developed. Experiments and observations that can be practically carried out, and can differentiate between this model and traditional or other new competing theories, should be planned and conducted. Inconsistent data should be identified, quantified, and addressed.

Physics as a whole tends to become dogmatic and to resist new ideas such as those presented here, especially if they come from outsiders. However, solutions to unsolved problems, as well as unification and simplification, may require their serious consideration. ***This "Waves of Space" model could potentially evolve into a new paradigm for physics, cosmology, and philosophy.*** It may contribute a partial map to reach the elusive "theory of everything," or at least of many things. Even if its reach does not turn out to be that significant, it is directly relevant as an alternative explanation for a number of unresolved scientific problems. In fact, even if only a small number of its hypotheses prove to have merit, it will have been an important contribution to our understanding of the universe.

A parting wish is that we shall all soon live in a world at peace and cooperation, with increased awareness that we are neighbors and cousins filling a tiny planet in a vast cosmos. Also, that disagreements among us will peaceably focus on the best ways for us to understand the universe, and for us and our fellow living things to survive and thrive in it together.

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Associate Professor, School of Medicine
Loma Linda University, Calilfornia, USA
1233 Friar Lane, Redlands, California, USA
1-909-838-4157
ronhattis@aol.com

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