the general science journal

English CPH E-Book

Theory of CPH

Section 1

Logical Foundation of CPH Theory

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Contains:

Introduction;

The greatest problem in theoretical physics is how quantum mechanics and general relativity are combinable? Scientists describe the universe in terms of two basic partial theories - the general relativity and quantum mechanics... The general theory of relativity describes the force of gravity and the large-scale structure of the universe. Quantum mechanics, on the other hands, deals with phenomena on extremely small scales. These two theories are known to be inconsistent with each other - they cannot both be correct. There are many ways to do combine these theories and many theories such as Loop Quantum Theory and String Theory had propounded.

But Theory of CPH (Theory of Creation Particle Higgs) takes a new way. CPH Theory has reconsidered 4 theories (Classical Mechanics, Quantum Mechanics, Relativity and Higg). In fact CPH Theory is a new looking and developing of **Quantum Chromodynamic**c. So, CPH Theory is a **Sub Quantum Chromodynamic theory**.

In this section I will have a summary looking on these theories then restate how we are able does that. In fact we must do change our understanding of graviton.

With Best Regards

Hossein Javadi

A Look at Classical physics

It is the great merit of Galileo that, happily combining experiment with calculation, he opposed the prevailing system according to which, instead of going directly to nature for investigation of her laws and processes, it was held that these were best learned by authority, especially by that of Aristotle, who was supposed to have spoken the last word upon all such matters, and upon whom many erroneous conclusions had been fathered in the course of time. Against such a superstition Galileo resolutely and vehemently set himself, with the result that he not only soon discredited many beliefs which had hitherto been accepted as indisputable, but aroused a storm of opposition and indignation amongst those whose opinions he discredited; the more so, as he was a fierce controversialist, who, not content with refuting adversaries, was bent upon confounding them.

Throughout his life Galileo would provide some of the most compelling arguments in favor of the heliocentric model; though this brought him endless trouble in his lifetime, he was vindicated by all subsequent investigators.

Isaac Newton continued Galileo’s discoveries. Isaac Newton discovered the laws that explained all phenomena known at the time, form the motion of the stars to the behavior of dust particles. It was his extremely successful model that leads people to believe that humanity was on the verge of understanding the whole of Nature.

1st Law and Newtonian space and time

One of the most important consequences of the First Law is that it *defines* what we mean by an inertial frame of reference.

***An inertial reference frame is a reference frame where isolated bodies are seen to move in straight lines at constant velocity*.**

An observer at rest with respect to an inertial frame of reference is called an *inertial observer*. The laws of physics devised by Newton take a particularly simple form when expressed in terms of quantities measured by an inertial observer (such as positions, velocities, etc.). For example, an inertial observer will find that a body on which no forces act moves in a straight line at constant speed or is at rest.

All motion occurs in space and is measured by time. In Newton's model both space and time are unaffected by the presence or absence of objects. That is *space and time are absolute*, an arena where the play of Nature unfolds. In Newton's words, *Absolute space in its own nature, without relation to anything external, remains always similar and immovable.*

...absolute and mathematical time, of itself, and from its own nature, flows equally without relation to anything external, and by another name is called duration.

A consequence of this is that a given distance will be agreed upon by any two observers at rest with respect to each other or in uniform relative motion, for; after all, they are just measuring the separation between two immovable points in eternal space. In the same way a time interval will be agreed upon by *any* two observers for they are just marking two notches on eternal time.

Newton's 2nd Law

The second law is of great practical use. One can use experiments to determine the manner in which the force depends on the position and velocity of the bodies and then use calculus to determine the motion of the bodies by obtaining the position as a function of time using the known form of F and the equation

$$F = m\, a$$

Note that in this equation m measures how strongly a body responds to a given force (the larger m is the less it will be accelerated); m measures the inertia of the body.

Once F is known the motion of any body is predicted: by measuring the falling an apple you can predict the motion of the Moon.

Newton's 3rd Law

For every action, there is an equal and opposite reaction

The statement means that in every interaction, there is a pair of forces acting on the two interacting objects. The size of the forces on the first object equals the size of the force on the second object. The direction of the force on the first object is opposite to the direction of the force on the second object. Forces always come in pairs - equal and opposite action-reaction force pairs.

Gravitation

Galileo's law of gravitation; Heavy objects fall *as fast* light objects.

Newton’s law of gravitation;

Every object attracts every other object, by virtue of their having mass.
An object with twice the mass will attract other objects with twice the force.

Newton's Law of Motion combined with his Law of Gravitation together embodies Galileo's Law of Gravitation. With this thought experiment Newton convincingly argued that an apple can behave in the same way as the Moon, and, because of this it is the very same force, gravity, which makes the apple fall and the Moon orbit the Earth. This is consistent with the hypothesis that gravitation is universal. In a way it represents the unification a several physical effects which appear unrelated at first sight: the falling of apples and the orbiting of planets.

The gravitational force between two bodies of masses m and M separated by a distance r is attractive and directed along the line joining the bodies, its value is

$$F_{\mathrm{grav}} = \frac{mMG}{r^2}$$

Where G is a universal constant.
Consider now the application of the second law to the case of the gravitational force.

$$\frac{mMG}{r^2} = F_{\mathrm{grav}} = ma$$

So that the factors of m cancel this implies that the motion of a body generated by the gravitational force is *independent* of the mass of the body, just as Galileo had observed.

Galileo relativity

Any two observers moving at constant speed and direction with respect to one another will obtain the same results for all mechanical experiments

According Galileo relativity, infinity velocity is acceptable and velocities will sum by vector rules.

In pursuing these ideas Galileo used the scientific method: he derived consequences of this hypothesis and determined whether they agree with the predictions.

This idea has a very important consequence: ***velocity is not absolute***. This means that velocity can only be measured in reference to some object(s), and that the result of this measurement changes if we decide to measure the velocity with respect to a different reference point(s).

This fact, formulated in the 1600's remains very true today and is one of the cornerstones of Einstein's theories of relativity.

Maxwell's Electrodynamics

Although the laws of electricity and of magnetism according to Gauss, Ampere, and Faraday worked remarkably well, there was a glaring problem: *taken together,* ***these laws did not "conserve charge".*** In other words, for these laws (as written) to work, one had to allow charge to be created or destroyed. And this is *not a good thing.* (Additionally, from the form of the equations of these theories, he noticed an interesting **symmetry** (a similarity) in the way the electric field and the magnetic field appeared. It wasn't a perfect symmetry, however.)

Maxwell modified Ampere's Law by adding a single term to it. This was what was needed to make the laws consistent with the conservation of charge. It also made the above symmetry closer to being a perfect symmetry.

$$\nabla \cdot E = \frac{1}{\varepsilon_0}\rho \qquad \textbf{(1)}$$

$$\nabla \cdot B = 0 \qquad \textbf{(2)}$$

$$\nabla \times E = -\frac{\partial B}{\partial t} \qquad \textbf{(3)}$$

$$\nabla \times B = \mu_0 J + \mu_0 \varepsilon_0 \frac{\partial E}{\partial t} \qquad \textbf{(4)}$$

$\in_0$ is the dielectric constant (space) and μ_0 is the magnetic permeability (space)

However, the addition of this term led to a remarkable prediction: **the existence of electromagnetic waves.** With the full set of equations, Maxwell was able to calculate the speed of these waves. **He found that their speed was a constant,** independent of the nature of the electric and magnetic fields.

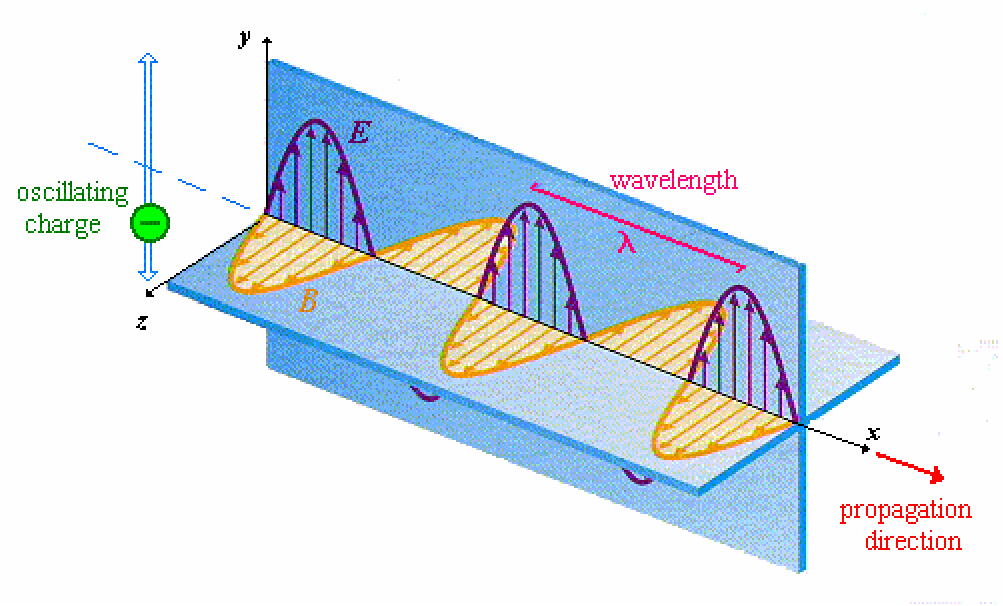
$$c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} = 3 \times 10^8 \text{ m/s}$$

c is the speed of light in vacuum,

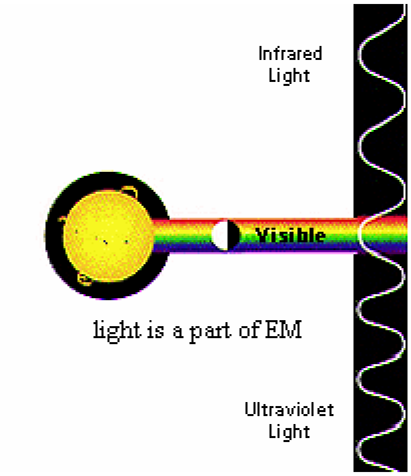
What Maxwell found was that electromagnetic waves traveled at the speed of light. **Maxwell had just discovered a fundamental constant of nature: the speed of light.**

Maxwell equations show an electromagnetic wave exists when the changing magnetic field causes a changing electric field, which then causes another changing magnetic field, and so on forever. **Unlike a STATIC field, a wave cannot exist unless it is moving.**

Once created, an electromagnetic wave will continue on forever unless it is absorbed by matter.



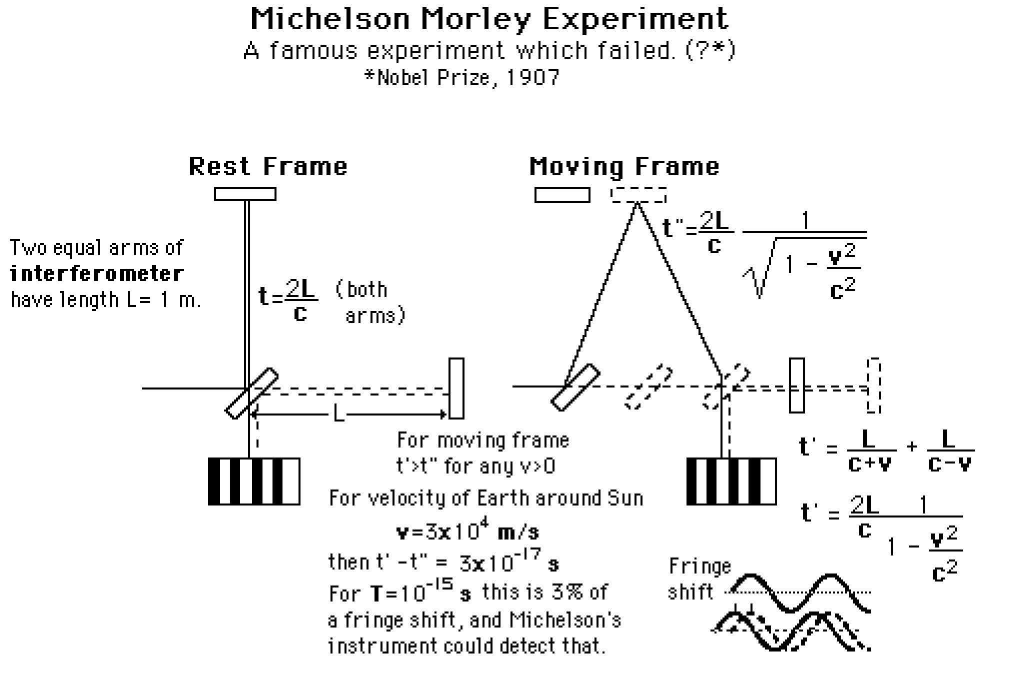
Thus, the Maxwell equations not only unify the theories of electricity and of magnetism, but of optics as well. In other words, electricity, magnetism, and light could all be understood as aspects of a single object: the electromagnetic field. Quite a remarkable achievement!



As a consequence, the Maxwell equations made the physical prediction that "light travels with the same speed, in all directions". In other words, "a spherical pulse of light will appear spherical".

The Michelson-Morley Experiment

When Clerk Maxwell wrote to D.P. Todd of the U.S. Nautical Almanac Office in Washington in 1879, he inquired about the possibility of measuring the velocity of the solar system through the ether by observing the eclipses of Jupiter's moons. Roemer had used measurements of the eclipse times to obtain a number for the speed of light. Maxwell concluded that the effects he sought were too small to measure - but that assertion came to the attention of a young naval instructor named A. A. Michelson who had just been transferred to that office. In 1878, Michelson had made an excellent measurement of the speed of light at the age of 25, and he thought the detection of motion through the ether might be measurable.



Michelson proceeded to invent a new instrument with accuracy far exceeding that which had been attained to that date, and that instrument is now universally called the Michelson interferometer. In trying to measure the speed of the Earth through the supposed **"ether"**, you could depend upon one component of that velocity being known - the velocity of the Earth around the sun, about 30 km/s. Using a wavelength of about 600 nm, there should be a shift of about 0.04 fringes as the spectrometer was rotated 360°. Though small, this was well within Michelson's capability. Michelson, and everyone else, was surprised that there was no shift. Michelson's terse description of the experiment: "The interpretation of these results is that there is no displacement of the interference bands. ... The result of the hypothesis of stationary **ether** is thus shown to be incorrect."

The Mysterious Ether

When we reached the point where we could demonstrate that light was a wave, and then it was presumed that the wave must have a medium in which to travel. All the other waves we knew about required a medium. Since no medium was apparent between the earth and the sun, it was presumed that this medium was transparent and therefore not readily observable - it was called the **"ether".**

The popular presumption was that this ether was stationary and filled all of space. This involved the presumption that there was an absolute reference frame in the universe, and that all the movement of planets and stars was through this ether.

These presumptions were part of the historical setting of the Michelson-Morley Experiment. With the interferometer which he invented, Michelson found no evidence of the ether, to his and everyone else's surprise. Michelson's terse description of the experiment: "The interpretation of these results is that there is no displacement of the interference bands. ... The result of the hypothesis of stationary ether is thus shown to be incorrect."

If scientific theories keep changing, where is the Truth?

In 1666 Isaac Newton proposed his theory of gravitation. This was one of the greatest intellectual feats of all time. The theory explained all the observed facts, and made predictions that were later tested and found to be correct within the accuracy of the instruments being used. As far as anyone could see, Newton's theory was ``the Truth". During the nineteenth century, more accurate instruments were used to test Newton's theory; these observations uncovered some slight discrepancies. Albert Einstein proposed his theories of Relativity, which explained the newly observed facts and made more predictions. Those predictions have now been tested and found to be correct within the accuracy of the instruments being used. As far as anyone can see, Einstein's theory is ``the Truth".

So how can the Truth change? Well the answer is that it hasn't. The Universe is still the same as it ever was. **When a theory is said to be ``true'' it means that it agrees with all known experimental evidence.** But even the best of theories have, time and again, been shown to be incomplete: though they might explain a lot of phenomena using a few basic principles, and even predict many new and exciting results, eventually new experiments (or more precise ones) show a discrepancy between the workings of nature and the predictions of the theory. In the strict sense this means that the theory was not ``true" after all; but the fact remains that it is a very good approximation to the truth, at lest where a certain type of phenomena is concerned.

When an accepted theory cannot explain some new data (which has been confirmed), the researchers working in that field strive to construct a new theory. This task gets increasingly more difficult as our knowledge increases, for the new theory should not only explain the new data, but also all the old one: a new theory has, as its first duty, to devour and assimilate its predecessors.

One other note about truth: science does not make moral judgments. Anyone who tries to draw moral lessons from the laws of nature is on very dangerous ground. Evolution in particular seems to suffer from this. At one time or another it seems to have been used to justify Nazism, Communism, and every other -ism in between. These justifications are all completely bogus. Similarly, anyone who says ``evolution theory is evil because it is used to support Communism" (or any other -ism) has also strayed from the path of Logic (and will not live long nor prosper).

The cosmology based on the ideas of Galileo and Newton reigned supreme up until the end of the 19th century: by this time it became clear that Newton's laws were unable to describe correctly electric and magnetic phenomena. It is here that Einstein enters the field, he showed that the Newtonian approach does not describe correctly situations in which bodies move at speeds close to that of light (in particular it does not describe light accurately). Einstein also provided the generalization of Newton's equations to the realm of such high speeds: the Special Theory of Relativity. Perhaps more importantly, he also demonstrated that certain properties of space and time taken for granted are, in fact, incorrect. We will see, for example, that the concept of two events occurring at the same time in different places is not absolute, but depends on the state of motion of the observer.

Not content with these momentous achievements, Einstein argued that the Special Theory of Relativity itself was inapplicable under certain conditions, for example, near very heavy bodies. He then provided the generalization which encompasses these situations as well: the General Theory of Relativity. This is perhaps the most amazing development in theoretical physics in 300 years: without any experimental motivation, Einstein single handedly developed this modern theory of gravitation and used it to predict some of the most surprising phenomena observed to date. of the most surprising phenomena observed to date. These include the bending of light near heavy bodies and the existence of black holes, massive objects whose gravitational force is so strong it traps all objects, including light.

Quantum Mechanics

Quantum mechanics is a fundamental branch of theoretical physics that replaces Newtonian mechanics and classical electromagnetism at the atomic and subatomic levels. It is the underlying framework of many fields of physics and chemistry, including condensed matter physics, quantum chemistry, and particle physics. Along with general relativity, it is one of the pillars of modern physics.

The term *quantum* (Latin, "*how much*") refers to the discrete units that the theory assigns to certain physical quantities, such as the energy of an atom at rest. The discovery that waves could be measured in particle-like small packets of energy called quanta led to the branch of physics that deals with atomic and subatomic systems which we today call Quantum Mechanics.

The electron was discovered in 1897. That it was not expected is illustrated by a remark made by J J Thomson, the discoverer of the electron. He said *"I was told long afterwards by a distinguished physicist who had been present at my lecture that he thought I had been pulling their leg."*

The neutron was not discovered until 1932 so it is against this background that we trace the beginnings of quantum theory back to 1859.

In 1859 Gustav Kirchhoff proved a theorem about blackbody radiation. A blackbody is an object that absorbs all the energy that falls upon it and, because it reflects no light, it would appear black to an observer. A blackbody is also a perfect emitter and Kirchhoff proved that the energy emitted E depends only on the temperature T and the frequency v of the emitted energy, i.e.

$$\boldsymbol{E = J\,(T,v)}$$

He challenged physicists to find the function J.

In 1879 Josef Stefan proposed, on experimental grounds, that the total energy emitted by a hot body was proportional to the fourth power of the temperature. In the generality stated by Stefan this is false. The same conclusion was reached in 1884 by Ludwig Boltzmann for blackbody radiation, this time from theoretical considerations using thermodynamics and Maxwell's electromagnetic theory. The result, now known as the Stefan-Boltzmann law, does not fully answer Kirchhoff's challenge since it does not answer the question for specific wavelengths.

In 1896 Wilhelm Wien proposed a solution to the Kirchhoff challenge. However although his solution matches experimental observations closely for small values of the wavelength, it was shown to break down in the far infrared by Rubens and Kurlbaum.

Kirchhoff had been at Heidelberg, moved to Berlin. Boltzmann was offered his chair in Heidelberg but turned it down. The chair was then offered to Hertz who also declined the offer, so it was offered again, this time to Planck and he accepted.

Rubens visited Planck in October 1900 and explained his results to him. Within a few hours of Rubens leaving Planck's house Planck had guessed the correct formula for Kirchhoff's J function. This guess fitted experimental evidence at all wavelengths very well but Planck was not satisfied with this and tried to give a theoretical derivation of the formula. To do this he made the unprecedented step of assuming that the total energy is made up of indistinguishable energy elements - quanta of energy. He wrote

Experience will prove whether this hypothesis is realized in nature

Planck himself gave credit to Boltzmann for his statistical method but Planck's approach was fundamentally different. However theory had now deviated from experiment and was based on a hypothesis with no experimental basis.

In 1901 Ricci and Levi-Civita published *Absolute differential calculus*. It had been Christoffel's discovery of 'covariant differentiation' in 1869 which let Ricci extend the theory of tensor analysis to Riemannian space of *n* dimensions. The Ricci and Levi-Civita definitions were thought to give the most general formulation of a tensor. This work was not done with quantum theory in mind but, as so often happens, the mathematics necessary to embody a physical theory had appeared at precisely the right moment.

In 1905 Einstein examined the photoelectric effect. The photoelectric effect is the release of electrons from certain metals or semiconductors by the action of light. The electromagnetic theory of light gives results at odds with experimental evidence. Einstein proposed a quantum theory of light to solve the difficulty and then he realized that Planck's theory made implicit use of the light quantum hypothesis. By 1906 Einstein had correctly guessed that energy changes occur in a quantum material oscillator in changes in jumps which are multiples of $h\nu$ where h is Planck's reduced constant and ν is the frequency.

$$E=nh\nu,\ h=6.626 \text{ times } 10^{-34} \text{ joule-second}$$

In 1913 Niels Bohr wrote a revolutionary paper on the hydrogen atom. He discovered the major laws of the spectral lines.

Arthur Compton derived relativistic kinematics for the scattering of a photon (a light quantum) off an electron at rest in 1923.

However there were concepts in the new quantum theory which gave major worries to many leading physicists. Einstein, in particular, worried about the element of 'chance' which had entered physics. In fact Rutherford had introduced spontaneous effect when discussing radio-active decay in 1900. In 1924 Einstein wrote:

There are therefore now two theories of light, both indispensable, and - as one must admit today despite twenty years of tremendous effort on the part of theoretical physicists - without any logical connection.

In the same year, 1924, Bohr, Kramers and Slater made important theoretical proposals regarding the interaction of light and matter which rejected the photon. Although the proposals were the wrong way forward they stimulated important experimental work. Bohr addressed certain paradoxes in his work.

(i) How can energy be conserved when some energy changes are continuous and some are discontinuous, i.e. change by quantum amounts.
(ii) How does the electron know when to emit radiation?

Einstein had been puzzled by paradox (ii) and Pauli quickly told Bohr that he did not believe his theory. Further experimental work soon ended any resistance to belief in the electron. Other ways had to be found to resolve the paradoxes.

Up to this stage quantum theory was set up in Euclidean space and used Cartesian tensors of linear and angular momentum. However, quantum theory was about to enter a new area.

The year 1924 saw the publication of another fundamental paper. It was written by Satyendra Nath Bose and rejected by a referee for publication. Bose then sent the manuscript to Einstein who immediately saw the importance of Bose's work and arranged for its publication. Bose proposed different states for the photon. He also proposed that there is no conservation of the number of photons. Instead of statistical independence of particles, Bose put particles into cells and talked about statistical independence of cells. Time has shown that Bose was right on all these points.

Work was going on at almost the same time as Bose's which was also of fundamental importance. The doctoral thesis of Louis de Broglie was presented which extended the particle-wave duality for light to all particles, in particular to electrons. Schrödinger in 1926 published a paper giving his equation for the hydrogen atom and heralded the birth of wave mechanics. Schrödinger introduced operators associated with each dynamical variable.

The year 1926 saw the complete solution of the derivation of Planck's law after 26 years. It was solved by Dirac. Also in 1926 Born abandoned the causality of traditional physics. Speaking of collisions Born wrote

One does not get an answer to the question, what is the state after collision? but only to the question, How probable is a given effect of the collision? From the standpoint of our quantum mechanics, there is no quantity which causally fixes the effect of a collision in an individual event.

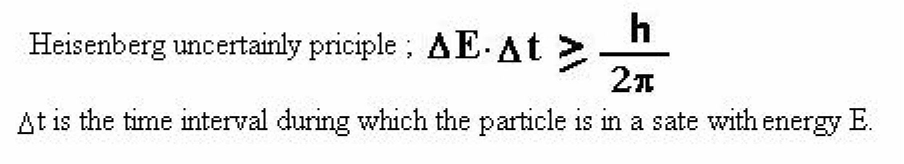
Heisenberg wrote his first paper on quantum mechanics in 1925 and 2 years later stated his uncertainty principle. It states that the process of measuring the position x of a particle disturbs the particle's momentum p, so that

$$\Delta x \cdot \Delta p \geq \frac{h}{2\pi}$$

where Δx is the uncertainty of the position and Δp is the uncertainty of the momentum. Here h is Planck's constant and $\hbar$ is usually called the 'reduced Planck's constant'. Heisenberg states that

"The no validity of rigorous causality is necessary and not just consistently possible."

The uncertainty can also be stated in terms of the energy of a particle in a particular state, and the time in which the particle is in that state:



Heisenberg uncertainly priciple ; $\Delta E \cdot \Delta t \geq \frac{h}{2\pi}$

Δt is the time interval during which the particle is in a sate with energy E.

Heisenberg's work used matrix methods made possible by the work of Cayley on matrices 50 years earlier. In fact 'rival' matrix mechanics deriving from Heisenberg's work and wave mechanics resulting from Schrödinger's work now entered the arena. These were not properly shown to be equivalent until the necessary mathematics was developed by Riesz about 25 years later.

Also in 1927 Bohr stated that space-time coordinates and causality is complementary. Pauli realised that spin, one of the states proposed by Bose, corresponded to a new kind of tensor, one not covered by the Ricci and Levi-Civita work of 1901. However the mathematics of this had been anticipated by Eli Cartan who introduced a 'spinor' as part of a much more general investigation in 1913.

Dirac, in 1928, gave the first solution of the problem of expressing quantum theory in a form which was invariant under the Lorentz group of transformations of special relativity. He expressed d'Alembert's wave equation in terms of operator algebra.

Dirac Equation

A tutorial discussion, as part of an overall introduction to relativistic electron structure theory and quantum chemistry by C Brian Kellogg, on the Dirac equation and it's relation to special relativity and quantum mechanics. Dirac’s relativistic wave equation is discussed in relation to: the Klein Gordon equation, Dirac’s frees particle equation, electron spin angular momentum and magnetic moment, hydrogenic solutions to Diracs equation, and the Dirac Coulomb Hamiltonian.

Feynman, during 1950 remade quantum electrodynamics—the theory of the interaction between light and matter—and thus altered the way science understands the nature of waves and particles.

Special Relativity

Newton's laws of motion give us a complete description of the behavior moving objects at low speeds. The laws are different at speeds reached by the particles at SLAC.

Einstein's Special Theory of Relativity describes the motion of particles moving at close to the speed of light. In fact, it gives the correct laws of motion for any particle. This doesn't mean Newton was wrong; his equations are contained within the relativistic equations. Newton's "laws" provide a very good approximate form, valid when v is much less than c. For particles moving at slow speeds (very much less than the speed of light), the differences between Einstein's laws of motion and those derived by Newton are tiny. That's why relativity doesn't play a large role in everyday life. Einstein's theory supercedes Newton's, but Newton's theory provides a very good approximation for objects moving at everyday speeds.

Einstein's theory is now very well established as the correct description of motion of relativistic objects that is those traveling at a significant fraction of the speed of light.

Because most of us have little experience with objects moving at speeds near the speed of light, Einstein's predictions may seem strange. However, many years of high energy physics experiments have thoroughly tested Einstein's theory and shown that it fits all results to date.

Theoretical Basis for Special Relativity

Einstein's theory of special relativity results from two statements -- the two basic postulates of special relativity:

1. The speed of light is the same for all observers, no matter what their relative speeds.
2. The laws of physics are the same in any inertial (that is, non-accelerated) frame of reference. This means that the laws of physics observed by a hypothetical observer traveling with a relativistic particle must be the same as those observed by an observer who is stationary in the laboratory.

Given these two statements, Einstein showed how definitions of momentum and energy must be refined and how quantities such as length and time must change from one observer to another in order to get consistent results for physical quantities such as particle half-life. To decide whether his postulates are a correct theory of nature, physicists test whether the predictions of Einstein's theory match observations. Indeed many such tests have been made -- and the answers Einstein gave are right every time!

The Speed of Light is the same for all observers

The first postulate -- the speed of light will be seen to be the same relative to any observer, independent of the motion of the observer -- is the crucial idea that led Einstein to formulate his theory. It means we can define a quantity c, the speed of light, which is a fundamental constant of nature.

Note that this is quite different from the motion of ordinary, massive objects. If I am driving down the freeway at 50 miles per hour relative to the road, a car traveling in the same direction at 55 mph has a speed of only 5 mph relative to me, while a car coming in the opposite direction at 55 mph approaches me at a rate of 105 mph. Their speed relative to me depends on my motion as well as on theirs.

Physics is the same for all inertial observers

This second postulate is really a basic though unspoken assumption in all of science -- the idea that we can formulate rules of nature which do not depend on our particular observing situation. This does not mean that things behave in the same way on the earth and in space, e.g. an observer at the surface of the earth is affected by the earth's gravity, but it does mean that the effect of a force on an object is the same independent of what causes the force and also of where the object is or what its speed is.

Einstein developed a theory of motion that could consistently contain both the same speed of light for any observer and the familiar addition of velocities described above for slow-moving objects. This is called the *special theory of relativity*, since it deals with the ***relative*** motions of objects.

Relativistic Definitions

Physicists call particles with v/c comparable to1 "relativistic" particle.

Particles with v/c< 1 (very much less than one) are "non-relativistic." At SLAC, we are almost always dealing with relativistic particles. Below we catalogue some essential differences between the relativistic quantities the more familiar non-relativistic or low-speed approximate definitions and behaviors.

Gamma (γ)

The measurable effects of relativity are based on gamma. Gamma depends only on the speed of a particle and is always larger than 1. By definition:

$$\gamma = \frac{1}{\sqrt{1-(v^2/c^2)}} \geq 1$$

c is the speed of light
v is the speed of the object in question

What do these gamma values tell us about the relativistic effects detected at SLAC? Notice; when the speed of the object is very much less than the speed of light *(*v << c*),* gamma is approximately equal to1. This is a non-relativistic situation (Newtonian).

Momentum

For non-relativistic objects Newton defined momentum, given the symbol *p*, as the product of mass and velocity - *p = m v.* When speed becomes relativistic, we have to modify this definition -- *p = gamma (mv)*

$$p = \frac{mc}{\sqrt{1-(v^2/c^2)}} \text{ or } m = \frac{m_0}{\sqrt{1-(v^2/c^2)}}$$

Notice that this equation tells you that for any particle with a non-zero mass, the momentum gets larger and larger as the speed gets closer to the speed of light. Such a particle would have infinite momentum if it could reach the speed of light. Since it would take an infinite amount of force (or a finite force acting over an infinite amount of time) to accelerate a particle to infinite momentum, we are forced to conclude that a massive particle always travels at speeds less than the speed of light.

Energy

Probably the most famous scientific equation of all time, first derived by Einstein is the relationship

$$E = mc^2$$

This tells us the energy corresponding to a mass m at rest. What this means is that when mass disappears, for example in a nuclear fission process, this amount of energy must appear in some other form. It also tells us the total energy of a particle of mass m sitting at rest.

Einstein also showed that the correct relativistic expression for the energy of a particle of mass m with momentum p is

$$E^2 = m^2c^4 + p^2c^2$$

This is a key equation for any real particle, giving the relationship between its energy E momentum p, and its rest mass m (it means m_0).

The energy E is the total energy of a freely moving particle. We can define it to be the rest energy plus kinetic energy ($E = KE + mc^2$) which then defines a relativistic form for kinetic energy. Just as the equation for momentum has to be altered, so does the low-speed equation for kinetic energy, $KE = (1/2)\ mv^2$

In fact Einstein's relationship tells us more; it says Energy and mass are interchangeable. Or, better said, rest mass is just one form of energy. For a compound object, the mass of the composite is not just the sum of the masses of the constituents but the sum of their energies, including kinetic, potential, and mass energy. The equation $E=mc^2$ shows how to convert between energy units and mass units. Even a small mass corresponds to a significant amount of energy.

In the case of an atomic explosion, mass energy is released as kinetic energy of the resulting material, which has slightly less mass than the original material.

In any particle decay process, some of the initial mass energy becomes kinetic energy of the products.

Peculiar Relativistic Effects

One of the strangest parts of special relativity is the conclusion that two observers who are moving relative to one another, will get different measurements of the length of a particular object or the time that passes between two events.

Consider two observers, each in a space-ship laboratory containing clocks and meter sticks. The space ships are moving relative to each other at a speed close to the speed of light. Using Einstein's theory:

Each observer will see the meter stick of the other as shorter than their own, by the same factor gamma (□- defined above). This is called **length contraction**.

Each observer will see the clocks in the other laboratory as ticking more slowly than the clocks in his/her own, by a factor gamma. This is called **time dilation**.

In particle accelerators, particles are moving very close to the speed of light where the length and time effects are large. This has allowed us to clearly verify that length contraction and time dilation do occur.

General Relativity

Newton's theory of gravitation was soon accepted without question, and it remained unquestioned until the beginning of this century. Then Albert Einstein shook the foundations of physics with the introduction of his Special Theory of Relativity in 1905, and his General Theory of Relativity in 1915. Newton's Law of Gravitation was only approximately correct, breaking down in the presence of very strong gravitational fields.

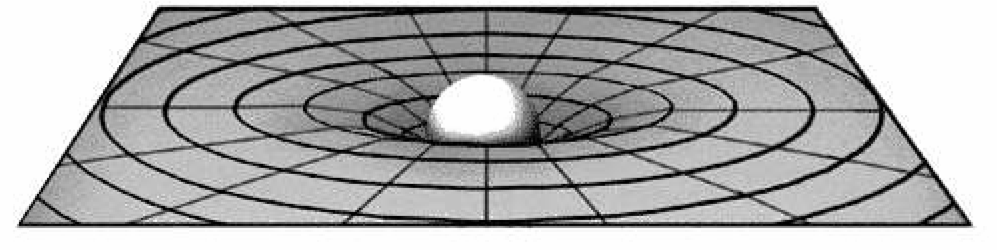
Principle of Equivalence

Experiments performed in a uniformly accelerating reference frame with acceleration a are indistinguishable from the same experiments performed in a non-accelerating reference frame which is situated in a gravitational field where;

The acceleration of gravity = g = -a = intensity of gravity field.

This theory, referred to as the **General Theory of Relativity**, proposed that matter causes space to curve.

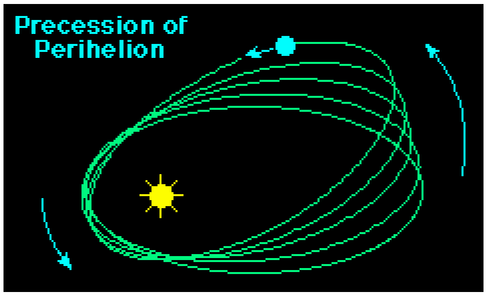
Embedding Diagrams; Picture a bowling ball on a stretched rubber sheet.



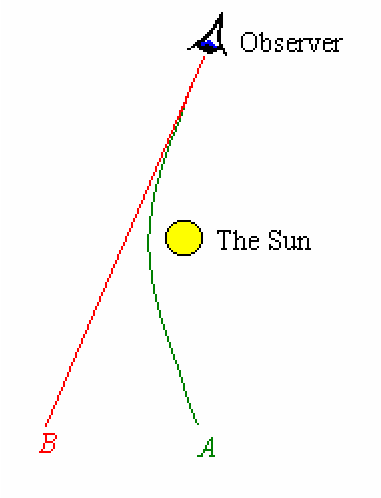
The large ball will cause a deformation in the sheet's surface. A baseball dropped onto the sheet will roll toward the bowling ball. Einstein theorized that smaller masses travel toward larger masses not because they are "attracted" by a mysterious force, but because the smaller objects travel through space that is warped by the larger object. Physicists illustrate this idea using **embedding diagrams.**

We shall consider Relativity in more detail later. Here, we only summarize the differences between Newton's theory of gravitation and the theory of gravitation implied by the General Theory of Relativity. They make essentially identical predictions as long as the strength of the gravitational field is weak, which is our usual experience. However, there are three crucial predictions where the two theories diverge, and thus can be tested with careful experiments.

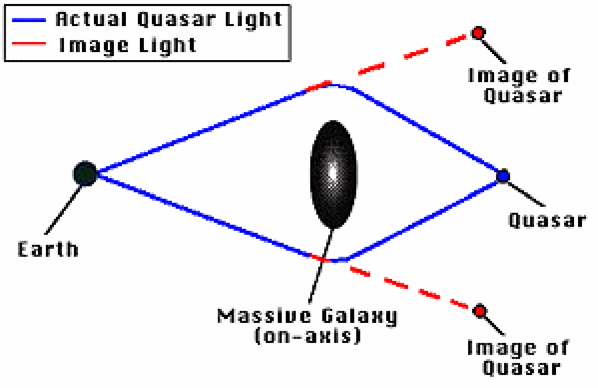
1- The orientation of Mercury's orbit is found to process in space over time, as indicated in the adjacent figure (the magnitude of the effect is greatly exaggerated in this figure). This is commonly called the "precession of the perihelion", because it causes the position of the perihelion to move. Only part of this can be accounted for by perturbations in Newton's theory. There is an extra 43 seconds of arc per century in this precession that is predicted by the Theory of General Relativity and observed to occur (a second of arc is 1/3600 of an angular degree). This effect is extremely small, but the measurements are very precise and can detect such small effects very well.



2- The General Theory of Relativity predicts that light coming from a strong gravitational field should have its wavelength shifted to larger values (what astronomers call a "red shift"), again contrary to Newton's theory. Once again, detailed observations indicate such a red shift, and that its magnitude is correctly given by Einstein's theory.



3- Einstein's theory predicts that the direction of light propagation should be changed in a gravitational field, contrary to the Newtonian predictions. Precise observations indicate that Einstein is right, both about the effect and its magnitude. A striking consequence is gravitational lensing.



4- The electromagnetic field can have waves in it that carry energy and that we call light. Likewise, the gravitational field can have waves that carry energy and are called *gravitational waves*. These may be thought of as ripples in the curvature of space-time that travel at the speed of light.

Just as accelerating charges can emit electromagnetic waves, accelerating masses can emit gravitational waves. However gravitational waves are difficult to detect because they are very weak and no conclusive evidence has yet been reported for their direct observation. They have been observed *indirectly* in the binary pulsar. Because the arrival time of pulses from the pulsar can be measured very precisely, it can be determined that the period of the binary system is gradually decreasing. It is found that the rate of period change (about 75 millionths of a second each year) is what would be expected for energy being lost to gravitational radiation, as predicted by the Theory of General Relativity.

5- As photons escape through a gravitational field, they lose energy, decreasing frequency and increasing wavelength, it calls redshift. And when photons fall in a gravitational field, they take energy, increasing frequency and decreasing wavelength that calls blueshift. The gravitational redshift and blueshift equations are:

$$v' = v\left(1 \pm \frac{GM}{r c^2}\right)$$

G is the gravitational constant; M is the mass of the body
c is the velocity of light, r is the distance from the body

The plus sign is for when photon is falling (Blue-shift) and minus sign is for when photon escapes a gravitational field (red-shift).

Gravitational Time Dilation

Einstein's Special Theory of Relativity predicted that time does not flow at a fixed rate: moving clocks appear to tick more slowly relative to their stationary counterparts. But this effect only becomes really significant at very high velocities that approach the speed of light.

When "generalized" to include gravitation, the equations of relativity predict that gravity, or the curvature of space-time by matter not only stretches or shrinks distances (depending on their direction with respect to the gravitational field) but also will appear to slow down or "dilate" the flow of time.

In most circumstances in the universe, such time dilation is miniscule, but it can become very significant when space-time is curved by a massive object such as a black hole. For example, an observer far from a black hole would observe time passing extremely slowly for an astronaut falling through the hole’s boundary. In fact, the distant observer would never see the hapless victim actually fall in. His or her time, as measured by the observer, would appear to stand still.

Black Hole

We know escape velocity is 11.2 km/s on the earth. What escape velocity is? Suppose an object with mass m and velocity v is moving upward the earth. When it loses its kinetic energy comes back to earth. With which velocity it never comes back to the surface of earth? It calls escape velocity that.

Radius for Black Hole of a Given Mass

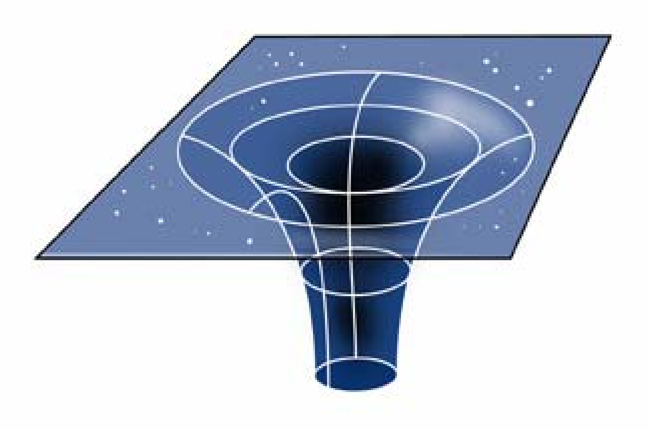
Object	Mass	Black Hole Radius
Earth	5.98×10^{27} g	0.9 cm

5 Solar Mass Star	9.945 x 10^{33} g	15 km

Photons always travel at the speed of light, but they lose energy when traveling out of a gravitational field and appear to be redder to an external observer. The stronger the gravitational field, the more energy the photons lose because of this *gravitational redshift*. The extreme case is a black hole where photons from within a certain radius lose all their energy and become invisible. Indeed, light in the vicinity of such strong gravitational fields exhibits quite bizarre behavior.

Event Horizons

The event horizon is the point outside the black hole where the gravitational attraction becomes so strong that the escape velocity (the velocity at which an object would have to go to escape the gravitational field) equals the speed of light. According to the relativity theory no object can exceed the speed of light that means that nothing, not even light, could escape the black hole once it is inside this distance from the center of the black hole. A more fundamental way of viewing this is that in a black hole the gravitational field is so intense that it bends space and time around itself so that inside the event horizon there are literally no paths in space and time that lead to the outside of the black hole: No matter what direction you went, you would find that your path led back to the center of the black hole, where the singularity is found.



Massive body curves space-time so much that light cannot escape.

How is a stellar black hole created?

A common type of black hole is the type produced by some dying stars. A star with a mass greater than 20 times the mass of our Sun may produce a black hole at the end of its life. In the normal life of a star there is a constant tug of war between gravity pulling in and pressure pushing out. Nuclear reactions in the core of the star produce enough energy to push outward. For most of a star's life, gravity and pressure balance each other exactly, and so the star is stable. However, when a star runs out of nuclear fuel, gravity gets the upper hand and the material in the core is compressed even further. The more massive core of the star, the greater the force of gravity that compresses the material, collapsing it under its own weight. For small stars, when the nuclear fuel is exhausted and there are no more nuclear reactions to fight gravity, the repulsive forces among electrons within the star eventually create enough pressure to halt further gravitational collapse. The star then cools and dies peacefully. This type of star is called the "white dwarf." When a very massive star exhausts its nuclear fuel it explodes as a supernova. The outer parts of the star are expelled violently into space, while the core completely collapses under its own weight.

To create a massive core a progenitor (ancestral) star would need to be at least 20 times more massive than our Sun. If the core is very massive (approximately 2.5 times more massive than the Sun), no known repulsive force inside a star can push back hard enough to prevent gravity from completely collapsing the core into a black hole. Then the core compacts into a mathematical point with virtually zero volume, where it is said to have infinite density. This is referred to as a singularity. When this happens, escape would require a velocity greater than the speed of light. No object can reach the speed of light. The distance from the black hole at which the escape velocity is just equal to the speed of light is called the event horizon. Anything, including light that passes across the event horizon toward the black hole is forever trapped.

Quantum field theory

Quantum field theory is a branch of quantum mechanics that study of the quantum mechanical interaction of elementary particles and fields. Quantum field theory applied to the understanding of electromagnetism is called quantum electrodynamics (QED), and it has proved spectacularly successful in describing the interaction of light with matter. The calculations, however, are often complex. They are usually carried out with the aid of Feynman diagrams (named after American physicist Richard P. Feynman), simple graphs that represent possible variations of interactions and provide an elegant shorthand for precise mathematical equations. Quantum field theory applied to the understanding of the strong interactions between quarks and between protons, neutrons, and other baryons and mesons is called quantum chromodynamics (QCD); QCD has a mathematical structure similar to that of QED

Quantum electrodynamics

Quantum electrodynamics (QED), quantum field theory that describes the properties of electromagnetic radiation and its interaction with electrically charged matter in the framework of quantum theory. QED deals with processes involving the creation of elementary particles from electromagnetic energy, and with the reverse processes in which a particle and its antiparticle annihilate each other and produce energy. The fundamental equations of QED apply to the emission and absorption of light by atoms and the basic interactions of light with electrons and other elementary particles. Charged particles interact by emitting and absorbing photons, the particles of light that transmit electromagnetic forces. For this reason, QED is also known as the quantum theory of light.

QED is based on the elements of quantum mechanics laid down by such physicists as P. A. M. Dirac, W. Heisenberg, and W. Pauli during the 1920s, when photons were first postulated. In 1928 Dirac discovered an equation describing the motion of electrons that incorporated both the requirements of quantum theory and the theory of special relativity. During the 1930s, however, it became clear that QED as it was then postulated gave the wrong answers for some relatively elementary problems. For example, although QED correctly described the magnetic properties of the electron and its antiparticle, the positron, it proved difficult to calculate specific physical quantities such as the mass and charge of the particles. It was not until the late 1940s, when experiments conducted during World War II that had used microwave techniques stimulated further work, that these difficulties were resolved. Proceeding independently, Freeman J. Dyson, Richard P. Feynman and Julian S. Schwinger in the United States and Shinichiro Tomonaga in Japan refined and fully developed QED. They showed that two charged particles can interact in a series of processes of increasing complexity, and that each of these processes can be represented graphically through a diagramming technique developed by Feynman. Not only do these diagrams provide an intuitive picture of the process but they show how to precisely calculate the variables involved. The mathematical structures of QED later were adapted to the study of the strong interactions between quarks, which is called quantum chromodynamics.

Quantum Chromodynamics

Quantum chromodynamic (QCD), quantum field theory that describes the properties of the strong interactions between quarks and between protons and neutrons in the framework of quantum theory. Quarks possess a distinctive property called color that governs their binding together to form other elementary particles. Analogous to electric charge in charged particles, color is of three varieties, arbitrarily designated as red, blue, and yellow, and—analogous to positive and negative charges—three anticolor varieties. Just as positively and negatively charged particles form electrically neutral atoms, colored quarks form particles with no net color. Quarks interact by emitting and absorbing massless particles called gluons, each of which carries a color-anticolor pair. Eight kinds of gluons are required to transmit the strong force between quarks, e.g., a blue quark might interact with a yellow quark by exchanging a blue-antiyellow gluonThe concept of color was proposed by American physicist Oscar Greenberg and independently by Japanese physicist Yoichiro Nambu in 1964. The theory was confirmed in 1979 when quarks were shown to emit gluons during studies of high-energy particle collisions at the German national laboratory in Hamburg. QCD is nearly identical in mathematical structure to quantum electrodynamics (QED) and to the unified theory of weak and electromagnetic interactions advanced by American physicist Steven Weinberg and Pakistani physicist Abdus Salam.

Quantum Gravity

The quantum gravity group carries out research on various aspects of quantum gravity as well as on some allied areas of mathematical physics, including certain topics in quantum mechanics and also in classical general relativity. A particular interest of the research group is the subject of quantum field theory in curved space-time. Our work often makes use of rigorous techniques drawn from functional analysis (e.g. the theory of operators on Hilbert spaces) or other areas of pure mathematics

While a satisfactory theory of full quantum gravity continues to elude us, the attempt to anticipate some of the properties of such a theory has led to many interesting developments. Especially, Hawkins's 1974 prediction of black hole evaporation, which was based on consideration of quantum field theory in curved space-time, suggests that there must be yet-to-be-discovered deep interconnections between quantum theory, gravity and thermodynamics. More generally, the very existence of the problem of quantum gravity has changed our perspective on each of the separate theories of classical general relativity and quantum field theory and focused attention on issues (e.g. the problem of singularities in classical general relativity or the problem of locality in quantum field theory) which might be expected to be of relevance for the unification problem. Further, both at the theoretical and experimental/observational level, the two subject areas have now essentially merged, with very-high-energy phenomena believed to have dominated the era just after the big bang and hence to have determined the present structure of the universe.

General relativity may be regarded as a constrained dynamical system. Although there is a standard method for quantizing constrained systems, due to **Dirac**, there are obstacles to applying this method to general relativity. There has been a claim that these obstacles can be overcome, and Higuchi is currently trying to determine whether or not this claim is justified.

The standard model

Through a combination of theory and experiment, a mathematical model that describes or explains all particle physics observed so far by physicists has been worked out. This model is called the Standard Model. From the experimental point of view, the Standard Model is studied and confirmed so well that things are, well, almost boring.
The Standard Model consists of elementary particles grouped into two classes: bosons (particles that transmit forces) and fermions (particles that make up matter).

The bosons have particle spin that is 0, 1 or 2. The fermions have spin 1/2.

Particles that transmit forces

Name	Spin	Electric charge	Mass	Observed?
Graviton	2	0	0	Not yet
Photon	1	0	0	Yes
Gluon	1	0	0	Indirectly
W$^+$	1	+1	80 GeV	Yes
W$^-$	1	-1	80 GeV	Yes
Z^0	1	0	91 GeV	Yes
Higgs	0	0	> 78 GeV	Not yet

The table above lists the elementary particles in the Standard Model that transmit the four forces observed in Nature. Note that the graviton isn't technically part of the Standard Model but we'll include it anyway. The Standard Model is from a technical standpoint incompatible with gravity, and that's why string theory became an active field of theoretical physics.

When we say that quarks and gluons are observed "indirectly", we mean that evidence of their existence inside hadrons exists but these particles have not been observed singly. In the theory of quarks and gluons, they are believed to be confined inside hadrons and unobservable as single particles, except possibly at extremely high temperatures such as could be found very early in the Big Bang.

Particles that make up matter

The fermions in the Standard Model, particles that make up matter, seem to be grouped into **three generations**. Notice that the quarks with charge 2/3 come in a group of three, as do the quarks with charge -1/3, as do the electron, muon and tau, and the electron, muon and tau neutrinos. In each group, the heavier particles are shown in the larger type.

Theoretical physics has not explained why there are three generations of particles that make up matter. Maybe string theory will come up with an answer for this.

Name	Spin	Electric charge	Mass	Observed?
Electron	1/2	-1	.0005 GeV	Yes
Muon	1/2	-1	.10 Gev	Yes

Tau	1/2	-1	1.8 Gev	Yes

Name	Spin	Electric charge	Mass	Observed?
Electron neutrino	1/2	0	0?	Yes
Muon neutrino	1/2	0	<.00017 GeV	Yes
Tau neutrino	1/2	0	<.017 GeV	Yes

Name	Spin	Electric charge	Mass	Observed?
Up quark	1/2	2/3	.005 GeV	Indirectly
Charm quark	1/2	2/3	1.4 GeV	Indirectly
Top quark	1/2	2/3	174 GeV	Indirectly

Name	Spin	Electric charge	Mass	Observed?
Down quark	1/2	-1/3	.009 GeV	Indirectly
Strange quark	1/2	-1/3	.17 GeV	Indirectly
Bottom quark	1/2	-1/3	4.4 GeV	Indirectly

Higgs Physics

One part of the Standard Model is not yet well established. We do not know what causes the fundamental particles to have masses. The simplest idea is called the *Higgs mechanism*. This mechanism involves one additional particle, called the Higgs boson, and one additional force type, mediated by exchanges of this boson .

The Higgs particle has not yet been observed. Today we can only say that if it exists, it must have a mass greater than about $80GeV/c^2$. Searches for a more massive the Higgs boson are beyond the scope of the present facilities at SLAC or elsewhere. Future facilities, such as the Large Hadron Collider at CERN, or upgrades of present facilities to higher energies are intended to search for the Higgs particle and distinguish between competing concepts.

Thus, this one aspect of the Standard Model does not yet have the status of "theory" but still remains in the realm of hypothesis or model.

How Particles Acquire Mass?

We know a good deal about why the nucleus is so small. We do not know, however, how the particles get their masses. Why are the masses what they are? Why are the ratios of masses what they are? We can't be said to understand the constituents of matter if we don't have a satisfactory answer to this question.

Peter Higgs has a model in which particle masses arise in a beautiful, but complex, progression. He starts with a particle that has only mass, and no other characteristics, such as charge, that distinguish particles from empty space. We can call his particle H. H interacts with other particles; for example if H is near an electron, there is a force between the two. H is of a class of particles called "bosons". We first attempt a more precise, but non-mathematical statement of the point of the model; then we give explanatory pictures.

In the mathematics of quantum mechanics describing creation and annihilation of elementary particles, as observed at accelerators, particles at particular points arise from "fields" spread over space and time. Higgs found that parameters in the equations for the field associated with the particle H can be chosen in such a way that the lowest energy state of that field (empty space) is one with the field not zero. It is surprising that the field is not zero in empty space, but the result, not an obvious one, is: all particles that can interact with H gain mass from the interaction.

Thus mathematics links the existence of H to a contribution to the mass of all particles with which H interacts. A picture that corresponds to the mathematics is of the lowest energy state, "empty" space, having a crown of H particles with no energy of their own. Other particles get their masses by interacting with this collection of zero-energy H particles. The mass (or inertia or resistance to change in motion) of a particle comes from its being "grabbed at" by Higgs particles when we try and move it.

If particles no get their masses from interacting with the empty space Higgs field, then the Higgs particle must exist; but we can't be certain without finding the Higgs. We have other hints about the Higgs; for example, if it exists, it plays a role in "unifying" different forces. However, we believe that nature could contrive to get the results that would flow from the Higgs in other ways. In fact, proving the Higgs particle does not exist would be scientifically every bit as valuable as proving it does.

These questions, the mechanisms by which particles get their masses, and the relationship among different forces of nature, are major ones and so basic to having an understanding of the constituents of matter and the forces among them, that it is hard to see how we can make significant progress in our understanding of the stuff of which the earth is made without answering them.

Over the past few decades, particle physicists have developed an elegant theoretical model (the Standard Model) that gives a framework for our current understanding of the fundamental particles and forces of nature. One major ingredient in this model is a hypothetical, ubiquitous quantum field that is supposed to be responsible for giving particles their masses (this field would answer the basic question of why particles have the masses they do--or indeed, why they have any mass at all). This field is called the Higgs field. As a consequence of wave-particle duality, all quantum fields have a fundamental particle associated with them. The particle associated with the Higgs field is called the Higgs boson.

Much of today's research in elementary particle physics focuses on the search for a particle called the Higgs boson. This particle is the one missing piece of our present understanding of the laws of nature, known as the Standard Model. This model describes three types of forces: electromagnetic interactions, which cause all phenomena associated with electric and magnetic fields and the spectrum of electromagnetic radiation; strong interactions, which bind atomic nuclei; and the weak nuclear force, which governs beta decay--a form of natural radioactivity--and hydrogen fusion, the source of the sun's energy. (The Standard Model does not describe the fourth force, gravity.)

In our daily lives, electromagnetism is the most familiar of these forces. Until relatively recently, it was the only one which we understood well. Since the 1970s, however, scientists have come to understand the strong and weak forces almost equally well. In the past few years, in high-energy experiments at CERN, the European laboratory for particle physics, near Geneva and at the Stanford Linear Accelerator Center (SLAC), physicists have made precision tests of the Standard Model. It seems to provide a complete description of the natural world down to scales on the order of one- thousandth the size of an atomic nucleus.

The Higgs particle is connected with the weak force. Electromagnetism describes particles interacting with photons, the basic units of the electromagnetic field. In a parallel way, the modern theory of weak interactions describes particles (the *W* and *Z* particles) interacting with electrons, neutrinos, quarks and other particles. In many respects, these particles are similar to photons. But they are also strikingly different. The photon probably has no mass at all. From experiments, we know that a photon can be no more massive than a thousand-billion-billion-billionth (10^{-30}) the mass of an electron, and for theoretical reasons, we believe it has exactly zero mass. The *W* and *Z* particles, however, have enormous masses: more than 80 times the mass of a proton, one of the constituents of an atomic nucleus.

What is String Theory?

Think of a guitar string that has been tuned by stretching the string under tension across the guitar. Depending on how the string is plucked and how much tension is in the string, different musical notes will be created by the string. These musical notes could be said to be **excitation modes** of that guitar string under tension.

In a similar manner, in string theory, the elementary particles we observe in particle accelerators could be thought of as the "musical notes" or excitation modes of elementary strings.

In string theory, as in guitar playing, the string must be stretched under tension in order to become excited. However, the strings in string theory are floating in space-time; they aren't tied down to a guitar. Nonetheless, they have tension. The string tension in string theory is denoted by the quantity 1/(2 p a'), where a' is pronounced "alpha prime "and is equal to the square of the string length scale.

If string theory is to be a theory of quantum gravity, then the average size of a string should be somewhere near the length scale of quantum gravity, called the **Planck length**, which is about 10^{-33} centimeters, or about a millionth of a billionth of a billionth of a billionth of a centimeter. Unfortunately, this means that strings are way too small to see by current or expected particle physics technology (or financing!!) and so string theorists must devise more clever methods to test the theory than just looking for little strings in particle experiments.

String theories are classified according to whether or not the strings are required to be closed loops, and whether or not the particle spectrum includes fermions. In order to include fermions in string theory, there must be a special kind of symmetry called **supersymmetry**, which means for every boson (particle that transmits a force) there is corresponding fermions (particle that makes up matter). So supersymmetry relates the particles that transmit forces to the particles that make up matter.

Supersymmetric partners to currently known particles have not been observed in particle experiments, but theorists believe this is because supersymmetric particles are too massive to be detected at current accelerators. Particle accelerators could be on the verge of finding evidence for high energy supersymmetry in the next decade. Evidence for supersymmetry at high energy would be compelling evidence that string theory was a good mathematical model for Nature at the smallest distance scales.

Why did Strings enter the story?

Once special relativity was on firm observational and theoretical footing, it was appreciated that the Schrödinger equation of quantum mechanics was not Lorentz invariant, therefore quantum mechanics as it was so successfully developed in the 1920s was not a reliable description of nature when the system contained particles that would move at or near the speed of light.

The problem is that the Schrödinger equation is first order in time derivatives but second order in spatial derivatives. The Klein-Gordon equation is second order in both time and space and has solutions representing particles with spin 0.

$$(\hbar^2\nabla^\mu\nabla_\mu + m^2c^2)\Phi = 0$$

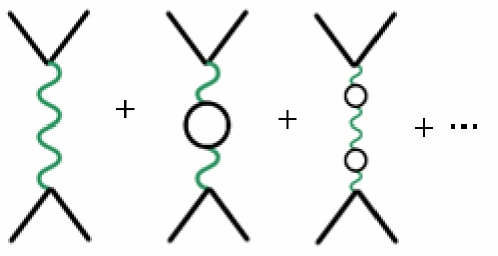
Dirac came up with "square root" of Klein-Gordon equation using matrices called "gamma matrices", and the solutions turned out to be particles of spin 1/2:

$$(\not{p} \pm mc)\Psi = 0, \quad \not{p} = \gamma^\mu p_\mu = i\hbar\gamma^\mu\nabla_\mu$$
$$\{\gamma^\mu,\gamma^\nu\} = \gamma^\mu\gamma^\nu + \gamma^\nu\gamma^\mu = 2\eta^{\mu\nu}$$

where the matrix $\eta_{\mu\nu}$ is the metric of flat space-time. But the problem with relativistic quantum mechanics is that the solutions of the Dirac and Klein-Gordon equation have instabilities that turn out to represent the **creation and annihilation of virtual particles** from essentially empty space.
Further understanding led to the development of **relativistic quantum field theory**, beginning with **quantum electrodynamics**, or **QED** for short, pioneered by Feynman, Schwinger and Tomonaga in the 1940s. In quantum field theory, the behaviors and properties of elementary particles can calculate using a series of diagrams, called **Feynman diagrams**, which properly account for the creation and annihilation of virtual particles.

String diagram Particle diagram

The set of the Feynman diagrams for the scattering of two electrons looks like



The straight black lines represent **electrons**. The green wavy line represents a **photon**, or in classical terms, the electromagnetic field between the two electrons that makes them repels one another. Each small black **loop** represents a photon creating an electron and a positron, which then annihilate one another and produce a photon, in what is called a **virtual process**. The full scattering amplitude is the **sum of all contributions from all possible loops** of photons, electrons, positrons, and other available particles.

The quantum loop calculation comes with a very big problem. In order to properly account for all virtual processes in the loops, one must integrate over all possible values of momentum, from zero momentum to infinite momentum. But these loop integrals for a particle of spin J in D dimensions take the approximate form

$$I_{loop} \sim \int p^{4J-8} d^{D} p$$

If the quantity 4J + D - 8 is negative, then the integral behaves fine for infinite momentum (or zero wavelength, by the de Broglie relation.) If this quantity is zero or positive, then the integral takes an infinite value, and the whole theory threatens to make no sense because the calculations just give infinite answers.

The world that we see has D=4, and the photon has spin J=1. So for the case of electron-electron scattering, these loop integrals can still take infinite values. But the integrals go to infinity very slowly, like the logarithm of momentum and it turns out that in this case, the theory can be **renormalized** so that **the infinities can be absorbed into a redefinition of a small number of parameters in the theory**, such as the mass and charge of the electron.

Quantum electrodynamics was a renormalize able theory, and by the 1940, this was regarded as a solved relativistic quantum theory. But the other known particle forces -- the weak nuclear force that makes radioactivity, the strong nuclear force that hold neurons and protons together, and the gravitational force that holds us on the earth -- weren't so quickly conquered by theoretical physics.

In the 1960s, particle physicists reached towards something called a dual resonance model in an attempt to describe the strong nuclear force. The dual model was never that successful at describing particles, but it was understood by 1970 that the dual models were actually **quantum theories of relativistic vibrating strings** and displayed very intriguing mathematical behavior. Dual models came to be called **string theory** as a result.

But in 1971, a new type of quantum field theory came on the scene that explained the weak nuclear force by uniting it with electromagnetism into **electroweak theory**, and it was shown to be renormalized able. Then similar wisdom was applied to the strong nuclear force to yield **quantum chromodynamics**, or **QCD**, and this theory was also renormalizing able.

Which left one force -- gravity -- couldn't be turned into a renormalize able field theory no matter how hard anyone tried. One big problem was that classical gravitational waves carry spin J=2, so one should assume that a graviton, the quantum particle that carries the gravitational force, has spin J=2. But for J=2, 4 J - 8 + D = D, and so for D=4, the loop integral for the gravitational force would become infinite like the fourth power of momentum, as the momentum in the loop became infinite.

And that was just hard cheese for particle physicists, and for many years the best people worked on quantum gravity to no avail.

But the string theory that was once proposed for the strong interactions contained a massless particle with spin J=2.

In 1974 the question finally was asked: **could string theory be a theory of quantum gravity?**

The possible advantage of string theory is that the analog of a Feynman diagram in string theory is a two-dimensional smooth surface, and the loop integrals over such a smooth surface lack the zero-distance, infinite momentum problems of the integrals over particle loops.

In string theory infinite momentum does not even mean zero distance, because for strings, the relationship between distance and momentum is roughly like

$$\Delta L \sim \frac{\hbar}{p} + \alpha' \frac{p}{\hbar}$$

The parameter α' (pronounced alpha prime) is related to the **string tension**, the fundamental parameter of string theory, by the relation;

$$T_{string} = \frac{1}{2\pi\alpha'}$$

The above relation implies a minimum observable length for a quantum string theory of;

$$L_{\min} \sim 2\sqrt{\alpha'}$$

The zero-distance behavior which is so problematic in quantum field theory becomes irrelevant in string theories, and this makes string theory very attractive as a theory of quantum gravity.

If string theory is a theory of quantum gravity, then this minimum length scale should be at least the size of the Planck length, which is the length scale made by the combination of Newton's constant, the speed of light and Planck's constant;

$$L_p = \sqrt{\frac{\hbar G_N}{c^3}} = 1.6 \times 10^{-33}\, cm$$

Although as we shall see later, the question of length scales in string theory is complicated by string duality, which can relate two theories with seemingly different length scales.

More than just strings

Another surprising revelation was that **superstring theories are not just theories of one-dimensional objects**. There are higher dimensional objects in string theory with dimensions from zero (points) to nine, called **p-branes**. In terms of branes, what we usually call a membrane would be a two-brane, a string is called a one-brane and a point is called a zero-brane.

What makes a p-brane? A p-brane is a space-time object that is a solution to the Einstein equation in the low energy limit of superstring theory, with the energy density of the no gravitational fields **confined to some p-dimensional subspace** of the nine space dimensions in the theory. (Remember, superstring theory lives in ten space-time dimensions, which means one time dimension plus nine space dimensions.) For example, in a solution with electric charge, if the energy density in the electromagnetic field was distributed along a line in space-time, this **one-dimensional line** would be considered a **p-brane with p=1**.

A special class of p-branes in string theory is called **D branes**. Roughly speaking, a D brane is a p-brane where the ends of open strings are localized on the brane. A D brane is like a collective excitation of strings.

These objects took a long time to be discovered in string theory, because they are buried deep in the mathematics of T-duality. D branes are important in understanding black holes in string theory, especially in counting the quantum states that lead to black hole entropy, which was a very big accomplishment for string theory.

How many dimensions?

Before string theory won the full attention of the theoretical physics community, the most popular unified theory was an eleven dimensional theory of supergravity, which is supersymmetry combined with gravity. The eleven-dimensional space-time was to be compactified on a small 7-dimensional sphere, for example, leaving four space-time dimensions visible to observers' at large distances.

This theory didn't work as a unified theory of particle physics, because it doesn't have a sensible quantum limit as a point particle theory. But these eleven dimensional theory would not die. It eventually came back to life **in the strong coupling limit of superstring theory in ten dimensions**.

How could a superstring theory with ten space-time dimensions turn into a supergravity theory with eleven space-time dimensions? We've already learned that duality relations between superstring theories relate very different theories, equate large distance with small distance, and exchange strong coupling with weak coupling. So there must be some duality relation that can explain how a superstring theory that requires ten space-time dimensions for quantum consistency can really be a theory in eleven space-time dimensions after all.

Since we know that all string theories are related, and we suspect that they are but different limits of some more fundamental theory, then perhaps that more fundamental theory exists in eleven space-time dimensions? These question bring us to the topic of **M theory**.

The theory currently known as M

Technically speaking, **M theory** is is the unknown eleven-dimensional theory whose low energy limit is the supergravity theory in eleven dimensions discussed above. However, many people have taken to also using **M theory** to label the unknown theory believed to

be the fundamental theory from which the known superstring theories emerge as special limits.
We still don't know the fundamental M theory, but a lot has been learned about the eleven-dimensional M theory and how it relates to superstrings in ten space-time dimensions.
In M theory, there are also extended objects, but they are called **M branes** rather than D branes. One class of the M branes in this theory has two space dimensions, and this is called an **M2 brane**.
Now consider M theory with the tenth space dimension compactified into a circle of radius R. If one of the two space dimensions that make up the M2 brane is wound around that circle, then we can equate the resulting object with the fundamental string (one-brane) of type IIA superstring theory. The type IIA theory appears to be a ten dimensional theory in the normal perturbative limit, but reveals an extra space dimension, and equivalence to M theory, in the limit of very strong coupling. **We still don't know what the fundamental theory behind string theory is**, but judging from all of these relationships, it must be a very interesting and rich theory, one where distance scales, coupling strengths and even the number of dimensions in space-time are not fixed concepts but fluid entities that shift with our point of view.

The cosmological constant

When Einstein first studied the universe at large using the General Theory of Relativity he propounded two following axioms in 1917:
1- Matter has an average density in space that universe which was isotropic and homogeneous.
2- The radius of space in depended to time.

Friedman showed if we do cancel the second axiom, then the first axiom is acceptable. Then Friedman is credited with developing a dynamic equation for the expanding universe in the 1920s. This was a time when Einstein, Willem de Sitter of the Netherlands, and Georges Lemaitre of France were also working on equations to model the universe. Friedman developed it as a relativistic equation in the framework of general relativity, but the description here will be limited to a simplified, non-relativistic version.

A convenient form of Friedman's equation with which to examine the expansion time and temperature for a big bang model of the universe is

$$(dR/dt)^2 - C/R + K = 0$$

$$C = \frac{8\pi\rho(t_0)R_0^3}{3}$$

ρ =density of universe at t=0

R_0 = radius of universe at t=0

K = curvature parameter

By solving this equation we have;

$$\frac{dR}{dt} = \sqrt{C/R - K}$$

Then by integration we reach to;

$$\int_0^R \frac{dR'}{\sqrt{C/R' - K}} = \int_0^t dt = t$$

So, it shows the radius of universe depends to time. It means many years before of Hubble, Friedman propounded the universe is expanding.

The curvature parameter indicates whether the universe is open or closed.

Another form of Friedman's equation shows by;

$$H^2 = \frac{8\pi G\rho}{3c^2} - \frac{k}{R^2}$$

That H is the Hubble constant.

Einstein considered adding another term, the famous (or infamous) cosmological constant which would produce a static universe.

Einstein proposed a modification of the Friedman equation which models the expanding universe. He added a term which he called the cosmological constant, which puts the Friedman equation in the form;

$$H^2 = \frac{8\pi G\rho}{3c^2} - \frac{k}{R^2} + \frac{\Lambda c^2}{3} \quad \text{where } \Lambda = \text{cosmological constant}$$

The original motivation for the cosmological constant was to make possible a static universe which was isotropic and homogeneous. When the expansion of the universe was established without doubt, Einstein reportedly viewed the cosmological constant as the "worst mistake I ever made". But the idea of a cosmological constant is still under active discussion. Rohlf suggests that the physical interpretation of the cosmological constant was that vacuum fluctuations affected space time. A non-zero value for the cosmological constant could be implied from measurements of the volume densities of distant galaxies, but such measurements give a negative result, showing an upper bound of;

$$|\Lambda| < 3 \times 10^{-52}\ \mathrm{m}^{-2}$$

This implies that on the scale of the whole universe, vacuum fluctuation effects cancel out. This assessment comes at a time when theoretical calculations suggest vacuum fluctuation contributions from quarks on the order of 10^-6 m^-2.

The Curvature Parameter

The Friedmann equation which models the expanding universe has a parameter k called the curvature parameter which is indicative of the rate of expansion and whether or not that expansion rate is increasing or decreasing. If k=0 then the density is equal to a critical value at which the universe will expand forever at a decreasing rate. This is often referred to as the Einstein-de Sitter universe in recognition of their work in modeling it. This k=0 condition can be used to express the critical density in terms of the present value of the Hubble parameter.

For k>0 the density is high enough that the gravitational attraction will eventually stop the expansion and it will collapse backward to a "big crunch". This kind of universe is described as being a closed universe, or a gravitationally bound universe. For k<0 the universe expands forever, there not being sufficient density for gravitational attraction to stop the expansion.

Greatest blunder

When Isaac Newton discovered the law of gravity, he realized that gravity is always attractive. Every object in the universe attracts every other object. If the universe truly were finite, the attractive forces of all the objects in the universe should have caused the entire universe to collapse on it. This clearly had not happened, and so astronomers were presented with a paradox.

When Einstein developed his theory of gravity in the General Theory of Relativity, he thought he ran into the same problem that Newton did: his equations said that the universe should be either expanding or collapsing, yet he assumed that the universe was static. His original solution contained a constant term, called the cosmological constant, which cancelled the effects of gravity on very large scales, and led to a static universe. After Hubble discovered that the universe was expanding, Einstein called the cosmological constant his "greatest blunder."

At around the same time, larger telescopes were being built that were able to accurately measure the spectra, or the intensity of light as a function of wavelength, of faint objects. Using these new data, astronomers tried to understand the plethora of faint, nebulous objects they were observing. Between 1912 and 1922, astronomer Vesto Slipher at the Lowell Observatory in Arizona discovered that the spectrum of light from many of these objects was systematically shifted to longer wavelengths, or redshifted. A short time later, other astronomers showed that these nebulous objects were distant galaxies.

The Discovery of the Expanding Universe

Meanwhile, other physicists and mathematicians working on Einstein's theory of gravity discovered the equations had some solutions that described an expanding universe. In these solutions, the light coming from distant objects would be redshifted as it traveled through the expanding universe. The redshift would increase with increasing distance to the object.

In 1929 Edwin Hubble, working at the Carnegie Observatories in Pasadena, California, measured the redshifts of a number of distant galaxies. He also measured their relative distances by measuring the apparent brightness of a class of variable stars called Cepheids in each galaxy. When he plotted redshift against relative distance, he found that the redshift of distant galaxies increased as a linear function of their distance. The only explanation for this observation is that the universe was expanding.

The fact that we see all stars moving away from us does not imply that we are the center of the universe! All stars will see all other stars moving away from them in an expanding universe. A rising loaf of raisin bread is a good visual model: each raisin will see all other raisins moving away from it as the loaf expands.

Hubble's law is a statement of a direct correlation between the distance to a galaxy and its recessional velocity as determined by the red shift. It can be stated as;

$$V(t) = H(t)\,X(t),$$

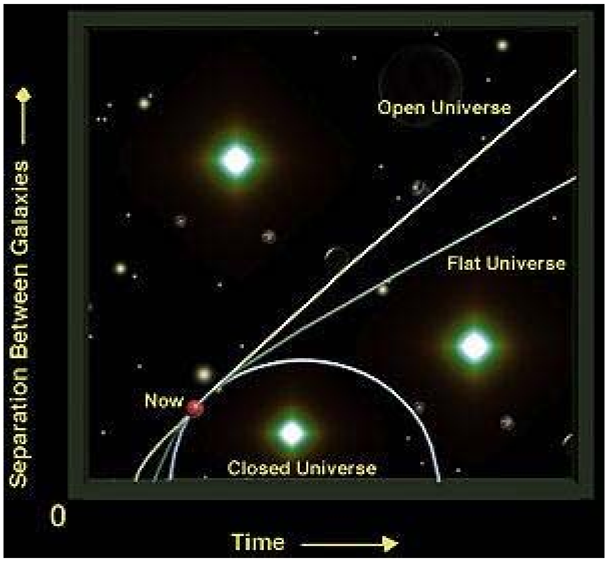
V, velocity of expandig (a function of time)
H, Hubble's constant (a function of time)
X, distance (a function of time)

Once scientists understood that the universe was expanding, they immediately realized that it would have been smaller in the past. At some point in the past, the entire universe would have been a single point. This point, later called the big bang, was the beginning of the universe as we understand it today.

The expanding universe is finite in both time and space. The reason that the universe did not collapse, as Newton's and Einstein's equations said it might is that it had been expanding from the moment of its creation. The universe is in a constant state of change. The expanding universe, a new idea based on modern physics, laid to rest the paradoxes that troubled astronomers from ancient times until the early 20th Century.

Properties of the Expanding Universe

The equations of the expanding universe have three possible solutions, each of which predicts a different eventual fate for the universe as a whole. Which fate will ultimately befall the universe can be determined by measuring how fast the universe expands relative to how much matter the universe contains.



The three possible types of expanding universes are called open, flat, and closed universes. If the universe were open, it would expand forever. If the universe were flat, it would also expand forever, but the expansion rate would slow to zero after an infinite amount of time. If the universe were closed, it would eventually stop expanding and collapse on itself again, possibly leading to another big bang. In all three cases, the expansion slows, and the force that causes the slowing is gravity.

Big Bang

When physicists accepted universe is expanding, then problem was that why and how is universe expanding? The answer was that the universe had beginning by an great explosion is called Big Bang.

According to the Big Bang theory, the universe began about 14 billion years ago as an unimaginably hot and dense fog of light and exotic particles. The Universe has since continuously expanded and cooled. The whole Universe is bathed in the afterglow light from the Big Bang. The light that is now reaching us has been traveling for about 14 billion years, thus allowing us a look back through time to see the early Universe.

At the big bang itself, the universe is thought to have had zero size, and so to have been infinitely hot. But as the universe expanded, the temperature of the radiation decreased. One second after the big bang, it would have fallen to about ten thousand million degrees. This is about a thousand times the temperature at the center of the sun, but temperatures as high as this are reached in H-bomb explosions

About one hundred seconds after the big bang, the temperature would have fallen to one thousand million degrees, the temperature inside the hottest stars

Within only a few hours of the big bang, the production of helium and other elements would have stopped. And after that, for the next million years or so, the universe would have just continued expanding, without anything much happening

According to this theory [strong anthropic principle], there are either many different universes or many different regions of a single universe, each with its own initial configuration and, perhaps, with its own set of laws of science. In most of these universes the conditions would not be right for the development of complicated organisms; only in the few universes that are like ours would intelligent beings develop and ask the question: "Why is the universe the way we see it?" The answer is then simple: If it had been different, we would not be here!

The Cosmic Microwave Background Radiation

In 1963, Arno Penzias and Robert Wilson, two scientists in Holmdale, New Jersey, were working on a satellite designed to measure microwaves. When they tested the satellite's antenna, they found mysterious microwaves coming equally from all directions. At first, they thought something was wrong with the antenna. But after checking and rechecking, they realized that they had discovered something real. What they discovered was the radiation predicted years earlier by Gamow, Herman, and Alpher. The radiation that Penzias and Wilson discovered is called the Cosmic Microwave Background Radiation, convinced most astronomers that the Big Bang theory was correct. For discovering the Cosmic Microwave Background Radiation, Penzias and Wilson were awarded the 1978 Nobel Prize in Physics

After Penzias and Wilson found the Cosmic Microwave Background Radiation, astrophysicists began to study whether they could use its properties to study what the universe was like long ago. According to Big Bang theory, the radiation contained information on how matter was distributed over ten billion years ago, when the universe was only 500,000 years old.

At that time, stars and galaxies had not yet formed. The Universe consisted of a hot soup of electrons and atomic nuclei. These particles constantly collided with the photons that made up the background radiation, which then had a temperature of over 3000 C.

Soon after, the Universe expanded enough, and thus the background radiation cooled enough, so that the electrons could combine with the nuclei to form atoms. Because atoms were electrically neutral, the photons of the background radiation no longer collided with them.

When the first atoms formed, the universe had slight variations in density, which grew into the density variations we see today - galaxies and clusters. These density variations should have led to slight variations in the temperature of the background radiation, and these variations should still be detectable today. Scientists realized that they had an exciting possibility: by measuring the temperature variations of the Cosmic Microwave Background Radiation over different regions of the sky, they would have a direct measurement of the density variations in the early universe, over 10 billion years ago.

Accelerating Universe

1998 - The universe is not only expanding, but that expansion appears to be speeding up. And as if that discovery alone weren't strange enough, it implies that most of the energy in the cosmos is contained in empty space — a concept that Albert Einstein considered but discarded as his "biggest blunder." The new findings have been recognized as 1998's top scientific breakthrough by Science magazine.

Last year's top breakthrough related to Dolly the sheep, the high-profile result of cloning experiments. This year, the topic is a little more esoteric, involving technical discussions about Type 1A supernovae, redshift, "antigravity" and a curious factor known as the cosmological constant, or lambda in geekspeak.

These observations are explained by postulating a kind of energy with negative pressure; **dark energy.**

Dark energy

The simplest explanation for dark energy is that it is simply the "cost of having space": that is, that a volume of space has some intrinsic, fundamental energy. This is the cosmological constant, sometimes called Lambda (hence Lambda-CDM model) after the mathematical symbol used to represent it, the Greek letter Λ. Since energy and mass are related by $E = mc^2$, Einstein's theory of general relativity predicts that it will have a gravitational effect. It is sometimes called a vacuum energy because it is the energy density of empty vacuum. In fact, most theories of particle physics predict vacuum fluctuations that would give the vacuum exactly this sort of energy. The cosmological constant is estimated by cosmologists to be on the order of 10^{-29}g/cm^3, or about 10^{-120} in reduced Planck units.

The cosmological constant has negative pressure equal to its energy density and so causes the expansion of the universe to accelerate (see equation of state (cosmology)). The reason why a cosmological constant has negative pressure can be seen from classical thermodynamics. The work done by a change in volume dV is equal to $-p\,dV$, where p is the pressure. But the amount of energy in a box of vacuum energy actually increases when the volume increases (dV is positive), because the energy is equal to ρV, where ρ is the energy density of the cosmological constant. Therefore, p is negative and, in fact, $p = -\rho$.

A major outstanding problem is that most quantum field theories predict a huge cosmological constant from the energy of the quantum vacuum, up to 120 orders of magnitude too large. This would need to be cancelled almost, but not exactly, by an equally large term of the opposite sign. Some supersymmetric theories require a cosmological constant that is exactly zero, which does not help. This is the **cosmological constant problem**, the worst problem of fine-tuning in physics: there is no known natural way to derive, even roughly, the infinitesimal cosmological constant observed in cosmology from particle physics. Some physicists, including Steven Weinberg, think the delicate balance of quantum vacuum energy is best explained by the anthropic principle.

In spite of its problems, the cosmological constant is in many respects the most economical solution to the problem of cosmic acceleration. One number successfully explains a multitude of observations. Thus, the current standard model of cosmology, the Lambda-CDM model, includes the cosmological constant as an essential feature.

Why CPH Theory have propounded?

Of the first let me say that CPH Stands of: Creation Particle Higgs, in CPH theory we will study how the fundamental particles were created. The second CPH Theory is based on a definition of CPH and a simply principle. Also, in discussion with my dear colleagues and other guys, I found understanding the properties of CPH and CPH principle needs a little assiduity. Please do attend that CPH properties come of theoretical physic's ambiguities and experimental conceptions, that have explain in section two. In this section I will give you the logical reasons that had make the CPH theory foundation. In section three you will see definition and principle of CPH. Section four has a few analyses about CPH Theory. Others sections belong to explaining the modern physics ambiguities by CPH theory. In fact CPH theory is an empiric and sensibility theory. And it does different CPH Theory with other theories. Shortly, CPH theory proclaims the following conceptions;

1- When we will be able to explain quantum level phenomenon, that we do thinking on sub quantum quantities.
2- To explaining relationship between fermions and bosons, we must do change our mind of gravity and graviton. In fact graviton behaves like a charge or magnet force in sub quantum levels.
3- We never can do combine Quantum mechanics with General Relativity without attention to Higgs theory. In fact there is an especial relationship between force and energy like mass and energy in relativity. This shows we reconsider the second Newton's law. It shows a unified theory comes up of reconsideration the quantum mechanics, relativity, Higgs theory and classical mechanics.

These are reasons that I proclaim CPH Theory.

Logical Foundation of CPH Theory

Principle

The business of physics is the abstract quantification of facts observed in nature. The rules we form for reconstruction and expression of the observed facts are the *laws of* ***nature*** **and** ***Principles of nature***. The distinction between them is tied to their generality. Principles are considered to be more general and by implication more basic. For example, the Principle of Least Action is inferred from several of the force laws and the principle of Conservation of Energy expresses all the various heat and energy flow laws. If the galaxies had been produced by a Big Bang only that it had happened in universe, we never have been witnessing the colliding the galaxies. Because, galaxies must were moving speeding away from each other. But we witness colliding galaxies, how we can explain it exactly?

1- Newton's second law and relativity mass-energy;

By Newton's second law an object could take any velocity to infinity. Infinity of velocity was unexpressive. Relativity propounded (and had showed) that the velocity has a limit in nature and infinity speed is not correct. So Einstein considered the Newton's second law. He found that when an object takes energy, its mass does increase. So Einstein understood that there is a relationship between the kinetic energy (increasing velocity) and mass. On this case Einstein gate the relativity mass with relation:

$$m=\frac{m_0}{\sqrt{1-v^2/c^2}}$$

But Relativity replaced an infinity quantity with other infinity quantity (mass lieu velocity).
For photon that moves with light’s speed, if m was nonzero, photon must has infinity mass when travels with light’s speed. So he supposed that the rest mass of photon is zero. But there is not any frame that photon reaches to rest condition.
Relativity claims light and gravity waves move the same velocity as equal c. Is it an accident that light and the graviton travel at the same speed?
The fixed light speed is not only emerging from a natural accident, and photon does form of sub photonic elements that they move with linear speed before than do form a photon. In CPH Theory, photon has lots elements that they move with linear speed in structure of photon and photon does form at speed of light conditions. So, photon never seems at rest mass. So, scrutinizing the structure of photon does help us to resolve many of universe’s mysteries.

2- Work and energy

Theoretical physics and evidence show energy is quantized, according to following relation;

$$W=dE=\Delta m\ c^2 \text{ and } \quad \text{or } (E = KE + mc^2)$$

It is not acceptable that energy was being quantized and work is were continuously, so Work is quantized too.
We know the frequency of photon does change in gravitational field. When gravity force acts on photon, then energy of photon does increase and its frequency increases. It means force is quantized and when applies on photon, gravity force does convert to electromagnetic energy.
In CPH Theory a quantum of work defines by

$$\mathbf{Wq=Fg.Lp}$$

Wq is a quantum work, Fg is a quantum of force and Lp is Plank’s length

Generally work defines with W=nWq=Fg.Lp , like Plank’s formula E=nhν

3- Photon’s electric field and magnetic field

According modern physics a photon becomes energy-laden by revolving. We know this because the electromagnetic fields around a "ray of light" are electromagnetic waves not static fields. Relativistically, the electromagnetic field generated by a photon is much stronger than the associated gravitational field. Further it is not clear at the present time whether the gravitational field of an energy-laden photon is static or oscillatory. It is not

understood how the photon generates two sets of fields (electromagnetic and gravitational) of so different intensities. This is an enigma.
It is resolvable simply, if we do consider to the effect of gravitational field on light. According red-shift and blue-shift we know energy (also frequency) of photon changes by effect of gravity. Also, energy of photon depends to intensity of its electric field and magnetic field. So, there is an important and considerable relationship between gravity and electromagnetic field. This relationship was explained by color-charge and color-magnet in CPH Theory.

4- Repulsive gravity force and limitation of speed

We know why and how a star forms and emits energy or other particle. Also, we know when a star explodes or collapses and becomes to a neutrino star or a black hole. But we do not know how and why a black hole explodes?
Also do attend to repulsive gravity force that of Newton's time to now have not any answer. In classical mechanics and relativity have been accepted that repulsive gravitational force and limitation of speed are two separable items. For that Einstein added a cosmetically constant to Friedman's equation. But evidences show this opinion is incorrect. Repulsive gravitational force and limitation of speed are depends to each other. In CPH Theory a black hole growth so much and eats other masses, light and the end it eats gravity and becomes to absolute black hole. Absolute black hole takes zero hour condition and explodes. Big Bang is comes up of exploding an absolute black hole.

4- Age of universe

How can we calculate The Universe's long time? But we do not know more about the essence of time. All our knowledge about time is this that time changes from a system to another system or on a Gravity field. How we can calculate these changes? By the electromagnetic waves, what are the electromagnetic waves? They are photons. So we must know more about the light. We must develop our knowledge about the structure of photon.
Really without external effects on photon, has it infinity time-life? When we are able find

its answer that we know the structure of photon and its sub elements.

6- The Cosmic Microwave Background Radiation

Is the cosmic microwave leaving of Big Bang? If answer is yes, why it reaches to earth

from of all sides of space? The answer of this question is in the structure of photon.

7- The Curvature of space

According General Relativity mass bends space. We know that is correct. But there is a great problem in General Relativity, because gravity is not a real force in General Relativity. So, we can not explain why space bends. For that reason General Relativity and Quantum mechanic does not combine.

But CPH Theory is able explain why and how space curves by gravity field.

8- Pair Production

Pair production shows a very interesting idea to resolving the relationship between fermions and bosons.
Before of pair production, we have electromagnetic energy only.
But after of pair production, we see fermions and boson that carries electric force.
In CPH Theory fermions produce bosons.

9- Limit of growing mass or curvature of space

According the Newton's universal gravitational law, we know that

$$g=GM/r^2$$

It shows the gravity field around a massive body is stronger than of a small body. Also, of the General Relativity we know that the massive body bends space more than the small bodies. These two theories usually give the same results. In Newton's universal gravitation growing mass has no limit, and in General Relativity density growth to infinity and volume goes to zero.
It is not acceptable, so in CPH Theory over than growing mass has a limit, no body has zero volume specially before of big bang.

With Best Regards
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