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21st Century Gravity
(a deeper understanding of why apples fall from trees)

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ABSTRACT: Physicists have tried to guess what gravity is and why it behaves as it does for centuries. An alternative to guessing, deduction from first principles of physics, leads to some surprisingly simple and intuitive physical descriptions of gravity, while remaining mathematically compatible with general relativity (GR). We call this physical interpretation "graviton general relativity" (GGR).

KEYWORDS: Speed of Gravity, Speed of Light. Special and General Relativity, Photons, Gravitons, Elysium, Elysons, Lorentian Relativity.

I. INTRODUCTION

Why do apples fall from trees? The simplistic answer "gravity" is sufficient for schoolchildren. But physicists and all who seek to understand nature want to know what gravity is, how it works, and why it behaves in that way.

Up to this point, the two models of gravity that have dominated physics over the past three centuries, Newtonian gravity and Einstein's general relativity (GR), have provided primarily mathematical answers to the question of how gravity works, but had little to say about the "why" question. Indeed, Isaac Newton explicitly said "I make no hypothesis" about why gravity behaves as it does.

When pressed for the physics involved in gravitation, relativists these days are partial to the "geometric interpretation" of GR because if gives the illusion of an explanation for why bodies accelerate in a gravitational field. This is in contrast to the "field interpretation" of GR, as preferred by Einstein, Dirac, and Feynman, among many others. In the field interpretation, gravity remains a classical force of nature, and that force is supplemented by various field effects such as light-bending. In the geometric interpretation, gravity is not a force, but is due to the "geometry" (curvature) of "space-time". (Space-time is a complex concept that is *not* a simple combination of 3-dimensional space plus a time coordinate expressed in space-like dimensions by multiplying by the speed of light, its inappropriate name notwithstanding. Space-time is more accurately thought of as "proper time" – as kept by real clocks affected by motion and gravitational potential – and normally has no purely space-like component [[1]].)

It is not our purpose here to critique the geometric interpretation of GR. That has been done elsewhere [[2]]. However, we must note in passing that curvature, whether of space-time or anything else, including space, cannot initiate motion in physics in the absence of a force acting. (Curvature can initiate motion in mathematics simply by hypothesis. But in physics, a physical cause is mandated.) There are two reasons why curvature cannot cause motion. (1) Curvature in the

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absence of any force is asymptotically flat within an infinitesimal neighborhood of any given point. Without initial motion, the local flatness would assure that motion never commenced. (2) Changing from non-motion to motion is a change of momentum. This new momentum must be transferred by a force, even if it is only an impulse force (i.e., one active only for an instant), by the very meaning of "force" – the transfer of momentum from one material body to another. The alternative would be creation of new momentum from nothing, which is always inadmissible as an explanation in physics because it requires a miracle.

GR uses the “rubber sheet” analogy to suggest how curvature could initiate motion. See Figure 1. A source mass makes a large dent in a rubber sheet, and a small particle starts at rest on the sloping side of the dent. GR argues that the small particle will then start rolling downhill deeper into the dent because of the curvature of the rubber sheet. But this same analogy serves equally well to show why the particle cannot be moved in this way. If the rubber sheet is in isolated space, and no force acts, then the particle must remain where it is because no direction in isolated space is “downhill”. The analogy works in our imaginations only because we are lured into thinking of the rubber sheet as residing on Earth, with a pre-existing force of gravity already operating underneath the rubber sheet to pull the particle downhill.

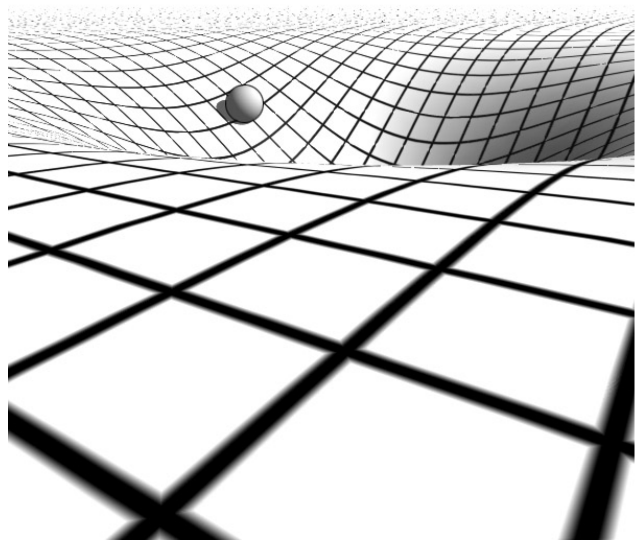

Figure 1. The “rubber sheet” analogy for curved space-time: A source mass makes the large dent, and a small particle rests on the side of the dent. © 2003.

II. PRINCIPLES OF PHYSICS

Experience shows that, when wishing to understand the nature of physical entities, assumptions can be hazardous and commonly lead to contradictions with observations or experiments at some point. Moreover, in a meaningful sense, assumptions are just guesses, even if “educated” ones and the resulting models are then highly dependent upon these guesses. We are therefore little better off than if we simply guessed the final model.

The alternative to using assumptions is, first, to recognize that assumptions are always questionable, even when arrived at inductively from the laws of physics. In part, this is because even the laws of physics are subject to change and improvements in understanding as knowledge advances. The second point to note is that the principles of physics derive from logic alone, and are therefore not subject to such limitations. And to the extent that our minds are operating logically, they are not subject to change or improvement as knowledge advances. The only "assumption" required by the principles of physics is that a common, shared reality exists. Although this assumption cannot be proved, the alternative (that reality is subjective) is known to lead to erroneous inferences, and is ultimately as arbitrary as allowing miracles as explanations; whereas the common, shared reality model is not known to lead to such failures. The principles of physics therefore provide a suitable alternative to making assumptions.

One of the most basic principles of physics (none of which have counterparts in mathematics) is the causality principle. In its most succinct yet complete form, it states, “Every effect must have a proximate, antecedent cause.” The only alternative to strict adherence to the causality principle by nature is magic, or equivalently a miracle or the supernatural [3]. However, the field of physics is tasked with explaining reality without invocation of such concepts for the simple reason that, if allowed, anything could be explained as magic or the action of a supernatural being without further ado, which would then frustrate any further attempt to understand the phenomenon, and usually makes predicting future occurrences impossible.

As applied to our desire to understand gravity, we note that a corollary of the causality principle is that "substance" (a generalization of “matter” to include anything material and tangible”) cannot be created or destroyed. The first half of this is obvious, given the causality principle, because creation of substance from nothing is an effect without a cause (miracles excluded). The various forms that substance can take, of course, always come into existence and pass out of existence. However, they were formed from other pre-existing substances (such as atoms or smaller constituents), all of which continue to exist in some form long after any particular form is gone.

The idea that substance cannot pass out of existence is more subtle, but equally compelling in logic once we get around the limitations of language and direct our attention to the meaning of the concept itself. For example, we use “pass out of existence” casually to describe the passing of forms, or to describe something so thoroughly decomposed or destroyed that we may no longer be able to detect the constituents from which it was made. Nonetheless, every such constituent is another form, and remains available somewhere to combine again with other constituents to make a new form, or to further decompose into smaller constituents. When we say that substance cannot be destroyed, we refer to the logical impossibility of something becoming nothing, the exact inverse of creation of something from nothing. Either would require a miracle. We will come to the issue of the interchangeability of matter and energy shortly.

Another application of the causality principle is that momentum also cannot be created or destroyed. Momentum is most simply described as the product of mass and velocity, although waves and other entities for which no simple “mass” concept exists also have momentum because their individual constituents have substance. Here, we will concentrate on the velocity part of momentum to avoid the issue of a generalized meaning for "mass".

As is well known in standard physics, when two bodies collide and rebound, they may exchange momentum, but the total momentum is unchanged. Likewise, when two bodies collide and merge, the new combined mass has the combined momentum of the separate bodies. So in a physically meaningful sense, the momentum (velocity) of any entity is as much a property of its existence as is its mass (measure of substance). Even if we adopt a reference frame in which a body’s speed is zero, in which case it has zero momentum in that frame, its momentum relative to other bodies is what really matters because no frame can claim to be universal.

The causality principle tells us that we cannot create or destroy momentum, just as we cannot create or destroy substance. Completing the parallel between substance and momentum, bodies can change their speeds in such a way that the total momentum is unchanged, just as bodies can change their forms while preserving their constituents.

Energy is also a function of mass and velocity. In physics, we say that mass and energy are interchangeable, with either being convertible into the other. But this does not imply that substance and speed can be exchanged. When a body explodes, part of its substance is released in the form of energy. We call this a “blast wave”. However, that energy consists of tiny substances (constituents of the original body) moving at very high speeds, and therefore possessing appreciable momentum. Some textbooks encourage thinking of energy as a mystical entity apart from substance. But that would be illogical, given that substance includes everything material and tangible by definition. Only substances can have velocities. It is irrelevant for our purposes here if an explosion breaks a body into constituents with some so tiny that no existing instrument can detect them. It must still be the case that the sum of the released constituents must be the equal of the original body.

Similar remarks apply to speeds. The only way that substances can interact is by contact. Contacts can result in the partial or total transfer of momentum from one substance to another. That momentum consists of mass and speed. If the contact results in combining the two masses, the result can be no more than the sum of the masses. Likewise, in the transfer of speed, one substance cannot push another faster than its own speed. Therefore, in an explosion, constituents with high speeds must already exist within the pre-explosion body in the electrons or smaller constituents moving or vibrating rapidly within atoms. The explosion then merely frees these constituents to escape from the body they were trapped in, traveling away at their pre-existing high speeds. An explosion cannot create such speeds from nothing. These high speeds might exist only in the electrons or smaller constituents moving or vibrating rapidly within atoms. The explosion then merely frees these constituents to escape from the body they were trapped in, traveling away at their pre-existing high speeds. An explosion cannot create such speeds from nothing.

So when bodies accrete other bodies, forms and speeds change, but total substance and total momentum are preserved. When a body decomposes or explodes, the substances and original speeds are released. Portions of the energy that seems to disappear into a body during accretion and reappear during an explosion are hidden as friction or heat. Physically, this means the motions or vibrations of molecules, atoms, or smaller constituents. But substance and momentum can neither come into existence from nothing nor pass out of existence into nothing.

III. NATURE OF FORCE

Given this starting position based on the causality principle and the principle that nothing and something are not interchangeable*, then the only physical means that bodies have available by which they can interact is through collision and the exchange of momentum. A single inelastic collision produces a one-time, discrete exchange of momentum. We describe this in physics as an “impulse force”. A continuing series of collisions and momentum exchanges of a similar character would produce a continuing exchange of momentum, which physics describes as a classical force. Mathematically, we describe this in the following way:

$$F = ma = \frac{d}{dt}(mv)$$

where *F* is force, *m* is mass, *a* is acceleration, *d/dt* is the derivative with respect to time *t*, *v* is velocity, and *mv* is momentum. Because $a = dv/dt$ by definition, force may be described as the time rate of change of momentum whenever mass is constant.

In this viewpoint, force always requires the collision of substances (however small, even if undetectable) and the consequent exchange of momentum. Then all forces are intrinsically of the pushing variety, and in the direction of the relative velocity of the colliding body. The easiest way to get a pulling force is to have isotropic pushing forces acting on a body from most or all directions at

* The two principles in question are "no creation *ex nihilo*" and "no demise *ad nihil*".

once, then to have another body block that isotropic force in one particular direction. The net of many pushing forces combined with the *absence* of a pushing force in some particular direction will create the effect of a pulling force in that direction. Other pulling forces, such as pulling a wagon by its handle, are really pushing forces in disguise. We wrap our hand around the handle and apply a pushing force toward ourselves against the inside of the handle.

IV. LE SAGE MODEL

Gravity is a type of pulling force. From the preceding reasoning, we are led quickly to what is called a “Le Sage-type” model to describe the “how” and “why” of gravity. In such models, the universe is filled with a sea of ultra-small, ultra-fast substances classically called “gravitons”. These will provide the isotropic flux needed to produce a pulling force. To ensure that the force affects all constituents within a body equally, these gravitons must be so small that they easily pass through most bodies without noticing, and only occasionally hit something that absorbs them. (Neutrinos also have this property, but are not nearly numerous enough to be the gravitons.) In that way, each comparable constituent of a body has an equal chance of absorbing a graviton. See Figure 2.

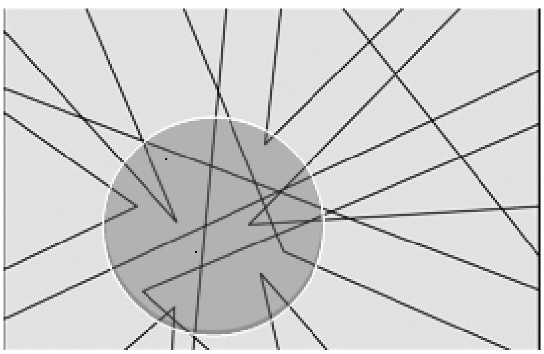

Figure 2. Gravitons can easily fly through bodies of planetary or stellar dimensions, but are occasionally absorbed as they do so.

The essence of the model is then simple. Any two bodies in space will shadow one another from some graviton impacts. See Figure 3. Then more impacts will occur that push the bodies together than apart because each body shadows the other from some impacts in proportion to that body’s own mass (or constituent count). With a bit of thought, one can soon see that the net effect of such pushes from the outside is identical to pulls from inside the bodies. So we are free to think about pushing or pulling gravity interchangeably, whichever is more convenient for understanding any given application [4].†

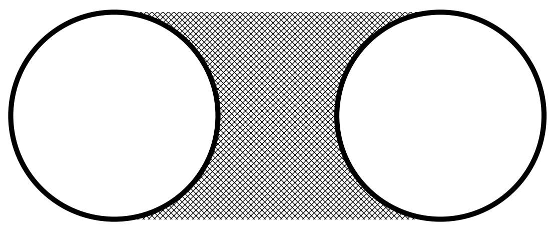

Figure 3. Any two bodies will shadow one another from some graviton impacts, resulting in a net push toward one another by the asymmetry of the gravitons that do collide.

The Earth is a body that absorbs some gravitons from the universal flux. The result is a net graviton wind always blowing downward toward Earth’s surface, because some of the balancing upward-bound gravitons in the universal flux are absorbed by the Earth. The basic Le Sage model then answers the “why” question: The apple falls to the ground because it is pushed in that direction by a vertical graviton wind, rather than by something reaching up from inside the Earth and pulling it down.

† Slight deviations from this symmetry, such as "drag" on bodies moving through the graviton medium might produce, can be neglected in any such comparison. For example, gravitational acceleration is proportional to mean graviton speed squared, whereas drag is proportional to the product of that speed and mean orbital speed, a much smaller quantity. The ratio of the source mass radius to the radius of the smallest entity producing drag also enters this comparison. See formulas on pp. 126 & 128 of the preceding reference.

V. BASIC GRAVITY PROPERTIES

In Newtonian gravitation, the acceleration of a target body is directly proportional to the source mass and inversely proportional to the square of the distance between the two. Unstated but implicit in Newton's universal law is that gravity appears to act instantly, without detectable propagation delay.

We have already seen why the basic Le Sage model yields an acceleration proportional to source mass – because the number of blocked gravitons depends on the number of comparable source mass constituents. The inverse square property is likewise easy to understand. A graviton shadow will spread in two dimensions as it extends in the third. See Figure 4. As with all substances, gravitons must have a finite speed and cannot act instantly. However, the mere existence of Lorentzian relativity (LR) eliminates the necessity for a universal speed limit as implied by special relativity (SR) []. So nothing prevents the Le Sage gravitons from propagating so fast that we cannot yet detect any propagation delay. Indeed, all six experiments bearing on the question of the speed of gravitational force propagation indicate a strongly faster-than-light speed. The strongest of them sets a lower limit of $2\text{x}10^{10}\ c$, where c is the speed of light [5].

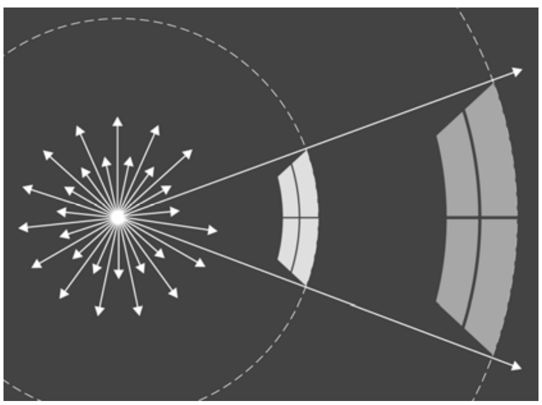

Figure 4. Any entity that spreads in two dimensions while propagating through a third will obey an inverse square law. © 2003.

So our developing understanding of gravity involves a propagating, pushing force rather than a pulling one. As such, gravitational force is necessarily a dynamic entity carrying energy and momentum, rather than a passive entity such as curvature. We will examine below some of the behavioral differences this implies.

VI. GRAVITY VS. LIGHT

Collectively, this sea of gravitons constitutes a space-filling medium. It is logical to ask if this medium might be the aether, the hypothetical light-carrying medium giving rise to the wave properties of light. However, while light exhibits all known wave properties[‡], our hypothetical gravitons are required to have only particle properties. Moreover, the speed of a wave in its generating medium must be close to the speed of the primary constituents comprising that medium. For example, in a gas, $v_{wave} = \left(\sqrt{5}/3\right) v_{gas\,molecule}$. But as we noted above, the mean speed of gravitons must be at least $v_g > 2\text{x}10^{10}\ c$. We will also mention evidence below that gravitons collide

[‡] Wave properties: wavelength, frequency, intensity, amplitude, refraction, diffraction, coherence, interference, polarization, absence of mutual collisions, radiation pressure, transverse and longitudinal vibration, sameness of properties for each discrete entity, propagation speed unaffected by speed of source. Light also exhibits two particle properties, the photoelectric effect and the Compton effect. But because these also have possible wave interpretations until the wave strikes matter and ejects electrons, it seems more reasonable to conclude that light is a pure wave phenomenon than to conclude that it is some kind of mathematical "dual entity", lacking a physical description.

with one another, whereas light waves cannot. And ordinary matter must be nearly transparent to gravitons, whereas it obviously is not transparent to light. So for all these reasons, the graviton medium and the light-carrying medium cannot be one and the same.

As it happens, this will turn out to be an advantage for our developing understanding of the nature of gravitation.

At this juncture, we need some terminology to help keep distinguishable concepts distinct. We have already co-opted the term “gravitons” for Le Sage’s carriers of gravitational force. On a larger scale, the expression “light-carrying medium” refers in a generic way to whatever as-yet-undiscovered medium is responsible for the wave properties of light.[§] In relativity, the expression “space-time medium” is used instead, but seems to have an identical meaning. The literature also uses other terms with the same basic meaning: “aether”, “LCM” (the initial letters of “light-carrying medium”), and “elysium” (because of its phonetic similarity to “LCM” and its appropriateness in Greek mythology, where it is also used to describe “fields”). We will here adopt this last term, elysium, in part because it carries the least baggage with it from past usages. We can then call the unit constituent of elysium the “elyson”, which is not too dissimilar-sounding from its larger cousin, the electron.

We next need to describe the properties of elysium. Elysons must be closely packed so that each is in intimate contact with neighboring elysons. There is no empty space between them in the same sense that there is no empty space between water molecules. Such close proximity is required for a medium that transmits a transverse wave, the type that light is known to be.[**] The nearest dominant mass, whether a nucleon or a galaxy, entrains nearby elysium, just as it would any gaseous medium such as an atmosphere. Elyson vibration or oscillation speed and local elysium density (if elysons are compressible) or pressure (if incompressible) then determine the propagation speed for light with respect to that locally entrained medium. Despite the lack of empty space between elysons, a material body can move easily through the elysium, much like fish through water. Elysons are too small and too low in density to provide significant resistance to motion or to interfere with gravitational, electromagnetic, or cohesive forces in material bodies.

VII. FORCE VS. POTENTIAL

We concluded above that gravitons cannot be photons, but rather are much smaller and faster constituents that inhabit space. But that implies that the larger-scale elysium must logically be affected by gravitons just as any other known form of substance is affected. So elysium near a source mass must be packed more densely because of the weight of the elysium above it, just as would be true for the atmosphere of a planet. This elysium weight compresses the elysons; and the compression increases the medium density by an amount that depends on the force of gravity. The effects of this are to reduce the speed of light in the denser medium, and to bend light beams by refraction wherever the medium has a density gradient. It is important to note that only a change in density with distance from a mass is needed to secure these effects. The elysium density at infinity can be arbitrarily large.

[§] The definition of "wave" in physics is "an oscillation that travels through a medium by transferring energy from one particle or point to another without causing any permanent displacement of the medium".

[**] Although not relevant to our model development, it seems likely that light may have both longitudinal and transverse components – a prediction that would be difficult to verify experimentally.

The importance of speed reduction in a medium affected by gravity was known to Einstein and Eddington at least by 1920. In his book [6], Eddington says: "Light moves more slowly in the material medium than in a vacuum, the velocity being inversely proportional to the refractive index of the medium. The phenomenon of refraction is in fact caused by a slowing of the wave-front in passing into a region of smaller velocity. We can thus imitate the gravitational effect on light precisely, if we imagine the space around the Sun filled with a refracting medium which gives the appropriate velocity of light. To give the velocity $c(1-2\mu/rc^2)$, the refractive index must be $1/(1-2\mu/rc^2)$, or, very approximately, $1+2\mu/rc^2$." In Eddington's notation, μ is the product of the gravitational constant and the source mass, and *r* is the distance from source mass to target body.

In the notation we will use here, the change in gravitational potential from its background value at infinity is $\phi=-\mu/r$, which ranges from zero at infinity to increasingly negative near a source mass. The value of background potential at infinity can be any arbitrary constant. But in the elysium model, each elyson has a vibration or oscillation speed that must be slightly faster than the wave speed of that medium. Specifically, if elysium were an ideal gas, average elyson speed would be $v_e=3c/\sqrt{5}$. So if we summed the kinetic energies $½m_e v_e^2$ of all elysons with mass m_e in a larger body at rest with total elyson mass *m*, we would arrive at a total energy of that body of 0.9 mc^2. This would seem to be the appropriate value of the additive constant for potential at infinity: 0.9 c^2 per unit mass. But it is interesting to compare this with Einstein's best guess for the total energy available in a body, $E=mc^2$. With elysium, we have found a firmer physical basis for our formula than Einstein had. But no existing experiment is accurate enough to tell us which one is the better formula. However, it is not at all certain that elysium behaves like an ideal gas, so the numerical constant we estimate here could change. Measurements of the actual constant in the future should provide important clues to the kind of medium elysium is.

A medium with wave velocity $c(1+2\varphi/c^2)$ and a density gradient imposed by the force of gravity matches this description perfectly. Then the change in the density of elysium falls inverse-linearly with distance from a source mass, just as the change in potential does. But this is an important twist from the usual understanding in relativity. We have just inferred the existence of a static field surrounding any source mass with an inverse-linear variation with distance from the source and having a wave speed equal to the local speed of light. This field is then fully capable of producing light-bending and other relativistic effects in the exact amount predicted by GR through the mechanism of refraction instead of "space-time curvature". Hence, ***elysium is indistinguishable from the effect of a gravitational potential field.*** Both are co-located, have an arbitrary background level, and change in an inverse-linear way near masses. It is therefore reasonable to conclude that they are one and the same thing. This is a major conclusion of this paper: the gravitational potential field is equivalent to the light-carrying medium.

Elysium is entrained in the same way, and out to the same distances, as potential satellite orbits are stable. In the case of the Earth, this goes out to over 100 Earth radii. Regarding experimental results bearing on elysium, the Michelson-Morley experiment did not detect Earth's orbital motion because the elysium within the interferometer is moving with the planet. But Earth's rotational motion is motion with respect to local elysium, so the Sagnac (1913) and Michelson-Gale (1925) experiments did detect the planet's rotational velocity in their speed-of-light measurements. Entrained elysium also explains the "paradox" that light from a star at the Moon's limb is shifted 20" by stellar aberration, whereas light from the Moon's limb itself is not shifted. Aberration must occur at the wide, soft boundary between elysium at rest with respect to the Sun and elysium at rest with respect to the Earth, which boundary must lie well beyond the Moon. This also provides a much simpler explanation for the absence of a solar potential effect on atomic clocks on the rotating Earth or in GPS satellites than that offered by relativity [[7]].

Electromagnetic theory is beyond the scope of this paper. We simply note in passing that an oscillating electric field, alternating quickly between two opposite directions, creates an oscillating magnetic field, which in turn generates a new oscillating electric field further away, and so on. The wave spreads with the speed of light, and Maxwell suggested that this indeed was light. But here, we see light as the wave manifestation in elysium when electric and magnetic forces operate. This is analogous to gravitational potential changes (gravitational waves) being the wave manifestation in elysium when gravitational forces operate. To use another analogy, force is like the impact of an asteroid, and electromagnetic waves in the elysium are like the sonic boom that impact sets off in a planetary atmosphere. The wave speed and the force speed are independent physical quantities. For consistency with Maxwell's equations, the electric permittivity of free space would need to vary as $1/(1+2\varphi/c^2)$. This would explain the gravitational bending of light in a flat space context without abandoning the ability of Maxwell's equations to explain other electromagnetic phenomena.

Note that the static gravitational potential field is not itself an energy reservoir for potential energy (PE). PE comes from gravitons and the application of gravitational force rather than from the gravitational potential field. PE requires work to create, and can do work when released. But the gravitational potential field cannot transfer momentum or do work under ordinary circumstances. (We will discuss gravitational waves later.) It can only modify the behavior of waves and of the wave properties of matter, but cannot directly affect the ballistic properties of matter. The absence of intrinsic potential energy in a potential field is evident for a body placed inside a uniform spherical shell. The interior has arbitrarily large potential but no force acting on the body, which then has no potential energy.

In this picture, gravitational force creates the gradient in the gravitational potential field, rather than vice versa. The direction of the arrow of causality is reversed. Because gravitons and elysium are unrelated mediums, in principle the gravitational potential field could cease to exist without effect on the Newtonian component of gravitational force between bodies.

VIII. GR PROPERTIES

We see that gravitons propagate and produce ordinary (Newtonian) gravitational force, the acceleration of masses, and therefore elliptical orbital motion in flat Euclidean space. The gravitational potential field is static and is responsible for the additional effects predicted by GR: light-bending, gravitational redshift, Shapiro delay, and perihelion advance. The mechanism for these effects is refraction in an optical medium, also existing in flat Euclidean space.

We have already seen how this operates in the case of light-bending. Details of how these effects are produced by refraction in an optical medium with a density gradient imposed by gravitational force may be found in [[8,9,10]]. Only the perihelion advance, which affects the ballistic motions of material bodies, requires a bit more exposition than simple refraction, which we develop elsewhere []. That explanation relies on the wave properties of matter – probably induced by extensive elysium "atmospheres" surrounding quantum particles. It is interesting to note in that derivation that this physical model yields the correct perihelion advance in a single term in the equations of motion, whereas GR requires contributions from three terms, one of which cancels 40% of the effect of the other two.

It seems important to note that our detailed physical picture of gravitation conforms to the same mathematics as Einstein's GR, at least through first-order terms in the potential ϕ. In that sense, it is merely an elaboration of the field interpretation of GR already in use for nearly a century, and scarcely merits being called a new model. Even the new physical elements are largely based on the old Le Sage model. Yet the physical picture developed here is undeniably different from that usually described in either GR or standard Le Sage models in significant ways that become ever more important as the precision of observations improves. So to avoid confusion, we will refer to our new physical picture as "graviton GR", or "GGR" for short.

IX. NEW PROPERTIES OF GGR

GGR conforms to all the traditional properties of Newtonian gravitation and first-order GR. But it does predict five new phenomena not yet generally recognized by physics. These are:

(1) The speed of propagation of gravitational force, or the rms speed of gravitons, is strongly faster than light, but in forward time. (SR allows such speeds only for mathematically "imaginary" masses in reverse time.) This speed is therefore in full conformity with Lorentzian relativity (LR), although not in accord with the expectations of SR. Specifically, the speed of gravity $v_g > 2\text{x}10^{10}\ c$. This new property is already confirmed by six experiments [5,11,2], and opens the door to solutions for dilemmas with apparent non-locality in quantum mechanics.

(2) The inverse square character of gravitational force cannot have the infinite range it has in Newtonian gravity because, at some mean distance, gravitons must collide with other gravitons and scatter into the graviton shadow of any source mass. It is interesting to note that, if the rms distance between graviton-graviton collisions is about 1-2 kpc, then over longer ranges gravity would more closely obey an inverse linear law, as is actually observed. This behavior is presently attributed to the effect of unseen "dark matter". GGR provides an alternative to dark matter.

(3) For very dense states of matter, gravitons would be more effectively absorbed. This could prevent gravitons from reaching the interior of such very dense bodies, or at least lower the frequency of interior graviton absorptions compared to near-surface absorptions. This is called a "gravitational shielding" effect, and prevents all matter within a dense body from making its presence felt in the body's external gravity. It also limits the degree of collapse of any body under gravitational forces, preventing the formation of a true singularity.

(4) Because gravitons are dynamic and deposit energy inside any mass that absorbs them, bodies receive heat from the graviton medium. The five largest planets in our solar system and our Moon are all known to radiate more heat into space than they receive from the Sun. The source of this heat is presently considered unknown, but graviton energy is a candidate.

(5) While the advance of the pericenter of elliptical orbits is the same in GR and GGR when the mass of the orbiting body is much smaller than the source mass (as for Mercury and the Sun), a predicted difference does arise when both masses are large []. Four cases of large-but-unequal stellar binaries with measured pericenter advance are known, and all are discordant with GR predictions. Tidal effects complicate the interpretation. But GGR does seem to work in the direction of lessening the discrepancies.

More details of these predicted properties and of the comparison with observations may be found at [8,12]. See also the next section.

X. GRAVITATIONAL WAVES

With our derived picture of gravitation involving the interaction of two distinct mediums, it is easy to see why the subject of "gravitational waves" (GW) has produced so much confusion among both physics students and teachers. Many have come to think of GW as changes in gravitational force. But that cannot be right if for no better reason than changes in gravitational forces are detected with gravimeters daily, whereas no gravitational wave has yet been detected from any source by terrestrial detectors. Indeed, such detectors have no hope of detecting GW from any solar system body because they are far too weak.

Consider, for example, walking into a room containing a sensitive gravimeter. The gravimeter easily tracks changes in your body's gravitational force on it as you walk around. Yet be assured that you will not be awarded a Nobel Prize for the first laboratory detection of gravitational waves. This puzzles physicists, because if GW are not changes in gravitational force, then what are they?

The explanation in GGR is simple. GW are elysium waves, or changes in the gravitational *potential* medium. They are unrelated to gravitational force. Indeed, when equations of motion are developed, no gradient of GW is taken to produce a force corresponding to these changes in the potential field. This further demonstrates the independence of these fields adopted in practice by GR. Changes in gravitational force do not produce GW, and vice versa.

But we have already identified elysium with the light-carrying medium. So how then do gravitational waves differ from very-long-wavelength electromagnetic waves? In "string theory" derived from conventional GR, the supposed difference is in the quantum spin of the constituents of these waves. The "gravitons" of string theory are massless, spin-2 quantum particles. However, no version of string theory has ever produced a means to unify gravitation and electromagnetism.

In GGR, GW *are* very-long-wavelength EM waves, or what we are accustomed to calling "photons". They are massless only in the sense that they are waves, understanding that constituents of the underlying medium (elysons) are bodies with substance. And photons are spin-1 entities, a predicted difference from the spin-2 expected in string theory. Physically, GW are simply the disturbances of elysium produced by bodies accelerating through it. When gravity is the only force producing that acceleration, GW (also called "gravitational radiation") are the energy loss associated with drag on material bodies by the elysium. The frequency of the waves generated is then simply the orbital frequency of the accelerating body. This picture readily explains why GW are such an ultra-weak effect, having impact only over very long time scales.

XI. LORENTZIAN RELATIVITY

We see that the elysium field plays a special role for the transmission of electromagnetic waves (light) of all wavelengths. Yet it is identical in properties to the gravitational potential field. We are (properly) accustomed to thinking of gravitational potential as a local phenomenon associated with some particular source mass, rather than as a universal medium. Yet one can add any constant to all gravitational potentials and introduce no change to the implied dynamics, or even to the refraction effects. The latter depend on changes in density, not on density itself.

It is therefore clear that the local gravitational potential field plays the role of a special frame of reference, despite its lack of universality. We can therefore identify it with the preferred frame of the

Lorentz Ether Theory (LET). The modernized LET with the preferred frame so identified is now called "Lorentzian relativity" (LR).

LR differs from SR in that the Lorentz transformations operate only one-way, from the elysium to any frame with a relative motion. The reciprocal transformations from the moving frame back to the elysium are not ordinary Lorentz transformations as they are in SR, but rather are inverse Lorentz transformations. For example, Global Positioning System (GPS) satellite clocks slow down relative to ground clocks due to their fast motion relative to the local gravitational potential field. That rate difference between ground and orbiting clocks is corrected pre-launch, so that once in orbit, the rates are the same and stay the same. But it should be evident that, if we undid the rate correction to the orbiting clocks, they would indeed tick slower than ground clocks, just as expected in SR. However, contrary to SR, the orbiting clocks would see the ground clocks ticking faster.

In every local gravitational potential field, clocks can be rate-compensated in this way so that, once synchronized, they will stay synchronized indefinitely despite high (but constant) speeds, significant accelerations, and even differing (but constant) potential heights relative to the source mass of that field. That is what happens in the GPS [13]: satellite clocks run faster in the weaker potential field at their height by 45,900 nanoseconds/day, but slower because of their orbital speed by 7,200 ns/day. The net of 38,700 ns/day is compensated before launch. Other inertial frames could likewise be rate-compensated to agree with some conventional "master clock", thereby developing a practical realization of LR's "universal time". The lack of remote simultaneity in SR has no counterpart in LR because time itself is unchanged, so neither do the various paradoxes that arise in SR.

Physically, the differences arise because time and space change in SR, whereas only clocks and meter sticks change in LR. In LR, nothing ever happens to time or space. That simple change of interpretation, in and of itself, is sufficient to nullify the "proof" in SR that no real mass could ever exceed the speed of light. In LR, the universe has no maximum speed limit. LR is derived from physical reasoning. It is not only consistent with all eleven independent experiments verifying the relativity of motion, but has been argued to offer much simpler explanations of those experiments [14].

XII. SUMMARY

The principles of physics require a push force to initiate motion and conserve momentum. That leads us to Le Sage-type "graviton" models as the simplest to satisfy both requirements. But the implied properties of the graviton and light-carrying mediums are incompatible, requiring two mediums in any viable physical model. The graviton medium then provides the force of gravity, while the elysium field provides the relativistic effects. The identification of the elysium field with the local gravitational potential field follows from their identical locations and properties. This new physical interpretation applies to the same (to first-order in potential) mathematical formalism of GR, but can be distinguished in higher orders. It is therefore named "graviton general relativity" (GGR). Gravitational waves may now be understood as long-wavelength electromagnetic waves. For the relativity of motion, LR replaces SR.

Many other issues arise, and have good answers in a corresponding cosmological context. But that context is beyond the scope of this paper. Among these issues are the roles of the equivalence principle of GR vs. the transparency principle of GGR, inertia, entropy, where gravitons come from, singularities, etc. Most of our answers may be found in or inferred from the first five chapters of [15].

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