COSMIC LONG-WAVELENGTH PHOTONS AND A FUNDAMENTAL UNDERSTANDING OF GRAVITATION

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Abstract: The text proposes machinery for gravitation not contained in Newton's or Einstein's theories. This proposal is an extension, not a replacement, of the work of Einstein. The proposed mechanism is radiation pressure which is a possible two-fold linkage of gravity with electromagnetism (quantum mechanics). The text explores the idea that ordinary (as opposed to virtual) cosmic long-wavelength photons exist at a very high density in the vacuum of space-time. Such cosmic quanta are likely to be a left-over background from the Big Bang, red-shifted light from distant galaxies and/or long-wavelength quanta from our own galaxy. Indeed, such radiation is abundant at long-wavelength radio frequencies. According to quantum mechanics, the vacuum is seething with energy. There does not appear to be any reason that ordinary cosmic long-wavelength quanta cannot compose a uniform radiation background. The machinery for gravitation can be thought of as a long-range Casimir force carried out by long-range ordinary long-wavelength photons. The unbalance of radiation pressure is due to the reflection of this background radiation by matter particles. This generates a negative energy gravitational field and the force responsible for the curvature of space-time, thus, leading to general relativity. In this scenario, gravity is driven by the absence of radiation pressure within matter particles. This concept is related to Casimir forces. Casimir forces have been examined in detail by the experimentalist S. K. Lamoreaux and more recently (and precisely) by U. Mohideen and A. Roy. The Casimir force has been shown to be an absence of vacuum radiation pressure between two metal plates. Radiation pressure from the vacuum pushes the plates together proving the existence of negative energy forces. If there is a large amount of ordinary very low energy radiation in the vacuum, it is predicted that the gravity from the mass of the plates themselves and the radiation pressure due to reflection by matter will be indistinguishable. When thought of in a time-reverse fashion, gravity demonstrates an inverse square relation symmetry, thus, the absence of photons within matter generates a force identical to gravity i.e., an attractive inverse square force. This symmetry is demonstrated with both radiation pressure and meteorological examples. Additionally, the prediction is put forward that gravitation is due to the surface-area, and not the mass, of a matter particle. Moreover, in this model, ordinary radiation pressure is proposed to be negative gravity. This gravity model leads to six falsifiable consequences or predictions.

Key Words: Gravity, Photon, Zero-Point Energy, Casimir Effect, Radiation Pressure, Long-Wavelength Photons, Vacuum Energy, Unification, Surface Area, Cosmic Radiation, Negative Gravity, Anti-Gravity, Cosmic Background Radiation (CBR), Wave Gravity

Introduction:

Any theory that can successfully combine common electromagnetic photons with the underlying cause of curved space-time, automatically qualifies as a two-fold unification of electromagnetism (quantum mechanics) with gravitation. Such theories are known among physicists as "already unified". Attempts to unify gravity have all failed mostly due to a lack of understanding at fundamental levels. The underpinnings of the gravitational attraction described so well in Einstein's theory, are still not that well understood (Puthoff, 1998).

Higher mathematical abstractions such as superstrings and supergravity so far have not unified both forces. Additionally, a mathematical unification is not likely in the future. This is because the basic machinery of space-time curvature is not yet properly understood. Both Newton's and Einstein's gravitation theories are only descriptive in nature. The underlying dynamics is missing in both theories. Simply stated the problems appear to be these: By what physical process does matter cause gravitation? Similar to the previous question, what characteristic of mass causes space-time to bend (or curve)? In short, what physical mechanism drives gravity?

In 1968, the Russian physicist Andrei Sakharov published a paper suggesting that gravity might be induced by changes in zero-point energy. He said that gravity might be caused by vacuum energy changes due to the presence of matter (Puthoff, 1998; Sakharov, 1968). This in turn might be responsible for the curvature of space and time (Harms, 1992). Vacuum energy is predicted by the quantum theory and is presently understood to be fluctuations of the vacuum itself. In this idea, short range virtual particles and antiparticles arise from the vacuum at a variety of frequencies.

This text proposes that there are ordinary long-wavelength electromagnetic photons that occur naturally in the vacuum of space-time. These natural cosmic-based quanta are responsible for gravity and are part of the cosmic background radiation (CBR). Such photons are ordinary as opposed to virtual quanta. If such long-wavelength radiation have frequencies of 0.01 hertz (3 x 10^8 meters) or longer, they would be difficult to detect (Hewitt, 1981). Moreover, negative energy in the vacuum may cancel out the positive leaving only a minute residual positive amount of energy (Hawking, 1996). Present cosmological theories predicting a flat Universe suggest that there is missing energy that may exist within the vacuum itself.

There is no upper limit to the wavelengths of ordinary long-wavelength quanta. Quanta lower than 0.01 hertz would likely be low-level "noise" to detection devices. Such a background may be dense and largely invisible to us (Yam, 1997). The Casimir experiment demonstates the existence of this invisible vacuum energy.

The proposed underlying dynamics of gravitation is based upon ordinary long-wavelength quanta and the absence of radiation pressure within matter particles. The Casimir effect, which has been examined in-depth by S. K. Lamoreaux and others, is a closely related effect to the gravitation idea proposed by this model.

Sophisticated mathematics has largely failed to fundamentally describe gravity. Very likely, the machinery of gravity will not be discovered by a more elegant equation. Therefore a process of what drives gravity will be offered, based upon the similar (and related) Casimir force and the concept of preexisting infinite range long-wavelength photons in the vacuum of space-time i.e., CBR. The proposed gravitational effect is identical to a long-range Casimir force, the short-range force was described by S. K. Lamoreaux.

This paper will endeavor to demonstrate the machinery of gravitation and in the process unify gravity with electromagnetism. In this text, unification is not the primary focus, but a side-effect of the proposed model. That unification can be accomplished, demonstrates the correctness of this approach to gravity.

Are There Ordinary Cosmic Long-Wavelength Quanta In Space-Time?

Ordinary long-wavelength photons in the fluctuating electromagnetic field are zero rest mass and spin one photons that compose an energy background. According to quantum mechanics, there is no reason that ordinary long-wavelength photons should not exist in the vacuum. Ordinary photons should be present at all available wavelengths. Indeed, there is no upper limit to long-wavelength radiation. Such electromagnetic radiation is not more obvious because of its extremely low energy and very uniform density. Bombardment by low energy photons is very uniform, thus, the net force acting upon any object is essentially zero (Yam, 1997).

If there are a large number of photons at long-wavelengths, how did it come to be that way? If one assumes that there was a hot Big Bang with the measured black body radiation curve followed in-turn by a space-time expansion, it follows that there must be ordinary photon energy at long-wavelengths. In the hot fires of the Big Bang, many microwaves and radio waves were produced. After the expansion of the Universe, these shorter wavelengths were red-shifted, resulting in a background of radiation at much longer wavelengths. This process, which is also the present explanation for the cosmic microwave background at the even higher energies of the Big Bang, describes in a reasonable fashion how the density can be very high at these long-wavelengths.

Moreover, the red-shifted light of the distant galaxies must also contribute to the background of ordinary long-wavelength radiation. Indeed, present cosmological theories predict a high energy density of this cosmic-based background radiation. In addition, as discovered by Karl Jansky in 1932, the central regions of our own galaxy (the Milky Way) are a strong source of long-wavelength radio waves (Thorne, 1994). Thus, as radio telescopes demonstrate, there is an abundant supply of long-wavelength radiation in the Universe.

Gravity, as far as can be determined, appears to go out forever inversely as the square of the distance. Gravity dominates the Universe on the large scale. In a similar manner, both gravity and light obey the inverse square law as the distance diminishes from the source. This text takes the viewpoint that the "cause" of gravity (which ultimately warps space-time) is exactly the opposite of ordinary radiation pressure. As described below, high and low air pressure systems in the Earth's atmosphere are similar to this model.

Gravity is negative radiation pressure and, thus, obeys the inverse square law because it is precisely a mirror image of ordinary radiation pressure. Since all ordinary electromagnetic radiation regardless of its spectral distribution obeys the same inverse square relation, so does cosmic-based negative radiation pressure. As the symmetrical comparison argument (with meteorology) below demonstrates, the "absence" of electromagnetic photons in the vacuum obey the same laws in either forward or backward directions of time and regardless of the frequencies of the radiation.

Is Gravity Similar To Meteorology?

The cause of gravitation as described by this text is similar to that of meteorology. For example, one can compare gravity with high and low pressure systems in the Earth's atmosphere. In this analogy, gravity is very similar to a low pressure system i.e., it attracts only. Low pressure atmospheric systems are caused fundamentally by the absence of air pressure (relatively speaking) in the atmosphere, whereas the cause of gravity in this model is due to the absence of radiation pressure. Two low pressure systems can, like massive bodies, attract each other if they are in close proximity. Both lows can be caught in each other's force fields leading to a mutual attraction. In high pressure systems, like radiation pressure from our Sun, all nearby objects are pushed away and eventually into low pressure systems.

The Sun and other stars appear rather confusing in this regard because, on these glowing gaseous bodies, both forces of attraction and repulsion are taking place simultaneously. In most normal situations, the force of attraction (gravity) is, on most stars, the vastly stronger force at work. However, in the unusual case of a supernovae explosion, where the outer regions of the star are blown off, the repulsive force of radiation pressure very quickly overcomes a star's own gravitation. Thus, in such an explosion all nearby objects are blasted far away and out into space. Two high pressure atmospheric systems, like two supernovae close together, always repel each other.

Although the low pressure systems in the atmosphere tend to be smaller in size than highs as a general rule, one can deduce from this analogy that low and high pressure systems are opposite processes. In the cosmic setting the opposite tends to be true, gravity i.e., a low pressure phenomena, generally overpowers ordinary radiation pressure. Thus, gravity, in the form of negative radiation pressure, dominates the Universe.

Consider the reversal of the direction of time, thus, running the picture backwards of an atmospheric sattelite movie photo. In reverse order, atmospheric low pressure system's push moisture (and air molecules) away and toward the high pressure cells. The high pressure areas, on the other hand, would be doing the attracting of the air and moisture produced by the low. This vividly demonstates the time-reversed symmetry between highs and lows proving that highs and lows are essentially similar processes only in reverse. In almost all particle experiments, the laws of physics do not distinguish between the forward or backward directions of time, similarly, there can be little difference in the case of atmospheric systems. In a similar fashion, since ordinary radiation pressure in the space-time vacuum obeys the same inverse square law as all material objects i.e., other low (negative) pressure systems, are attracted.

Although due only to short-range virtual particles, the Casimir force demonstrates without any doubt that the absence of radiation pressure does indeed generate an attractive force and it operates by the fundamental principles as described above.

The Machinery Of Gravitation

The Casimir effect was first predicted by H. B. G. Casimir in 1948. Casimir calculated that two closely spaced parallel metal plates, if brought sufficiently close together, will very slightly attract each other. It is presently claimed by the experimentalists U. Mohideen and A. Roy that Casimir's theory is now verified to within one percent of Casimir's original 1948 calculations (Mohideen et al., 1998).

The primary reason for the attraction is that the narrow distance between the plates reflect long-wavelength vacuum quanta. A photon can exist between the plates only if its wavelength is less than twice the distance between the plates. As a consequence, long-wavelength quanta are missing from the gap between the plates. In simple terms a force is created, the Casimir force, which is actually the result of radiation pressure. This was demonstrated by S. K. Lamoreaux in 1997 and more precisely in 1998 by Mohideen and Roy. There is more vacuum radiation to push the plates together than to push them apart. Like gravity, the Casimir force is attractive (Milonni et al., 1988). A photon can occur in the space between the plates only if their wavelengths (the distance between the crest of one wave and the next) fit a whole number of times into the gap (Hawking, 1996). The Casimir effect proves without a doubt that the negative vacuum exists.

Radiation pressure was first demonstrated by the Russian physicist Peter Lebedev. He observed that under some conditions radiation pressure could be "more important than gravitation". Lebedev also noticed the similarity between gravity and radiation pressure. He noted that gravity was caused by mass, but radiation pressure was due to an object's surface (Gillispie, 1973). As is predicted by this gravity model, it is surface area, and not mass, that is responsible for gravity. This important point is discussed subsequently.

Casimir forces are induced by the "absence" of radiation pressure. In this view, gravity is fundamentally a disturbance of the vacuum energy due to the presence of matter. Matter keeps ordinary cosmic-based vacuum energy continuously disturbed or unbalanced (Harms, 1992).

As Galileo showed, all objects fall with the same acceleration. Mass is a measure of inertia or resistance to a change in motion. When we step on bathroom scales, we are in fact determining the force that gravity exerts on our bodies. More massive objects require a bigger force in the same proportion as its mass is bigger than a less massive object. Or stated differently, gravity pulls on a more massive object with a greater force in just the right amount to give it the same acceleration (Wolfson, 1997).

This amazing fact is the principle of equivalence of gravitational mass and inertial mass. It is widely known (and proven by E. Rutherford) that atoms are mostly empty space. Cosmic long-wavelength quanta are reflected by atomic nuclei and electrons in the interior of atoms. Otherwise long-wavelength quanta, due to their long-wavelengths, do not interact with atoms. The interior of the Earth has gravity because long-wavelength quanta mostly pass straight through (and penetrate deeply) without much interaction at all. What interaction there is, is due to a direct impact and reflection by atomic nuclei.

Reflection may be an absorption and reemission of these long-wavelength photons, without a loss of energy (energy is, therefore, conserved). Matter with electrical conductivity can block long-wavelength radiation. However, all "warm" matter particles also emit a certain amount of long-wavelength quanta as long as their temperatures are above 2.735 Kelvin [Dennis Anthony, personal communication (November 9, 1998)]. The more dense the substance, the bigger the chance a long-wavelength photon will collide and be reflected by an atomic nucleus. This is how gravity "knows" how much matter (which really may be a measure only of its surface area) is contained in a substance and gives more massive objects a bigger push in just the right amount in a gravitational field (Wolfson, 1997).

The Casimir force is not directly responsible for gravity, because the Casimir experiment demonstrates that the force is short-ranged. Very likely this is because virtual vacuum quanta only have a short-range before being reabsorbed. The Casimir force is thought only to be affected by virtual vacuum quanta. Moreover, the Casimir effect takes place between the objects and not within the particles of matter themselves.

Ordinary long-wavelength photons should exist and have the same effect upon the metal plates as do virtual quanta. That is, ordinary long-wavelength quanta cannot be allowed within the matter making up the plates which results in a longer-range Casimir force. This long-range force and gravity are indistinguishable. Thus, when we measure the gravity of an object, we are in fact also determining its negative radiation pressure. In the Casimir experiment, the long-range Casimir force (the gravity of the plates) is factored-out to yield the short-range force (due to virtual long-wavelength photons).

Moreover, nature should not distinguish between virtual and ordinary photons. However, virtual photons will not produce ordinary long-range gravity. The Casimir force cannot be distinguished from ordinary gravitation and space-time curvature. The long-range Casimir force is responsible for the warping of space-time.

In the Lamoreaux experiment, when the metal plates were brought far enough apart, the Casimir force fell off to essentially zero. Long-range Casimir forces caused by ordinary long-wavelength photons, like gravity, are much weaker at short-range. The device used by Lamoreaux had a small surface area of 2.54 cm in diameter and 0.5 cm thick (Lamoreaux, 1997).

Because radiation from the Sun has only a small outward pressure upon orbiting planets, ordinary long-wavelength quanta at low energies in the vacuum must be vastly more dense than the solar radiation output to account for the underlying dynamics of gravitation. A dense sea of fluctuating electromagnetic radiation at long-wavelengths must exist for this theory of gravity to be valid. This sea must contain ordinary cosmic-based long-wavelength photons, which can roughly be defined as quanta of wavelengths of perhaps 0.05 meters or longer, an approximate figure based upon the Casimir experiment results.

There are good reasons to believe that gamma-rays are the smallest wavelength (highest frequency) quanta possible due to their emission from small atomic nuclei. However, there does not seem to be an upper limit on the wavelengths of ordinary quanta from space. The difficulty of detecting photons below the frequency of 0.01 hertz means it is very difficult to estimate the residual density (difference between positive and negative energy) of cosmic long-wavelength radiation (Hewitt, 1981).

As Maxwell showed, the equation for the radiation pressure of reflected photons is given by:

$P = 2U/C$

Where:

P = Momentum delivered to massive object

U = Energy of photon

C = Speed of light

The above equation demonstrates that the energy of each individual photon is an important component of the momentum necessary for gravity to be possible (Halliday et al., 1988). However if reflection by matter does takes place, the negative force created abides by the inverse square law as does all ordinary radiation.

A competing long-wavelength photon theory proposed by the physicist John Kierein suggests that this reflection by matter may be Compton scattered and generate a weak radiation void or shadow surrounding the matter particles. Kierein's model is a "push gravity" theory suggesting that shadows are cast by the absence of radiation between material bodies. When two bodies interact, they exchange shadows on each other's surfaces and positive radiation pressure from the opposite side (being stronger) pushes the bodies toward each other. This is also what fundamentally takes place in the Casimir experiment, although not with Compton scattering. Such a model also leads to an inverse square relation between the particles.

"Push gravity" theories do not adequately address the radiation "void" that exists within the particles themselves (and indeed there is no radiation pressure within the atomic nuclei or the electrons). Thus, push gravity models ignore the absence of radiation pressure within the particles and focus primarily on the radiation void between (and surrounding) the particles. Moreover, if the reflection of the long-wavelength radiation is not a Compton scattering interaction, then there is no shadow-like void produced around the matter particles.

The Compton effect works predominantly on medium energy photons of about 0.5 to 3.5 MeV (Giffin, 1996). In the laboratory, long-wavelength photons have not been found to scatter electrons because their energies are not high enough to exceed the electron's binding energy. Thus, such photons are also too low in energy to scatter atomic nuclei (which have an even higher binding energy than an electron does). In any event, the inability of long-wavelength photons to be Compton scattered appears to eliminate long-wavelength radiation "push gravity" as a viable gravitation model.

Are there indications that the density of cosmic long-wavelength quanta can be this high, brighter than the Sun? The Casimir force itself demonstrates that there is a significant density of long-wavelength quanta. In addition, the Lamb shift is thought to take place because of vacuum long-wavelength photons. Moreover, such photons may be responsible for certain types of inescapable low-level "noise" in optical and electronic equipment. Indeed, according to quantum mechanics the vacuum is seething with energy (Puthoff, 1998).

Quantum theory allows the energy density to be negative in some places (such as within matter particles), if it is made up for by the existence of positive energy in other places so that the total energy is balanced and is positive. The Casimr effect demonstrates the existence and "taps in" to this negative energy in the vacuum. If the energy density between the plates in the Casimir effect is less than the energy density far away, it must be negative (Hawking, 1996). This negative energy must be vastly greater than the flux of solar radiation because the gravity from the Sun itself is far greater than its own radiation pressure.

The machinery of gravitation is in essence the radiation pressure from all the ordinary red-shifted long-wavelength quanta emitted by all the objects in the Universe and residual radiation left-over from the Big Bang. Such left-over cosmic radiation was created originally as microwave and short wavelength radio waves that were red-shifted due to the expansion of space-time after the Big Bang. This is how the large amount of long-wavelength radiation came to exist and why gravity, caused by radiation pressure, must presently dominate the Universe on the large scale. Mass can roughly be viewed as those material particles that generate a negative energy field by reflecting long-wavelength cosmic quanta i.e., CBR.

Atomic nuclei of perhaps 10^-15 meters across and all other matter particles reflect long-wavelength photons. This takes place even at microscopic levels. Such nuclei cannot be completely tightly packed, because this would result in shielding of the various protons and neutrons from cosmic-based long-wavelength quanta. At the scales of long-wavelength photons, atomic nuclei are relatively far apart from each other due to the repulsion caused by the exclusion principle, thus, there is no shielding effect (Hawking, 1996). Moreover, long-wavelength quanta are continuously absorbed and re-emitted by "warm" protons and neutrons. An atomic nucleus may be a "swarm" of ordinary long-wavelength quanta.

Time-Reversed Gravitation

The meteorology example above uses a time-reversed technique to demonstrate how radiation pressure and gravitation are related. What if this same time-reversed idea were applied to negative radiation pressure model of gravitation? Thus, is gravity time-symmetric?

When the direction of time is reversed in the proposed model, it is possible to envision the gravitational field as negative energy. For example, if the Sun's gravity and radiation pressure are time-reversed, radiation emitted by the Sun is now being absorbed moving in reverse toward it. Such backward radiation would behave precisely like the proposed gravitational field of the Sun, as an absence of radiation pressure. Moreover in this time-reversed scenerio, the Sun now actively emits vacuum gravitational quanta which are actually negative energy particles. Such negative radiation would push on the surrounding planets, like ordinary radiation pressure does presently, in accordance with inverse square relations. This is how radiation pressure and gravity are considered exactly inverse processes i.e., time-symmetric. In this proposal, gravity can be thought of as a time-reversible process.

This idea that the gravitational field is actually negative radiation being attracted by matter has also been observed by S. W. Hawking where he states: "...the gravitational field has negative energy. In the case of a universe that is approximately uniform in space, one can show that this negative gravitational energy exactly cancels the positive energy represented by the matter. So the energy of the universe is zero. " Hawking states also that the gravitational field contains negative energy because: "Two pieces of matter that are close to each other have less energy than the same two pieces a long way apart, because you have to expend energy to separate them against the gravitational force that is pulling them together" (Hawking, 1996). Hawking suggests that the gravitational field is negative energy, and this gravity model is in agreement.

Negative Radiation Pressure And Space-Time Curvature

It is tempting to replace general relativity with this gravity model, since bodies can be shown to attract each other obeying the inverse square relation. However, the main premise of general relativity, that the laws of physics are the same in accelerated frames of reference, is very likely to be valid. In addition, the predictions of general relativity appear to be true in the large-scale Universe. Therefore, this gravitational model should lead to a general relativistic description of the Universe. This is the approach of this section.

Einstein's field equation states that mass and pressure warp space-time (Thorne, 1994). This gravity model suggests another possibility. It is that space-time is also warped by an equivalent force. Such a force is indistinguishable from the apparent movement of bodies through a curved space following a geodesic path. This force is a difference in radiation pressure between matter and the surrounding space, an unbalance of the radiation pressure of the vacuum.

Like closely-spaced metal plates, ordinary long-wavelength quanta do not pass through matter particles but are reflected. In this text, the reflection of cosmic long-wavelength quanta by matter is assumed to be true. This reflection in-turn creates a radiation pressure "force" which slightly warps the fabric of space-time near a given object. Matter particles remain in a perpetual state of unbalance of radiation pressure, due to a lack of long-wavelength CBR within them. This generates a negative energy field around all matter particles. This unbalance is the machinery behind space-time curvature, the "force" behind gravitation (Harms, 1992).

Forces affect the curvature of space and time. It is well established that when a force acts, space-time curvature is affected. As S. W. Hawking notes: "Space and time are now dynamic quantities: when a body moves, or a force acts, it affects the curvature of space and time--and in turn the structure of space-time affects the way in which bodies move and forces act" (Hawking, 1996). Such distortions of space-time can be regarded as those due to another force.

As this model proposes, the energy flux of the vacuum creates an unbalance of radiation pressure, an attractive force between bodies. The force leads directly to general relativity by curving space-time as S. W. Hawking at Cambridge University, U.K. notes. The force obeys the inverse square law in Newtonian gravity. As Darrell Moffitt has shown, Newton's gravitational constant is to within 99.85% of that of the Casimir potential and may be even closer when the Lamb shift is taken into account (Moffitt, 1998).

An Einsteinian gravitational interpretation i.e. both the bending of light and slowing of clocks in gravitational fields, is due to the warping of space-time from the radiation energy pressure differential within matter particles in the vacuum.

As stated earlier, radiation pressure is only the "machinery" of gravitation. General relativity is the proper theory of gravity. Negative radiation pressure is the next step in understanding gravity, a quantum description. Curved space-time is the fundamental reason why objects attract each other. Radiation pressure creates "the force", as Hawking notes, behind the warpage of space-time in the vicinity of all massive objects.

Radiation pressure is the"force" behind gravity. Thus, radiation pressure creates an equivalent force. This force cannot actually be distinguished from the general relativistic curvature of space-time itself, which is not really a force in itself. A force, thus, creates the curvature of space-time which is not actually a force.

Einstein's approach says, in effect, that matter, just by its presence alone, tells space-time how much to curve. It is space-time then that tells matter how to move (Elton, 1997). It is proposed, therefore, that negative radiation pressure "measures" the amount of matter contained in a body and generates a differential force between the object and the space-time around it. This force is responsible for the warpage of space-time. Thus, forces curve space-time.

Negative radiation pressure determines the strength of gravity on all planets by "telling" space-time how much to curve or warp. How much curvature produced by a given object, is closely related to the spectral make-up of the cosmic vacuum radiation which diminishes as the square of the distance. Thus, radiation pressure "measures" how much matter a body contains (by its surface area) and affects (warps or bends) space-time accordingly.

So is gravity really a force? The answer may be no, because although radiation pressure is directly proportional to gravity, radiation pressure may not actually do the attracting. Radiation pressure only causes all material objects to travel in straight lines in a curved space--a geodesic.

<u>Gravity Due To Surface Area</u>

Peter Lebedev noted that radiation pressure is different than Newtonian gravitation due to the mass of an object. That is, radiation pressure affects objects due primarily to their surface area (Gillispie, 1973). Lebedev pointed-out that gravity was similar to the opposite of gravity, however, he had no knowledge of the Casimir force which only recently has demonstrated the reality of negative radiation pressure in the vacuum. Thus, the absence of radiation pressure creates an attractive force.

With the relatively large objects in our everyday world (like apples or planets), gravity due to a massive body and radiation pressure would appear totally different. However, when we are speaking about long-wavelength ordinary cosmic vacuum energy at the scales of protons, neutrons and electrons, it becomes more difficult to believe that only mass is important for gravity. Do we know precisely the surface area of a proton or a neutron? The surface areas of these very small objects might not be small perfectly-round spheres as is usually portrayed by textbooks, but may have quite a different "structured-like" surface differing drastically from that of a sphere. This is presently not known.

Even if we can closely estimate the surface area of a proton, do we know if this figure and the associated vacuum energy differential are fundamentally different than the mass of a proton? It appears obvious that it is the surface area of the proton (and not its mass) and the amount of associated negative vacuum energy i.e., spectral make-up of the cosmic radiation background, that may actually determine a protons very weak gravitational attraction. That gravity is due to surface area, and not mass, is a powerful and undeniable prediction of this gravitational model. With better technology in the coming century, perhaps a suitable test of this falsifiable prediction can be devised. Perhaps, an object's mass and its surface area are exactly equivalent i.e, they are in direct proportion.

<u>Is Ordinary Radiation Pressure Negative Gravity?</u>

Since the absence of radiation pressure is proposed to be gravity, is ordinary radiation pressure anti- or negative gravity? This conceptual model, brought to its logical conclusion, predicts that the absence of radiation pressure warps space-time, then ordinary radiation pressure must also (in the direction opposite to gravity) affect space-time curvature (Harms, 1992). Gravity is viewed as being absolutely reversible, working by the same process in either forward or backward time directions.

Therefore, radiation pressure as negative gravity must affect space-time curvature causing a "bump" in space-time. In this author's other texts (links provided below), matter and radiation are viewed as opposites. Matter is envisioned at fundamental levels as a distortion of space-time, thus, radiation pressure must also distort space-time oppositely to matter. Therefore, radiation pressure warps space-time in an opposite direction as matter does.

Thus, during any eclipse where the Sun's light is blocked by an interposing planet, there must be a measurable effect or minute change in the orbit of the planet in question. Indeed, if the meteorology example is a close analogy, two very strong emitters of ordinary radiation, like two supernovae, should strongly repel each other. This is because ordinary radiation pressure in this model, as gravity's opposite, is the same as anti-gravity. Ordinary radiation pressure, therefore, has an effect upon space-time curvature (as does negative radiation pressure).

Since the amount of gravity is due to the unbalance of radiation pressure (a radiation void or shadow) inside matter, perhaps there are materials that might block such incoming long-wavelength quanta. Such materials formed into a hollow shell devoid of air inside could generate a long-wavelength radiation void (absence of radiation) within. This might generate a gravitational force where there is no matter, thus, the object would be heavier in the Earth's gravitational field than the amount of matter it contains. Thus, the object would weigh more than the sum of its parts separately.

The Italian scientist Majorana has measured a decrease in gravity inside spherical shells of mercury. This is not generally explained by the conventional view of general relativity (Radziyevskiy and Kagal'nikova, 1960). In the view of gravity presented here, this might be explained as a decrease in the internal "void", meaning that the element mercury is somehow more transparent to incoming long-wavelength radiation. Thus, the radiation is not reflected as much by the substance mercury. If this experiment is true, perhaps, there is a quantum mechanical explanation for this transparency phenomena.

If it is assumed that the matter is completely ordinary (not mercury, for example), and a star may become as dense as neutron star matter, this density may lead to a stellar implosion into a black hole. The incoming cosmic long-wavelength radiation is, therefore, blocked (by a dense substance) leading to an even greater absence of radiation pressure within the core of the neutron star. This gravity, however, is greater than the amount of matter the star contains. Thus, an artificial void is created by a gravitational sheilding effect and this causes a stellar implosion into a black hole.

Perhaps, as a star becomes increasingly dense, its gravity increases due to this sheilding effect. This is an increase of the long-wavelength photon shadow within due to the star's density. This is how objects collapse to become a black hole as density increases and the surface implodes. The sheilding of long-wavelength photons describe how black holes form and explains how gravity increases with a star's decreasing size and increasing density. Thus, the sheilding effect explains how, as stars collapse and become more dense, their gravity becomes stronger. Indeed, according to general relativity, a massive star has an increase in gravity above that predicted by Newtonian gravity. Perhaps, an increase in density, the shielding effect and the negative radiation "shadow" are responsible.

"Wave" Gravity

As is suggested by quantum mechanics, matter and radiation also have a wave interpretation. Can this gravity model only be envisioned as waves i.e., waves of matter interacting with waves of radiation? The answer is yes. The "wave gravity" interpretation is as follows: Long-wavelength "wave" radiation creates a void or shadow if it is exactly canceled-out by identical long-wavelength matter waves. Thus, all matter waves (that do respond to gravity) must have a wave component that is of a long wavength (and exactly out-of-phase) with the incoming long-waves of radiation. Since the incoming long-waves are canceled-out, a shadow or void is created within the matter particles at long-wavelengths. This void is always attractive and equivalent to the "particle" description above.

Therefore, a disturbance of the vacuum energy is generated (a force), by the canceling-out of long-wavelength background radiation due to the presence of matter waves of the same frequencies.

Gravity And The Flat Universe

The recent discovery that the expansion of the Universe is speeding up (accelerating) was predicted only by cosmological models where there was a positive cosomological constant, an anti-gravitational force. The cosmos is expanding ten to fifteen percent more slowly in the past than can be accounted for without a cosmological constant (Cowen, March 1998).

According to Einstein's general theory of relativity, it is the density of matter and energy that determines the geometry and fate of the Universe. A flat Universe must have neither too much nor too little density, an amount equal to the critical density. In fact, measurements show that the total density of matter is about forty percent of the critical density (Cowen, December 1998). Therefore, either we live in a negatively-curved Universe or there is a missing energy component (Cowen, February 1998). It was just this energy component (a cosmological constant) that led to the prediction of a Universe that is speeding up. The net effect of the cosmological constant is the anti-gravity which ultimately accelerates the expansion of the Universe (Cowen, December 1998).

It is desirable that the Universe is indeed flat because the theory of inflation logically follows from a flat Universe. Measurements suggest that the geometry of the Universe is as flat as the inflation theory predicts (Cowen, December 1998). Moreover, inflation predicts not only that the Universe is flat, but also solves two cosmological conundrums. Inflation explains why the Universe looks the same in all directions on the cosmic scale and tells how the Universe evolved from a smooth soup of particles into a lumpy collection of galaxies, galaxy clusters, and super-clusters (Cowen, February 1998). Inflation does explain these riddles, but most inflation model's work best only in a flat Universe scenerio. Thus a flat Universe is the most desirable, but the missing energy problem is still a mystery because sixty percent of the critical energy density is missing (Cowen, February 1998).

The leads us into the suggestion that was made previously that for gravity to work, due to the absence of radiation pressure, the density of vacuum radiation must be vastly greater than the solar radiation output. The missing energy in the form of radiation, may in fact be cosmic long-wavelength ordinary quanta (CBR) left-over from the Big Bang (and also other sources) as previously described. As allowed by quantum mechanics, negative energy could balance with this radiation which in-turn clusters in all massive objects. Or stated differently, the large energy density of cosmic-based long-wavelength photons in the vacuum is continuously reflected by matter particles, creating a permanent imbalance of the vacuum energy due to its absence within material objects. Gravity is the result of the imbalance created by the negative energy as demonstrated by the Casimir effect experiment. This results in a difference in the radiation pressures from one place to another. The sum of the positive energy with the negative energy both balance so as not to be noticeable, resulting in a flat Universe. Therefore, the missing energy is not actually missing. It is a part of the energy density of the vacuum in the form of cosmic long-wavelength quanta, which is in absolute agreement with the present observation of a flat Universe.

Conclusion

It is possible to envision gravity in two different ways in this text:

1) The differences in radiation pressure between inside matter particles and elsewhere in the vacuum creates the force of gravity. The Casimir experiment demonstrates that this absence of radiation pressure is always attractive.

2) The force as described in # 1 leads to a space-time curvature and it is this curvature that attracts objects to each other. Thus, forces lead to an Einsteinian description of gravity.

These two descriptions are basically equivalent to each other. The finest minds have worked on gravity and have failed to understand it at a fundamental level. The primary reason that gravity has not yielded its secrets so easily is that gravity is very complicated. The two descriptions above when combined solve all aspects of the gravity puzzle. The Casimir experiment, negative radiation pressure and long-wavelength photons complete the rest of the picture.

The late physicist Richard Feynman in his famous lecture series made the following statement concerning gravity: "No machinery has ever been invented that "explains" gravity without also predicting some other phenomena that does not exist" (Feynman, 1995). If Feynman was correct this suggests there is something fundamentally "flawed" with radiation pressure as the machinery for gravitation. Feynman's statement may no longer be valid.

This gravitation model proposes six probable predictions:

1) Demonstrating that ordinary long-wavelength quanta are not plentiful (and dense) in enough quantities to cause gravity is a fast way to disprove this model, although negative energy would balance with the positive making detection difficult. Observations of this only measure the difference between positive and negative energy.

2) Radiation pressure does alter space-time. It is ironic that in the "wave" view of gravity that radiation and matter waves are seen as opposites. See link to other texts below. If matter is envisioned as a distortion of space-time, then radiation waves (the opposite of matter waves) are, therefore, distortions of space-time in the opposite direction. Thus, radiation pressure must warp space-time in the opposite fashion as does gravity (or negative radiation pressure).

3) At the scale of protons and neutrons, it is the "surface area" and not "mass" that determines the gravitational attraction of objects. Perhaps future advances in technology will better describe the surface areas of a proton or neutron.

4) The gravitational field may be composed of negative energy, thus, any experiment showing otherwise may disprove the model. The Casimir effect appears to prove the existence of a negative energy field and may also demonstrate a considerable density of long-wavelength vacuum quanta (as in prediction #1 above).

5) There can be no fundamental difference between gravity due to the curvature of space-time and that from negative radiation pressure. Thus, when an object's gravity is measured, so its negative radiation pressure i.e.,a long-range Casimir force.

6) Ordinary radiation pressure is negative gravity (anti-gravity). If there is not an inverse symmetry relation between gravity and radiation pressure, then this model is disproved.

With these six probable consequences or predictions, the model should be falsifiable.

Einstein has often said that general relativity was just a beginning in attempting to better understand gravitation (Elton, 1997). Since this model extends (and includes) Einstein's theory and is, thus, an "already unified" model, perhaps this model is the next logical next step beyond general relativity.

Perhaps, such an electromagnetic description leads straight to a quantum theory of gravity, a new more precise model describing events near a singularity (Thorne, 1994). Perhaps, this model is quantum gravity! A singularity is a situation where the laws of general relativity break down, but where a model based upon negative radiation pressure might not. This topic is discussed in more detail in the author's black hole text. See link below.

That gravity and electomagnetism are unified by this approach is an indicator of the correctness of this model. This unification is not the primary focus of this text, but comes only as an added benefit.