An idea for quantum gravity

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Abstract

All the predictions of general relativity have been experimentally confirmed except gravitational waves, dark matter and dark energy. Einstein's perpetual efforts to unify general relativity with Maxwell's electromagnetic theory were not successful. Einstein ignored weak and strong nuclear forces. Abdus Salam and Steven Weinberg unified electromagnetic and weak nuclear forces. The combined theory of general relativity and quantum physics is one of the most challenging problems to the research community. In this work, the author proposes an entirely new idea to attempt to achieve quantum gravity.

Key words: General Relativity, Quantum Forces, Geometry

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A brief introduction

It is the most persistent and greatest adventure in human history, this search to understand the universe, how it works and where it came from. It is difficult to imagine that a handful of residents of a small planet circling an insignificant star in a small galaxy have as their aim a complete understanding of the entire universe4,a small speck of creation truly believing that it is capable of comprehending the whole. Still the universe seems to operate by several sets of rules that act in layers, independently of each other. The most apparent basic rules of nature, gravity, controls the biggest objects in the universe , the stars , the planets , you and me. The other three that scientists have uncovered operate at the sub atomic level: the strong nuclear force trillions of times more powerful than gravitation, holds the nucleus of an atom together; electromagnetism keeps electrons in place around the nucleus, making ordinary matter seem solid; the weak nuclear force causes radioactive decay in certain atoms, like uranium.

Galileo was Newton's , Einstein's as well as Hawking's direct intellectual forebear in the sense that he was the first to define gravitation, nature's most pervasive yet, paradoxically its weakest force. Since Galileo it has been a matter of correcting, redefining, and adjusting the original explanation. Newton repaired and refined Galileo; Einstein honed and broadened Newton's basic laws to include the entire universe. Now physicists and cosmologists are trying to do the same to Einstein's general relativity, the modern explanation of gravitation and the force that most concerns cosmologists. The most remarkable thing about general relativity was that Einstein away with the concept of gravitation as a force. In fact , he said , there was no such thing as the force of gravity. It was instead the geometry of the universe – the curved geometry supplied by Riemann – that was responsible for the force we think of gravity. Einstein called his curved space a space-time continuum. Einstein's field equations describe the geometry of space-time, and he was certain they would work for the geometry of all space-time – that is , for the universe from its beginning to the end. Einstein's predictions have been experimentally verified time and again.

Quantum mechanics is a mathematical system developed during the 1920s and 1930s and is wholly alien to general relativity. It explains the interactions that take place at the sub atomic level, and at its core is the uncertainty principle first announced in 1927 by the German physicist Werner Heisenberg, The uncertainty principle states that certain pairs of qualities, such as the position and momentum of an electron , cannot be measured simultaneously. This means that the electron is not the objective, Absolute and determinable bit of matter that classical physics describes, but a sort of objective entity that in a sense is smeared out around the nucleus. This uncertainty principle distinguishes quantum mechanics from all other physics because it declares mathematically that atomic and nuclear particles are distributed in an uncertain and random fashion. The location at any instant of any particle can be described only using a system of probabilities and statistics. It was this element of unpredictability that made quantum mechanics unacceptable to Einstein. He insisted on viewing the universe as an orderly, predictable place. General relativity was a perfect reflection of that view. To Einstein the quantum system was philosophically and mathematically unequipped to exist in the same universe with general relativity. Today's physicists, though , consider it of equal importance to general relativity. And like general relativity, quantum mechanics has met every experimental test ever devised for it. These experiments are conducted in particle accelerators that break apart the constituents of atoms to find out what they are made of, a process that some theorists caustically liken to smash a watch to see what falls out. Physicists have been unable to reconcile this system with the view of the universe posited by general relativity. While general relativity allows a perfect point like singularity at the beginning of time, quantum mechanics does not , for it prohibits defining at the same time the precise location, velocity and size of any single particle or singularity. But let us recall that Einstein's unification of mass and energy led to the age of the atomic bombs. And this quantum mechanics paved the way for the invention of lasers.

A new approach to quantum gravity

Recently, the author has found the following results in spherical geometry:

(1) There exists a spherical triangle whose interior angle sum is equal to 360 degrees.
[http://vixra.org/pdf/1305.0152v1.pdf]

(2) We can construct a spherical triangle whose interior angle sum add to 540 degrees
[http://vixra.org/pdf/1305.0152v1.pdf]

Conclusion

The fundamentals of Euclidean geometry are one of the basics for Newtonian mechanics. And the concepts of non Euclidean mathematics are the pillars of Einstein's relativity theories. A new branch of geometry can create a new filed of physics. In this rapprochement, the authors new ideas may be useful for the reality of quantum gravity. Further exploration of the above mentioned findings will yield new type of spherical trigonometry and differential equations. On these glues, the dream of quantum gravity may become a real phenomenon.

“ Significant scientific breakthroughs are rarely accepted en they are first announced. A scientist who makes a ground breaking – a Copernicus , a Galileo , or a William Harvey – is likely to be ignored or even ostracized for years.” [*Thomas Kuhn in his The structure of scientific revolutions]*

References

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Special relativity changed the whole theme of space and time. Through special relativity, Einstein resolved the conflict of motion and the constancy of the speed of light. By the end of his special relativity, he realized that special relativity dictated. Special relativity dictated that nothing could outrun the speed of light. This, in turn, was against Newton's law of universal gravitation, proposed at the end of the seventeenth century. The problem with Newton's law of universal gravitation was that it predicts that bodies would exert forces on each other instantaneously. According to special relativity, however, nothing can travel faster than light. Therefore, instantaneous events are not allowed in nature. After years of extremely intense studies, Einstein resolved this dilemma, along with other puzzling dilemmas that special relativity dictated, in his stunning General Theory of Relativity. In this theory, Einstein once again revolutionized our understanding of space and time. He showed that the warp of space would produce all kind of weird effects on the space and time around them. We shall investigate that closely.

Newton's Problem

Before the advent of general relativity, Newton's theory was lacking one important characteristic. Other than the instantaneousness dictated by Newton's law of universal gravitation, the law was lacking one important aspect: it did not explain what gravity is. It just dealt with gravity as it is. Although it can offer very accurate predictions about how objects move under the influence of gravity, it does not explain the force itself. The problem is set in the following example: how can two physical bodies exert gravitational forces on each other despite the presence of enormous distances between them? (As in the case of planets, for example). How does gravity carry out its mission? Newton was no fool. He realized this one missing aspect. In his monumental "Principles of Natural Philosophy", he wrote:

"It is inconceivable, that intimate brute matter, should, without the mediation of something else, which is not material, operate upon and affect other matter without mutual contact. That Gravity should be innate, inherent and essential to matter so that one body may act upon another at a distance in a vacuum without the mediation of anything else, by and through which their action and force may be conveyed, from one to another, is to me so great an absurdity that I believe no Man who has in philosophical matters a competent faculty of thinking can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws; but whether this agent be material or immaterial, I have left to the consideration of my readers".

Einstein's Solution

In 1915, Einstein proposed General Relativity. He developed the theory to explain and try to solve the apparent conflicts between the laws of relativity and the laws of gravity. To modify such classical principles, such as gravity, required some hard work. Einstein began to learn differential geometry. He extensively used the geometry developed by Bernhard Riemann in the nineteenth century. The difference between Euclid's plane geometry and Riemann's geometry is that Riemann's includes all curved spaces in general. Einstein's genius came when he discovered that Reimannian geometry seemed magically designed to serve the physics of gravity. To resolve the conflicts between classical gravitational physics and relativity, Einstein developed an entirely innovative and smart approach to the concept of gravity. This was based on his new "Principle of Equivalence". The principle of equivalence boldly states that the effects and forces produced by gravity are in every way similar to the effects and forces produced by acceleration, so that it is theoretically impossible to distinguish between the effects and forces produced by gravity and those produced by acceleration. You might think: What has gravity has to do with acceleration? Well, in special relativity, Einstein says that a person sitting in an absolutely smooth train car, could not determine by any possible way (except for looking out of the curtains!), whether he was at rest or moving in uniform motion. In general relativity, Einstein stated that if the train car has speeded up or slowed down or driven around a curve, the passenger couldn't tell whether the forces produced on his body were due to gravitation or whether they were acceleration forces brought into play by placing pressure on the train accelerator or on the brake or by turning the train sharply right or left!

Closer look at Acceleration

Do you remember what acceleration is? Well, technically speaking it is the rate of change of velocity with respect to time. We also need to describe some other things, which are considered essential in order to understand general relativity. In general relativity, Einstein proposed that space and time may be united into a one, 4-dimensional geometry, the one invented by Riemann.

This geometry consists of 3 space dimensions and 1 time dimension. This geometry is known as space-time geometry. In space-time, the motion of particles from one point to another, as time progresses, are represented by curves known as world lines. If there is no gravity acting, the most regular lines are straight ones; they represent particles that move with constant velocity and don't change directions. They fit perfectly within special relativity's foundations, because special relativity deals with non-inertial frames. If, however, any force (such as the gravitational force) acts upon a particle, then its world line will not be straight anymore. In a curved geometry, there are no straight lines. Instead, there are special kinds of curves known as geodesics. These curves are at each point as straight as possible, and they are the most natural lines in curved geometry. Let's see if you can get a glimpse of what general relativity means in the following thought experiment.

Stationary Accelerating Objects

Consider an astronaut standing in a stationary rocket that still had not departed from Earth. Because of the earth's gravity, his or her feet are pressed against the floor of the rocket with a force equal to the person's weight, w. When the rocket goes far out into an area of space that has no star nor planets, or in other words, an area where there are no gravitational influences, should the rocket be accelerating, then the astronaut is again being pressed against the floor of the rocket. If the acceleration is 9.8 m/sec^2 (test your physics knowledge here . . . similar to that of Earth), the force of which the astronaut is pressed against the floor is again equal to w. Without referring to any outside reference frames (less technically speaking, looking out of the window), the astronaut has no way of knowing whether the rocket was at rest on Earth or accelerating in the realms of the cosmos! The force of acceleration as far as the astronaut is concerned is in no way different than the force of gravity. According to Einstein, Newton's gravitational law is an unnecessary one; Einstein relates all forces, both gravitational and those associated with acceleration, to the effects of acceleration. In other words, acceleration causes gravity, and gravity is a direct effect of acceleration.

When the rocket was still standing at rest on Earth, it is attracted towards the Earth's core. Einstein boldly states that the phenomenon of gravitational attraction is an effect of the rocket's acceleration. But how in the world, is the rocket accelerating, when it is standing in a stationary position on Earth? Well, Einstein argues, that in 3-dimensional space, the rocket is indeed stationary, however, in 4- dimensional space-time, the rocket is in motion along its world line. Less technically speaking, the rocket is accelerating; however, it is doing so in its 4-dimensional space-time. According to Einstein, this world line is curved (or its 4-dimensional space-time), because of the curvature of the continuum in the neighborhood of the earth.

Let's describe this more simply. Of course, all of us are familiar with the star known as the "Sun". The sun exerts a powerful gravitational field all around it. Newton posed his powerful law of universal gravitation, to describe the effects of gravity and not to describe gravity as a force by its own, as previously mentioned. Well, Einstein envisions the sun as a bowling ball with fabric placed around it. You can imagine this fabric as a piece of strong paper (just strong enough so that the bowling ball wouldn't tear through it). What happens if you place a bowling ball in the middle of a piece of paper? Well, probably, the area surrounding the bowling ball will go down so it could withstand the mass of the bowling ball. The center area will be where the paper will go down the farthest. As you go away from the center of the paper (the place where the bowling ball is present), you would fine the paper beginning to curve up until it is nearly straight at the edges of the paper. This is exactly what happens with gravity. A star, like the sun causes a warp of the fabric around it. What is this fabric in reality? It is 4-dimensional space-time.

Therefore, Newton's law of universal gravitation states that every object attracts every other object in direct proportion to its mass is replaced by the new relativistic hypothesis that the continuum is curved in the neighborhood of massive objects. Einstein's law of gravity simply states that the world line of every object is a geodesic in the continuum. **The formulas themselves are complicated and you probably won't understand them, unless, of course, if you thoroughly understand Rimenaanian geometry, differential calculus and differential equations, and possible some Linear Algebra. If you do understand all of these things in great detail, then this is old stuff.**

Space-time curvature

According to Einstein, a gravitational force does not exist. Rather, the presence of a mass causes a curvature of space-time in the vicinity of the mass, and this curvature dictates the space-time path that all freely moving objects must follow. In 1979, John Wheeler summarized Einstein's general theory of relativity in a single sentence: "Space tells matter how to move and matter tells space how to curve."

Einstein eventually identified the property of spacetime which is responsible for gravity as its *curvature*. Space and time in Einstein's universe are no longer flat (as implicitly assumed by Newton) but can pushed and pulled, stretched and warped by matter. Gravity feels strongest where spacetime is most curved, and it vanishes where spacetime is flat. This is the core of Einstein's theory of general relativity

'Classical' general relativity, which is the theory developed by Einstein in 1915, is a theory where gravitational fields are continuous entities in nature. They also represent the geometric properties of 4-dimensional spacetime. In quantum mechanics, fields are discontinuous and are defined by 'quanta'. So, there is no analog in conventional quantum mechanics for the gravitational field, even though the other three fundamental forces have now been described as 'quantum fields' after considerable work in the 1960-1980s. Quantum mechanics is incompatible with general relativity because in quantum field theory, forces act locally through the exchange of well-defined quanta.

Gravity according to general relativity is equivalent to the geometric properties of space-time; in fact they are equal and inseparable descriptions which you are free to move between. Geodesics are geometric objects which represent the straightest possible line that can be drawn between two points, so whenever you talk about what geodesics look like, you are invoking the geometric description of gravity and not its familiar Newtonian description in terms of forces. Geodesics curve near matter because the geometry of space-time is curved.

Light escaping a gravitational field will be shifted to longer wavelengths as it loses energy, and this is what distant observers see as a red shift.

Experiments continue to show that there is no 'space' that stands apart from space-time itself...no arena in which matter, energy and gravity operate which is not affected by matter, energy and gravity. General relativity tells us that what we call space is just another feature of the gravitational field of the universe, so space and space-time can and do not exist apart from the matter and energy that creates the gravitational field. This is not speculation, but sound observation.

A gravitational field contains energy just like electromagnetic fields do. This energy also produces its own gravity, and this means that unlike all other fields, gravity can interact with itself and is not 'neutral'.

IS SPACE-TIME ORIENTABLE?

There is no evidence for this...certainly not within our own space-time. Whether it is orientable in some larger space/time we do not know how to confirm or disprove this because all that we can ever experience is within our space-time only.

IS THE GRAVITY OF DISTANT OBJECTS THE CAUSE OF INERTIA?

IF SPACE EXISTS, WHAT IS IT? ****

This is the single most important question in modern physics. Einstein himself said that so far as his general relativity is concerned, space (actually space-time) and the gravitational field are the SAME THINGS. We see it as something that is empty because, in modern language, we cannot see the quantum particles called gravitons out of which it is 'manufactured'. We exist much like the raisins in a bread, surrounded by the invisible but almost palpable 'dough' of the gravitational field. In many respects there is no difference between the field that we are embedded in and the apparently solid matter out of which we are made. Even at the level of quarks, over 95 percent of the 'matter' that makes up a 100 kg person is simply locked up in the energy of the gluonic fields out of which protons are fashioned. The rest is a gift from the way quarks and electrons interact with a field called the Higgs field which permeates space. We are, really and truly, simply another form of the gravitational field of the universe, twisted by the Big Bang into a small family of unique particle states.

WHAT DOES LIGHT TRAVEL TIME HAVE TO DO WITH LOOKING INTO THE PAST OR FUTURE?

If an object is 5 billion light years distant you are seeing what it looked like 5 billion years ago. You cannot receive an image from an object that is later than its light travel distance. In other words, the light from the distant object that was emitted 4 billion years ago, is still on its way to us, and the light it emitted 6 billion years ago already passes us by over a billion years ago. You can never look into the future. Honest. You cannot see light from an object BEFORE it emitted the light.

Many different tests that we are capable of performing IMPLY VERY STRONGLY that General Relativity in its most simple form, is the way that nature seems to work. This means that the underlying principles are also sound. Specific ones like the bending of light by gravitational fields and the equality between gravitational and inertial mass can be individually tested and have been found to be correct to within experimental error.

WHY DO THE LAWS OF PHYSICS BREAK DOWN IN SINGULARITIES?

Because particular quantities that define the physics (velocity, density, mass, size) no longer have any finite meaning. The relevant quantities either become 'zero' or infinite with nothing in between in a mathematical sense.

WHAT PROOFS ARE THERE FOR GENERAL RELATIVITY?

So far, GR has made the following specific predictions:

1...The entire orbit of Mercury rotates because of the curved geometry of space near the sun. The amount of 'perihelion shift' each century was well known at the time Einstein provided a complete explanation for it in 1915.

2...Light at every frequency can be bent in exactly the same way by gravity. This was confirmed in the 1919 Solar Eclipse for optical light using stars near the Sun's limb, and in 1969-1975 using radio emissions from star-like quasars also seen near the limb of the Sun. The deflection of the light was exactly as predicted by GR.

3...Clocks run slower in strong gravitational fields. This was confirmed by Robert Pound and George Rebka at Harvard University in 1959, and by Robert Vessot in the 1960's and 70's using high-precession hydrogen maser clocks flown on jet planes and on satellites.

4...Gravitational mass and inertial mass are identical. Most recently in 1971, Vladimir Braginsky at Moskow University confirmed GRs prediction of this to within 1 part in a trillion of the exact equality required by GR.

5...Black holes exist. Although these objects have been suspected to exist since they were first introduced to astronomers in the early 1970's, it is only in 1992 that a critical acceptance threshold was crossed in the astronomical community. It was then that Hubble Space Telescope observations revealed monstrous, billion-sun black holes in the cores of nearby galaxies such as Messier 87, Messier 33 and NGC 4261.

6...Gravity has its own form of radiation which can carry energy. Russel Hulse and Joseph Taylor in 1975 discovered two pulsars orbiting each other, and through careful monitoring of their precise pulses during the next 20 years, confirmed that the system is loosing energy at a rate within 1 percent of the prediction by GR based on the emission of gravitational radiation.

7...A new force exists called 'gravito-magnetism'. Just as electric and magnetic fields are linked together, according to GR, a spinning body produces a magnetism-like force called gravitomagnetism. GR predicts that rotating bodies not only bend space and time, but also make empty space spin. A NASA satellite called Gravity Probe B will be launched in the next few years to see whether this effect exists. This is a killer. If it is not found, GR is mortally wounded despite its long string of other successes. **Verify this**

8...Space can stretch during the expansion of the universe. This was confirmed by Edwin Hubble's detection of the recession of the galaxies ca 1929. More recently in 1993, Astronomer Kenneth Kellerman confirmed that the angular sizes of distant radio sources shrink to a minimum then increase at greater distances exactly as expected for a dilating space. This is not predicted by any other cosmological model that does not also include the dilation of space as a real, physical phenomenon.

WHAT IS THE RELATIONSHIP BETWEEN SPACE AND TIME?

Mathematically, and in accordance with relativity, they are in some sense interchangeable, but we do know that they form co-equal parts of a larger 'thing' called space-time, and it is only within space-time that the most complete understanding of the motion and properties of natural objects and phenomena can be rigorously understood by physicists. Space and time are to space-time what arms and legs are to humans. In some sense they are interchangeable, but you cannot understand 10,000 years of human history without including both arms and legs as part of the basic human condition.

IS SPACE REALLY QUANTIZED?

No experiments indicate this today, and no one knows how to perform the experiments that might best reveal such a property to space. We don't have the technology

CAN GRAVITY WAVES BE USED TO CARRY INFORMATION?

In principle they can, but the engineering required to detect modulated gravity waves is formidable. Many natural phenomena also produce modulated gravity waves.

"SPACETIME DOES NOT CLAIM EXISTENCE ON ITS OWN BUT ONLY AS A STRUCTURAL QUALITY OF THE [GRAVITATIONAL] FIELD"

..TIME AND SPACE ARE MODES BY WHICH WE THINK AND NOT CONDITIONS IN WHICH WE LIVE."

They are free creations of the human mind to use one of Einstein's own expressions.

Einstein stated that in his General relativity, there would be no mathematical difference between what we call the gravitational field, and what we identify as 'space-time'. Space-time is, therefore, not a consequence of gravity, it **IS** the gravitational field itself. The cosmological gravitational field created at the Big Bang encompasses everything and is the dynamical embodiment of space-time itself.

Space and time form the very fabric of the cosmos. Yet they remain among the most mysterious of concepts. Is space an entity? Why does time have a direction? Could the universe exist without space and time? Can we travel to the past? Greene has set himself a daunting task: to explain non-intuitive, mathematical concepts like String Theory, the Heisenberg Uncertainty Principle, and Inflationary Cosmology with analogies drawn from common experience. From Newton’s unchanging realm in which space and time are absolute, to Einstein’s fluid conception of spacetime, to quantum mechanics’ entangled arena where vastly distant objects can instantaneously coordinate their behavior, Greene takes us all, regardless of our scientific backgrounds, on an irresistible and revelatory journey to the new layers of reality that modern physics has discovered lying just beneath the surface of our everyday world.

Gravitational waves

Most scientists describe gravitational waves as "ripples in space-time." Just like a boat sailing through the ocean produces waves in the water, moving masses like stars or black holes produce gravitational waves in the fabric of space-time. A more massive moving object will produce more powerful waves, and objects that move very quickly will produce more waves over a certain time period.

Gravitational waves are usually produced in an interaction between two or more compact masses. Such interactions include the binary orbit of two black holes, a merge of two galaxies, or two neutron stars orbiting each other. As the black holes, stars, or galaxies orbit each other, they send out waves of "gravitational radiation" that reach the Earth, However, once the waves do get to the Earth, they are extremely weak. This is because gravitational waves, like water waves, decrease in strength as they move away from the source. Even though they are weak, the waves can travel unobstructed within the 'fabric' of space-time. This is how they are able to reach the Earth and provide us with information that light cannot give.

In physics, **gravitational waves** are ripples in the curvature of spacetime which propagate as a wave, travelling outward from the source. Predicted to exist by Albert Einstein in 1916 on the basis of his theory of general relativity, gravitational waves theoretically transport energy as **gravitational radiation**. Sources of detectable gravitational waves could possibly include binary star systems composed of white dwarfs, neutron stars, or black holes. The existence of gravitational waves is possibly a consequence of the Lorentz invariance of general relativity since it brings the concept of a limiting speed of propagation of the physical interactions with it. Gravitational waves cannot exist in the Newtonian theory of gravitation, since in it physical interactions propagate at infinite speed.

Although gravitational radiation has not been *directly* detected, there is *indirect* evidence for its existence. For example, the 1993 Nobel Prize in Physics was awarded for measurements of the Hulse-Taylor binary system which suggests gravitational waves are more than mathematical anomalies. Various gravitational wave detectors exist. However, they remain unsuccessful in detecting such phenomena.

In Einstein's theory of general relativity, gravity is treated as a phenomenon resulting from the curvature of spacetime. This curvature is caused by the presence of massive objects. Roughly speaking, the more massive the object is, the greater the curvature it produces and hence the more intense the gravity. As massive objects move around in spacetime, the curvature changes to reflect the changed locations of those objects. In certain circumstances, objects that are accelerated generate a disturbance in spacetime which spreads, as the metaphor goes, "like ripples on the surface of a pond", although perhaps a better analogy would be electromagnetic waves. This disturbance is known as gravitational radiation. Gravitational radiation is thought to travel through the Universe at the speed of light, diminishing in strength but never stopping or slowing down.

Gravitational waves should penetrate regions of space that electromagnetic waves cannot. It is hypothesized that they will be able to provide observers on Earth with information about black holes and other mysterious objects in the distant Universe. Such systems cannot be observed with more traditional means such as optical telescopes and radio telescopes. In particular,

gravitational waves could be of interest to cosmologists as they offer a possible way of observing the very early universe. This is not possible with conventional astronomy, since before recombination the universe was opaque to electromagnetic radiation. Precise measurements of gravitational waves will also allow scientists to test the general theory of relativity more thoroughly.

In astrophysics, a **gravitational wave** is a wavering or fluctuation in space-time, traveling outwards from the source. In short, it is like a 'ripple in space-time', just like the small waves produced by a boat sailing through a sea. This is caused by large, moving celestial bodies such as stars and black holes. The more massive an object is, the more powerful the gravitational wave is produced. And the faster the movements of that source, more gravitational waves are propagated.

Such waves come from the interaction of two solid masses, such as black holes orbiting around each other, a merging of two galaxies, or two stars moving around one another. Binary star systems like white dwarfs and neutron stars are also sources of gravitational waves. Because of such interaction, they produce gravitational waves.

However, like waves in the water, they decrease in strength as they go farther away from the source. Scientists use various instruments to detect them from the Earth. Gravitational waves have never actually been detected 'directly', but were rather 'indirectly' shown to exist

In General Relativity gravity is viewed as a curvature of Spacetime so Gravitational Waves are ripples in the fabric of space and time itself. A gravitational wave alternately stretches and shrinks space as it passes through, but on a very small scale (as little as a factor of 10^{-21} even for a very strong source).

WHAT IS A BLACK HOLE?

A black hole is a region of spacetime from which nothing can escape, even light.

DO THEY REALLY EXIST?

It is impossible to see a black hole directly because no light can escape from them; they are black. But there are good reasons to think they exist.

When a large star has burnt all its fuel it explodes into a supernova. The stuff that is left collapses down to an extremely dense object known as a neutron star. We know that these objects exist because several have been found using radio telescopes

Einstein's general theory of relativity describes gravity as a curvature of spacetime caused by the presence of matter. If the curvature is fairly weak, Newton's laws of gravity can explain most of what is observed. For example, the regular motions of the planets. Very massive or dense objects generate much stronger gravity. The most compact objects imaginable are predicted by General Relativity to have such strong gravity that nothing, not even light, can escape their grip.

Scientists today call such an object a black hole. Why black? Though the history of the term is interesting, the main reason is that no light can escape from inside a black hole: it has, in effect, disappeared from the visible universe.

Why Study Black Holes?

Here are some good reasons:

1. Human curiosity: they are among the most bizzare objects thought to exist in the universe.
2. They should be strong sources of gravitational waves.
3. As such, black holes should reveal much about gravity, a fundamental force in the cosmos.

Confirmation that they exist will strengthen confidence in current models of cosmic evolution, from the Big Bang to the present universe

Dark Matter is something that can't be seen, but its presence has been revealed by observations of the universe. Billions of years ago, the universe sprang forth with a cataclysmic big bang. As eons of time passes, this early universe slowly cooled and began to evolve. Eventually, stars, galaxies, and the rest of the visible universe took shape. The size of our universe is staggering. Our Sun is large enough to hold one million Earths. The Sun is an average-sized star. Our galaxy contains over 100 billion stars. That's more stars than there grains of sand on the average beach. But there's more. The universe is known to contain billions of galaxies. There is a lot of matter out there. But something seems to be missing. It appears that what we can see may not be all there is. Strong evidence is mounting that suggests there exists large amounts of dark matter in the universe. Scientists estimate that what we do see may only account for 10% of the mass of the universe. That means that 90% of the matter is invisible. Some estimates even place this number as high as 99%. Astronomers refer to this invisible mass as dark matter.

Because dark matter does not seem to give off or reflect light, x-rays, or any other radiation, the instruments which can find normal matter (like hot gas, stars, planets, and us) are unable to find dark matter. It seems that dark matter is not made of the same thing as the matter we see everyday on Earth. The only way we can tell it is there is by how it affects things we can see by gravity.

More is unknown than is known. We know how much dark energy there is because we know how it affects the Universe's expansion. Other than that, it is a complete mystery. But it is an important mystery. It turns out that roughly 70% of the Universe is dark energy. Dark matter makes up about 25%. The rest - everything on Earth, everything ever observed with all of our instruments, all normal matter - adds up to less than 5% of the Universe. Come to think of it, maybe it shouldn't be called "normal" matter at all, since it is such a small fraction of the Universe.

One explanation for dark energy is that it is a property of space. Albert Einstein was the first person to realize that empty space is not nothing. Space has amazing properties, many of which are just beginning to be understood. The first property that Einstein discovered is that it is possible for more space to come into existence. Then one version of Einstein's gravity theory, the version that contains a cosmological constant, makes a second prediction: "empty space" can possess its own energy. Because this energy is a property of space itself, it would not be diluted as space expands. As more space comes into existence, more of this energy-of-space would appear. As a result, this form of energy would cause the Universe to expand faster and faster. Unfortunately, no one understands why the cosmological constant should even be there, much less why it would have exactly the right value to cause the observed acceleration of the Universe.

Dark Matter Core Defies Explanation

This image shows the distribution of dark matter, galaxies, and hot gas in the core of the merging galaxy cluster Abell 520. The result could present a challenge to basic theories of dark matter.

Another explanation for how space acquires energy comes from the quantum theory of matter. In this theory, "empty space" is actually full of temporary ("virtual") particles that continually form and then disappear. But when physicists tried to calculate how much energy this would give empty space, the answer came out wrong - wrong by a lot. The number came out 10^{120} times too big. That's a 1 with 120 zeros after it. It's hard to get an answer that bad. So the mystery continues.

By fitting a theoretical model of the composition of the Universe to the combined set of cosmological observations, scientists have come up with the composition that we described above, ~70% dark energy, ~25% dark matter, ~5% normal matter. What is dark matter?

Dark matter is non-luminous matter that cannot be directly detected by observing any form of electromagnetic radiation (light), but whose existence is suggested because of the effects of its gravity on the rotation rate of galaxies and the presence of clusters of galaxies.

In addition to dark matter, the universe contains large amounts of another invisible ingredient known as dark energy. Overall, the cosmos seems to consist of 4% ordinary matter (mostly in the form of hydrogen and helium), 23% dark matter, and 73% dark energy.

In the Beginning

The Big Bang model of the universe's birth is the most widely accepted model that has ever been conceived for the scientific origin of everything. No other model can predict as much as the Big Bang model can.

A common question that people ask is "What happened before the Big Bang?" The phrase "in the beginning" is used here to refer to the birth of our universe with the Big Bang. In the creation of the universe, everything was compressed into an infinitesimally small point, in which all physical laws that we know of do not apply. No information from any "previous" stuff could have remained intact. Therefore, for all intents and purposes, the Big Bang is considered the beginning of everything, for we can never know if there was anything before it

Main Evidence

The Big Bang is the leading theory that almost all astrophysicists believe explains the origin of the universe. This is because all observations so far made support the Big Bang theory; there are four main lines of evidence that are most-often used.

The first was discussed above: The expansion of the universe. The universe is expanding now, so in the past it must have been smaller. If it were smaller in the past, then there probably was a time when it was infinitesimally small. One could ask why don't we think that it might be expanding now but it could have been shrinking before and we just don't know about it. The answer is that there is simply no mechanism that we know about that could accomplish this transition on a universal scale.

The second line of evidence is the Cosmic Microwave Background Radiation (CMB) that was discovered in 1965 by Arno Penzias and Robert Wilson from Bell Labs. They were working with a microwave receiver, but were getting noise from every direction they pointed the receiver. It was coming from all over the sky at what seemed to be exactly the same frequency. This was the first evidence for the CMB, and they later shared a Nobel Prize for this discovery

The second fundamental principle of General Relativity is that the presence of *matter curves space*. In this view, gravity is not a force, as described by Newton, but a curvature in the fabric of space, and objects respond to gravity by following the curvature of space in the vicinity of a massive object. The description of the curvature of space is the mathematically complicated part of general relativity involving "metrics", which describe the way that matter curves space, and tensor calculus

Well, that's not really the way science works and besides, Newton was not completely wrong and Einstein is not completely right. Newton's Theory is perfectly fine for most calculations of gravity where the field is not too strong. NASA scientists do not use General Relativity to calculate the paths of spacecraft that are sent to explore the solar system (not because it would be too complicated or difficult, but because it would be a waste of time - Newton was right as far as most things in the Solar System are concerned). Furthermore, General Relativity fails on very small scales when quantum mechanical effects become important. Theoretical Physicists are working very hard on theories of "Quantum Gravity", but so far no one has succeeded in improving Einstein's Theory; no doubt the next better theory of gravity will still be an approximation of the "Truth". Science works by:

1. developing theories or hypotheses,
2. testing them repeatedly by experiment and observation,
3. using them where they are shown to be applicable, and
4. revising & improving them when they are shown to disagree with experiment.

This *Scientific Method* is a never ending cycle.

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The starting principle of the general theory, known as the equivalence principle, is that frames of reference undergoing acceleration and frames of reference in gravitational fields are equivalent. Among its predictions, which have been borne out by observation, are the advance of the perihelion of Mercury, the bending of light in a gravitational field (including gravitational lenses), and the spin-down of pulsars (due to the emission of gravitational waves, which have yet to be detected directly). Also predicted by general relativity is that time runs more slowly in strong gravitational fields.

http://www.physicsoftheuniverse.com/sources.html

POSTULATES OF A GENERAL THEORY

The general theory is based on a seemingly common observation about gravity and accelerations. The two postulates of Einstein's general theory of relativity are:

1) All the laws of nature have the same form for observers in any frame of reference, whether accelerated or not.

2) In the vicinity of any point, a gravitational field is equivalent to an accelerated frame of reference in the absence of gravitational effects. This is the principle of equivalence, which forms the basis of the general theory of relativity.

Mass have seemingly different properties: a gravitational attraction and an inertial property that resists acceleration. To designate these two attributes, we use the subscripts g and i and write:

Gravitational property $F_g = m_g g$

Inertial property $\sum F = m_i a$.

The second postulate implies that gravitational mass and inertial mass are completely equivalent, not just proportional. What were thought to be two different types of mass are actually identical.
http://myfundi.co.za/e/Relativity_I:_General_theory_of_relativity

Particle physics proposals

Everything is made up of atoms. In side atoms are protons, neutrons and electrons, which in turn are made up of quarks and leptons. Forces that hold together these particles are carried by bosons.

In 1964, Peter Higgs along with two teams from Belgium and US, proposed the bosons must be creating a sticky field that weighs the elementary particles down and gives them mass. Since 2008, physicists at CERN had been trying the existence of this Higgs boson. Using the guest celebrity analogy, what the scientists did was to make one clump of people cannon in to another, and then examine the debris to make out who is who. Scientifically speaking, the physicists shot beams of protons at nearly the speed of light using the electromagnetic fields. After the protons gained the enormous kinetic energy , the beams were allowed to intersect. The collision of protons released energy , thanks to which new particles , some of them very unstable , were formed. The physicists caught a glimpse of a boson, which , they say, was consistent with the one Higgs proposed.

***Graviton* -** In addition to the above bosons, theories of quantum gravity also propose another type of boson, the graviton, which would mediate the gravitational force. To date, however, this boson has not been confirmed

According to Peter Higgs, the most interesting thing now is going to be testing the theories that go beyond the standard model for describing the universe , like super-symmetry. Because with the discovery of this new boson, this model is essentially complete.

Peter Higgs' best-known paper on the new particle was initially rejected. But this was a blessing in disguise, since it led Higgs to add a paragraph introducing the now-famous Higgs particle. In 1964, ***Higgs wrote two papers, each just two pages long***, on what is now known as the Higgs field. The journal ***Physics Letters*** accepted the first but sent the second back. Yoichiro Nambu, a highly regarded physicist who had reviewed the second paper, suggested Higgs add a section explaining his theory's physical implications. Higgs added a paragraph predicting that an excitation of the field, like a wave in the ocean, would yield a new particle. He then submitted the revised paper to the competing journal ***Physical Review Letters***, which published it.

The Higgs finding is expected to throw fresh light on several cosmic mysteries. For example, it could point to different predictions about how much of the universe is dark matter, an enigmatic substance that exerts a gravitational force on entire galaxies

Higgs bosons obey the conservation of energy law, which states that no energy is created or destroyed, but instead it is transferred. First, the energy starts out in the gauge boson that interacts with the Higgs field. This energy is in the form of kinetic energy as movement. After the gauge boson interacts with the Higgs field, it is slowed down. This slowing reduces the amount of kinetic energy in the gauge boson. However, this energy is not destroyed. Instead, the energy is converted into mass-energy, which is normal mass that comes from energy. The mass created is what we call a Higgs boson. The amount of mass created comes from Einstein's famous equation $E=mc^2$, which states that mass is equal to a large amount of energy (i.e. 1 kg of mass is equivalent to almost 90 quadrillion joules of energy—the same amount of energy used by the entire world in roughly an hour and a quarter in 2008). Since the amount of mass-energy created by the Higgs field is equal to the amount of kinetic-energy that the gauge boson lost by being slowed, energy is conserved.

According to a theory, Higgs field**,** an energy field made up of a particle called the Higgs boson slow some particles but not photons. Higgs boson are a set of particles from which we can attempt to know about the fundamental building blocks of the universe and how the Universe was made.

Any particle that travels through universe:

1. Attracts Higgs boson: Then they combine to form matter and gain all the properties of mass (weight, gravity, etc.).
2. Pushes Higgs boson away: Then it continues to travel as a form of energy over an infinite range (light).

3. Higgs boson joined with other particles creates life: humans, plants, rocks, etc.

The challenges that are to be faced by the standard model

Mass is, quite simply, a measure of how much stuff an object - a particle, a molecule, or a Yorkshire terrier - contains. If not for mass, all of the fundamental particles that make up atoms and terriers would whiz around at light speed, and the Universe as we know it could not have

clumped up into matter. The Higgs mechanism proposes that there is a field permeating the Universe - the Higgs field - that allows particles to obtain their mass. Interactions with the field - with the Higgs bosons that come from it - are purported to give particles mass. This is not unlike a field of snow, in which trudging through impedes progress; your shoes interacting with snow particles slows you down.

Matter has many definitions, but the most common is that it is any substance which has mass and occupies space. All physical objects are composed of matter, in the form of atoms, which are in turn composed of protons, neutrons, and electrons.

The Standard Model of Particle Physics is at the core of modern physics. In this model, three of the four fundamental forces of physics are described, along with the particles that mediate these forces - gauge bosons. Technically, gravity isn't included in the Standard Model, though theoretical physicists are working to extend the model to include a quantum theory of gravity.

A graviton is a theoretical virtual particle which would mediate the force of gravity. It is proposed by various theories of quantum gravity. The graviton would support a quantum representation of gravity which would consolidate it with the other fundamental forces of physics, which are also mediated by virtual particles. Gravitons have not been experimentally observed. The theoretical models that include them predict a mass less particle of spin 2, which would make it a boson.

The current quantum mechanical interpretation of these forces is that the particles do not interact directly, but rather manifest virtual particles that mediate the actual interactions. All of the forces except for gravity have been consolidated into this "Standard Model" of interaction.

Theoretical and experimental research has attempted to extend the Standard Model into a Unified Field Theory or a Theory of everything, a complete theory explaining all physical phenomena including constants. Inadequacies of the Standard Model that motivate such research include:

1) It does not attempt to explain gravitation, although a theoretical particle known as a graviton would help explain it, and unlike for the strong and electroweak interactions of the Standard Model, there is no known way of describing general relativity, the canonical theory of gravitation, consistently in terms of quantum field theory. The reason for this is, among other things, that quantum field theories of gravity generally break down before reaching the Planck scale. As a consequence, we have no reliable theory for the very early universe;

2)Some consider it to be *ad-hoc* and inelegant, requiring 19 numerical constants whose values are unrelated and arbitrary. Although the Standard Model, as it now stands, can explain why neutrinos have masses, the specifics of neutrino mass are still unclear. It is believed that explaining neutrino mass will require an additional 7 or 8 constants, which are also arbitrary parameters;

3) The Higgs mechanism gives rise to the hierarchy problem if any new physics (such as quantum gravity) is present at high energy scales. In order for the weak scale to be much smaller than the Planck scale, severe fine tuning of Standard Model parameters is required;

4) It should be modified so as to be consistent with the emerging "Standard Model of cosmology." In particular, the Standard Model cannot explain the observed amount of cold dark matter (CDM) and gives contributions to dark energy which are far too large. It is also difficult to accommodate the observed predominance of matter over antimatter (matter/antimatter asymmetry). The isotropy and homogeneity of the visible universe over large distances seems to require a mechanism like cosmic inflation, which would also constitute an extension of the Standard Model.

5) The Standard Model (SM) predicts that neutrinos should be massless. However, recent developments have found neutrino oscillations, indicating that neutrinos have mass. The SM can be adjusted to include the masses, but it should include them with no changes needed.

6) In fact, the SM doesn't predict any of the masses of any particle. A good model should predict the masses of all the particles and not simply their existence.

7) Another problem with the SM is dark matter. Dark matter is supposed to be a particle.

Dark Matter & Dark Energy

1) Dark matter concentrates around galaxies and galaxy clusters.
Dark energy is smoothly distributed throughout the universe.

2) Dark matter is pressure less, with rest mass dominating the energy density.
Dark energy has a strongly negative pressure, of the same order as its energy density.

3) Dark matter has been important to the evolution of the universe since around the epoch of matter-radiation equality, when the universe was less than 100,000 years old.
Dark energy has been important to the evolution of the universe since the universe was about 7 billion years old.

4) Dark matter interacts through gravity and presumably the weak nuclear force.
Dark energy interacts only through gravity.

5) Dark matter makes up about 20% of the total energy density in the universe today, and about 70% at the time of the last scattering of the cosmic microwave background radiation.
Dark energy makes up about 75% now, and a negligible amount at CMB last scattering.

So other than their names, there really isn't much similarity. Of course it is attractive to solve two mysteries with one explanation, so we would like to find a way to tie them together. Speculations involving more complicated connections exist, but in the simplest pictures dark energy and dark matter are independent.

Black Holes

One alternative to the existence of dark matter is that the added gravitational forces are actually caused by numerous Black Holes in the galaxies. Since light cannot escape Black Holes, they would be unseen. They also exhibit a large gravitational force. A problem with the argument is that the Black Holes would also affect the orbits of any galaxies or suns that passed by, and that has not been observed.

Another alternative to dark matter is the *Modified Newtonian Dynamics Theory*, which proposes that at higher speeds or accelerations seen in stars at the outer edges of galaxies, gravitational attraction would fall off as a simple inverse of the separation instead of the inverse square of the separation in the Universal Gravitation Equation. This would allow stars on the outer edge of a galaxy to be held by a stronger gravitational pull.

One more concept is the existence of large quantities of particles, such as the neutrino, that do not readily interact with other forms of matter and are difficult to detect

The existence of dark energy begs the question of why it only affects galaxies and not smaller objects of matter. Instead of being anti-gravitation, it could be a characteristic of space or perhaps some other unknown force that is applicable for only extremely large masses. Some feel that dark energy implies that the General Relativity Theory does not apply in certain situations. Dark matter and dark energy affect gravitation in opposite ways. Dark matter is invisible material that seems to add to the gravitation in galaxies. Dark energy seems to accelerate the expansion of the Universe with an anti-gravitation force. Both dark matter and dark energy are theories to explain anomalies in gravitation for objects at the galaxy scale of measurement

Gravitational waves

Most scientists describe gravitational waves as "ripples in space-time." Just like a boat sailing through the ocean produces waves in the water, moving masses like stars or black holes produce gravitational waves in the fabric of space-time. A more massive moving object will produce more powerful waves, and objects that move very quickly will produce more waves over a certain time period.

Gravitational waves are usually produced in an interaction between two or more compact masses. Such interactions include the binary orbit of two black holes, a merge of two galaxies, or two neutron stars orbiting each other. As the black holes, stars, or galaxies orbit each other, they send out waves of "gravitational radiation" that reach the Earth, However, once the waves do get to the Earth, they are extremely weak. This is because gravitational waves, like water waves, decrease in strength as they move away from the source. Even though they are weak, the waves can travel unobstructed within the 'fabric' of space-time. This how they are able to reach the Earth and provide us with information that light cannot give..

According to big-bang theories, at the beginning of time, all of the matter and energy in the universe was concentrated in a very dense state, from which it "exploded," with the resulting expansion continuing until the present. This "big bang" is dated between 10 and 20 billion years ago. In this initial state, the universe was very hot and contained a thermal soup of quarks, electrons, photons, and other elementary particles

Pre - big bang

The Singularity means that some terms become infinite and others unhelpfully become zero. So General Relativity has not been able to predict (or retrodict) what happens before, or how this process really began. The general assumption has been that it was some kind of giant Quantum Event. This assumption, when explained using a more complete theory of Quantum Gravity, may yet be correct.

However in the last few years, several mathematical cosmologists have taken seriously the idea that there was a Pre-Big Bang. Part of the reason for this may be because of the Cosmic Background Radiation data from satellites like WMAP. This data shows larger scale structure in the early universe than the older theories would have predicted.

In particular Roger Penrose has developed a view that the period since the Big Bang should be called an aeon, and that there were earlier a eons each infinitely long. This makes the Big Bang a kind of transition period between two a eons. The theory is speculative in several respects, but it is based on some mathematical constructions in General Relativity. This theory is called Conformal Cyclic Cosmology (CCC for short).

From the above paragraphs, we have to arrive at a conclusion that gravitons and darkons are to be included in the standard model. The next task for experimentalist is to detect gravitons, darkons, gravitational waves, black holes , dark matter and dark energy. The timely important mission theoretical physicists have to face is gemetrization of standard model of particle physics. Only this will pave the way for the general relativistic interpretation of quantum physics. According to Gödel's incompleteness theorems a physical theory of everything is not possible. This implies that we can NOT know the ultimate nature of this universe. Needless to say Einstein's relativistic theories revolutionized physics and cosmology. But general relativity is unable to interpret Sagnac experiment which was conducted in 1914.This is a serious drawback. Unfortunately the research community does not sleep on this problem. Let us assert that even after the gemetrization of standard model of particle physics and unifying general relativity with quantum physics, further future problems will rise and challenge scientists. So, the journey will not stop, it will continue for ever … and for ever.

Let us recall how Einstein geometrized gravity:

The gravitational field is no longer a physical field that exists in spacetime; rather it is now part of the curvature of spacetime itself. Einstein demoted the status of the gravitational field from physics to geometry. The metric field is physically real and just is what was previously called the gravitational field. Einstein elevated the status of the metric field from geometry to physics.

Both interpretations agree that the *structure* of spacetime is no longer flat, as in Special Relativity and Newtonian dynamics. The interpretations disagree over how this structure manifests itself. It's the structure of a real spacetime. It's the structure of a real physical field (the metric field)

The Principle of Equivalence

The gemetrization procedure assumes $m_g = m_i$. All empirical evidence supports this assumption. Einstein elevates it to a principle

The inertial mass and gravitational mass of any object are equal.

or equivalently:

The effects due to a (homogeneous) gravitational field are indistinguishable from the effects due to uniform acceleration.

The Principle of Equivalence says these are indistinguishable reference frames: Any experiments (involving Newton's Laws of Motion, Maxwell's Laws, or Newton's Law of Gravity) cannot distinguish one from the other

The unification of particle physics with general relativity will answer the following big questions:

1) What is the fundamental nature of matter, energy, space, and time?

2) What are the origins of mass? How did the universe begin?

3) What are dark matter and dark energy?

4) Are there extra dimensions of space-time?

5) Black Holes

6) Gravitational Waves

7) Pre big bang