Fundamental of particle & Unification of Force & Cosmology

Submitted to the department of General Science in partial Fulfilment of the Requirements for the A.B or BSc. in Degree of General Science

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Chapter One

Fundamental of particle

Introduction

This research contain in three chapters, chapter one consist history of the discovery of the basic or elementary particle. Chapter two consist of the fundamental forces ibn the universal and chapter three describe the cosmology and the theory of the cosmology and deplovement of the universal from the fundamental particles.

(1-1) Classical Era (1897 – 1932)

The physics was born in 1897 with J.J. Thomson`s discovery of the electron. It is fashionable to carry the story all the way back to Democritus and the Greek atomists but apart from a few suggestive words their metaphysical speculations have nothing in common with modern science and although they may be of modest antiquarian interest their genuine relevance is negligible Thomson knew that cathode rays emitted by a hot filament could be deflected by a magnet .this suggested that they carried electric charge in fact the direction of the curvature required that the charge be negative . It seemed therefore that these were not rays at all but rather streams of particle by passing the beam through crossed electric and magnetic fields and adjusting the field strength until the net deflection was zero Thomson was able to determine the velocity of the particle (about a tenth the speed of light)as well as their charge –to-mass ratio.

charge late that name was taken over for the particles themselves. Thomson correctly surmised that these electrons were essential constituents of atoms however since atoms as a whole are electrically neutral and very much heavier than electron (1).

(1-2) The photon (1900-1924)

In same respect, the photon is very `modern` particle, having more in common with the W and Z (which were not discovered until 1983) than with the classical trio. Moreover, it`s hard to say exactly when or by whom the photon was really " discovered ", although the essential stages in the process are clear enough. The first contribution was made by Planck in 1900. Planck was attempting to explain the so-called blackbody spectrum for the electromagnetic radiation emitted by a hot object.– if he assumed that electromagnetic radiation is quantized, coming in little "packages" of energy

$$E = h\upsilon \qquad \mathbf{(1-1)}$$

Where v is frequency of the radiation and h is constant, which Planck adjusted to fit the data. Planck did not profess to know why the radiation as quantized (1).

(1-3) Mesons (1934-1947)

The first significant theory of the strong force was proposed by Yukawa in 1934 . Yukawa assumed that the proton and neutron are attracted to one another by some sort of field, just as the electron is attracted to the nucleus by an electric field and the moon to the earth by a gravitational field. This field should properly be quantized, and Yukawa asked the question: what must be the properties of its quantum - the particle (analogous to the photon) whose exchange would account for the known features of the strong force? For example, the short range of the force indicated that the mediator would be rather heavy; Yukawa calculated that its mass should be nearly 300 times that of the electron, or about a sixth the mass of a proton . Because it fell between the electron and the proton, Yukawa's particle came to be known as the meson (meaning 'middle-weight'). In the same spirit, the electron is called a lepton ('light-weight'), whereas the proton and neutron are baryons ('heavy-weight'). Now, Yukawa knew that no such particle had ever been observed in the laboratory (1,3,4,5).

(1-4)Antiparticles (1930-1956).

Stuckelberg and Feynman provided a much simpler and more compelling interpretation of the negative-energy states. In the Feynman-Stuckelberg formulation,

the negative-energy solutions are re-expressed as positive energy states of a different particle (the positron); the electron and positron appear on an equal footing, and there is no need for Dirac's 'electron sea' or for its mysterious 'holes' We'll see in Chapter 7 how this - the modern interpretation - works. Meantime, it turned out that the dualism in Dirac's equation is a profound and universal feature of quantum field theory: for every kind of particle there must exist a corresponding antiparticle, with the same mass but opposite electric charge. The positron, then, is the antielectron. (Actually, it is in principle completely arbitrary which one you call the 'particle' and which the 'antiparticle' I could just as well have said that the electron is the antipositron. But since there are a lot of electrons around, and not so many positrons (1,3,7).

(1-5) Neutrinos (1930-1962)

The study of nuclear beta decay. In beta decay, a radioactive nucleus A is transformed into a slightly lighter nucleus B, with the emission of an electron: AB+e Conservation of charge requires that B carry one more unit of positive charge than A. (We now realize that the underlying process here is the conversion of a neutron, in A, into a proton, in B; but remember that in 1930 the neutron had not yet. been discovered.) Thus the daughter' nucleus (B) lies one position farther along on the periodic table. There are many examples of beta decay: potassium goes to calcium (1K20 Ca), copper goes to zinc (Cu → Zn), tritium goes to helium (H→ He), and so on.* Now, it is a characteristic of two-body decays (A → B+C) that the outgoing energies are kinematically determined, in the center-of-mass frame. Specifically, if the 'parent' nucleus (A) is at rest, so that B and e come out back-to-back with equal and opposite momenta (1).

(1-6)Strange particles (1946- 1960).

For a brief period in 1947, it was possible to believe that the major problems of elementary particle physics were solved. After a lengthy detour in pursuit of the muon, Yukawa' meson (the л) had finally been apprehended. Dirac's positron had been found, and Pauli's neutrino,

although still at large (and, as we have seen, still capable of making mischief), was widely accepted. plate·(1,7).

(1-7)The Quark Model (1964).

n particle physics, the quark model is a classification scheme for hadrons in terms of their valence quarks—the quarks and antiquarks which give rise to the quantum numbers of the hadrons. The quark model underlies "flavor SU(3)", or the Eightfold Way, the successful classification scheme organizing the large number of

lighter hadrons that were being discovered starting in the 1950s and continuing through the 1960s. It received experimental verification beginning in the late 1960s and is a valid effective classification of them to date. The model was independently proposed by physicists Murray Gell-Mann,[1] who dubbed them "quarks" in a concise paper, and George Zweig,[2][3] who suggested "aces" in a longer manuscript. André Petermann also touched upon the central ideas from 1963 to 1965, without as much quantitative substantiation.[4][5] Today, the model has essentially been absorbed as a component of the established quantum field theory of strong and electroweak particle interactions, dubbed the Standard Model.

Hadrons are not really "elementary", and can be regarded as bound states of their "valence quarks" and antiquarks, which give rise to the quantum numbers of the hadrons. These quantum numbers are labels identifying the hadrons, and are of two kinds. One set comes from the Poincaré symmetry—J^{PC}, where J, P and C stand for the total angular momentum, P-symmetry, and C-symmetry, respectively.

The other set is the flavor quantum numbers such as the isospin, strangeness, charm, and so on. The strong interactions binding the quarks together are insensitive to these quantum numbers, so variation of them leads to systematic mass and coupling relationships among the hadrons in the same flavor multiplet.

All quarks are assigned a baryon number of ⅓. Up, charm and top quarks have an electric charge of +⅔, while the down, strange, and bottom quarks have an electric charge of −⅓. Antiquarks have the opposite quantum numbers. Quarks are spin-½ particles, and thus fermions. Each quark or antiquark obeys the

Gell-Mann−Nishijima formula individually, so any additive assembly of them will as well.

Mesons are made of a valence quark−antiquark pair (thus have a baryon number of 0), while baryons are made of three quarks (thus have a baryon number of 1). This article discusses the quark model for the up, down, and strange flavors of quark (which form an approximate flavor SU(3) symmetry). There are generalizations to larger number of flavors (1,2,3,4,5,7)**.**

There And are two composition rules:

1. Every baryon is composed of three quarks (and every antibaryon is compose of three quarks.

2. Every meson is composed of a quark and an antiquark. With this, it is a matter of elementary arithmetic to construct the baryon decuplet and the meson octet. All we need to do is list the combinations of three quarks (or quark-antiquark pairs) and add up their charge and strangeness (1).

Chapter Two

Unification Of The Forces

(2-1) Particles and Antiparticles:-

The Greek philosophers Leucippus and Democritus suggested that matter is composed of fundamental or elementary particles called atoms. only four elementary particles were known; the electron, the proton, the neutron, and the photon. Other particles were soon discovered in cosmic rays. Cosmic rays are particles from outer space that impinge on the top of the atmosphere. Some of them make it to the surface of the earth, whereas others decay into still other particles before they reach the surface. Other new particles were found. Today, there are hundreds of such particles. Except for the electron, proton, and neutron, most of these elementary particles decay very quickly.The first attempt at order is the classification of particles according to the scheme shown in figure (2-1) . All the elementary particles can be grouped into particles called hadrons or leptons.

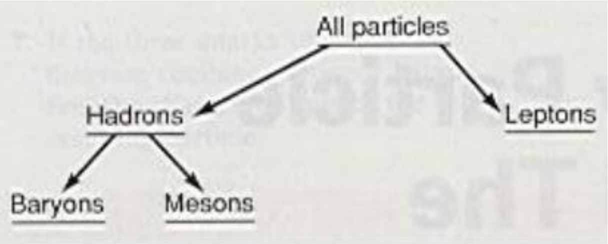


Figure (2-1) all the elementary particles can be grouped into particles called hadrons or leptons.

Leptons

The Leptons are particles that are not affected by the strong nuclear force. They are very small in terms of size, in that they are less than 10 19 m in diameter. They all have spin 1⁄2 in units of . There are a total of six leptons: the electron, e , the muon μ^- , and the tauon τ^- , each with an associated neutrino. They can be grouped in the form

$$(\nu_e)\ (\nu_\mu)\ (\nu_\tau) \qquad (e^-)\ (\mu^-)\ (\tau^-)$$

There are thus three neutrinos: the neutrino associated with the electron, e; the neutrino associated with the muon ν_μ ; and the neutrino associated with the tauon ν_τ . The muon is very much like an electron but it is much heavier. It has a mass about 200 times greater than the electron. It is not stable like the electron but decays in about 10^{6} s.

Originally the word lepton, which comes from the Greek word leptos meaning small or light in weight. However, in 1975 the lepton was discovered and it has twice the mass of the proton. That is, the lepton is a heavy lepton, certainly a misnomer. Leptons are truly elementary in that they apparently have no structure. That is, they are not composed of something still smaller. Leptons participate in the weak nuclear force, while the charged lepton, e^- , μ^- τ^-

The muon was originally thought to be Yukawa's meson that mediated the strong nuclear force, and hence it was called a meson.

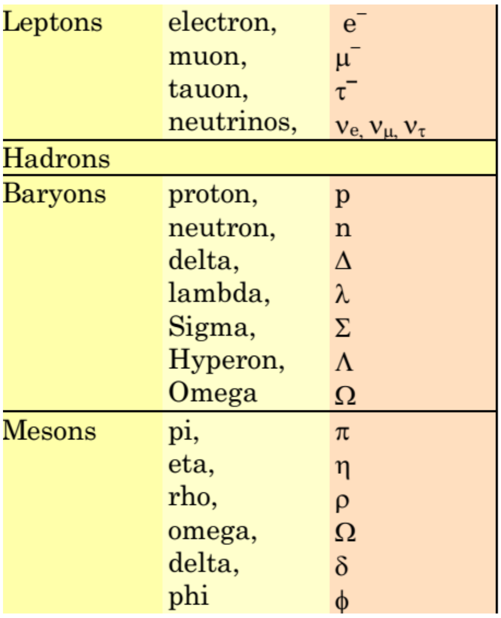
Hadrons

Hadrons are particles that are affected by the strong nuclear force. There are hundreds of known hadrons. Hadrons have an internal structure, composed of what appears to be truly elementary particles called quarks. The hadrons can be further broken down into two subgroups, the baryons and the mesons.

1**. Baryons**. Baryons are heavy particles that, when they decay, contain at least one proton or neutron in the decay products. The baryons have half-integral spin, that is, 1/2 , 3/2 , and so on. We will see in a moment that all baryons.

2. Mesons.

Originally, mesons were particles of intermediate-sized mass between the electron and the proton. All mesons have integral spin, that is, 0, 1, 2, 3, and so on. The mass of the meson increases with its spin. A list of some of the elementary particles is shown in table (2-) .



Leptons	electron,	e^-
	muon,	μ^-
	tauon,	τ^-
	neutrinos,	$\nu_{e,}\ \nu_{\mu,}\ \nu_\tau$
Hadrons		
Baryons	proton,	p
	neutron,	n
	delta,	Δ
	lambda,	λ
	Sigma,	Σ
	Hyperon,	Λ
	Omega	Ω
Mesons	pi,	π
	eta,	η
	rho,	ρ
	omega,	Ω
	delta,	δ
	phi	ϕ

Table (2-1) some of the Elementary particles

This new particle was called the antielectron or the positron. This was the first prediction of the existence of antimatter. The positron was found in 1932.

For every particle in nature in nature there is associated an antiparticle. The antiparticle of the proton is the antiproton. It has all the

Characteristics of the proton except that it carries a negative charge. Some purely neutral particles such as the photon and the π° meson are their own antiparticles. Antiparticles are written with a bar over the symbol for the particle. Hence, p is an antiproton and n is an antineutron.

Matter consists of electrons, protons and neutrons, whereas antimatter consists of antielectrons (positrons), antiprotons, and antineutrons. Figure (2-2) shows atoms of matter and antimatter. The same electric forces that hold matter.

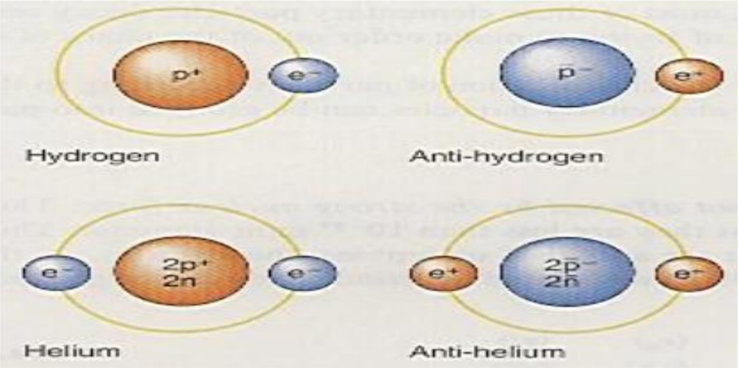


Figure (2-2) matter and antimatter

together, hold antimatter together. (Note that the positive and negative signs are changed in antimatter.) The antihelium nucleus has already been made in high- energy accelerators.

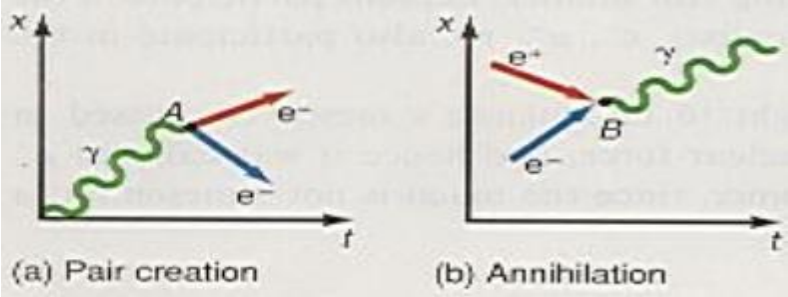
Whenever particles and antiparticles come together they annihilate each other and only energy is left. For example, when an electron comes in contact with a positron they annihilate according to the reaction

$$e^- + e^+ = 2\gamma \qquad \textbf{(2-1)}$$

where the 2γ's are photons of electromagnetic energy. (Two gamma rays are necessary in order to conserve energy and momentum.) This energy can also be used to create other particles. Conversely, particles can be created by converting the energy in the photon to a particle-antiparticle pair such as

$$\gamma \rightarrow e^- + e^+ \qquad \textbf{(2-2)}$$

Creation or annihilation can be shown on a spacetime diagram, called a Feynman diagram, after the American physicist Richard Feynman (1918-1988), such as in figure 2-2. Figure 2-2(a) shows the creation of an electron-positron pair.



(a) Pair creation (b) Annihilation

Figure (2-3) Creation and annihilation of particles

Photon γ moves through spacetime until it reaches the spacetime point A, where the energy of the photon is converted into the electron-positron pair. Figure 2-2(b) shows an electron and positron colliding at the spacetime point B where they annihilate each other and only the photon γ now moves through spacetime. (In order to conserve momentum anenergy in the creation process, the presence of a relatively heavy nucleus is required.) (1,3).

(2-2) The Four Forces of Nature:-

In the study of nature, four forces that act on the particles of matter are known. They are:

1. The Gravitational Force. The gravitational force is the oldest known force. It holds us to the surface of the earth and holds the entire universe together. It is a long-range force, varying as 1/r2. Compared to the other forces of nature it is by far the weakest force of all.

2. The Electromagnetic Force. The electromagnetic force was the secoforce known. In fact, it was originally two forces, the electric force

and the magnetic force, until the first unification of the forces tied them together as a single electromagnetic force. The electromagnetic force holds atoms, molecules, solids, and liquids together. Like gravity, it is a long-range force varying as 1/r2.

3. The Weak Nuclear Force. The weak nuclear force manifests itself not so much in holding matter together, but in allowing it to disintegrate, such as in the decay of the neutron and the proton. The weak force is responsible for the fusion process occurring in the sun by allowing a proton to decay into a neutron such as given in equation. The proton-proton cycle then continues until helium is formed and large quantities of energy are given off. The nucleosynthesis of the chemical elements also occurred because of the weak force. Unlike the gravitational and electromagnetic force, the weak nuclear force is a very short range force.

4. The Strong Nuclear Force. The strong nuclear force is responsible for holding the nucleus together. It is the strongest of all the forces but is a very short range force. That is, its effects occur within a distance of about 10 15 m, the diameter of the nucleus. At distances greater than this, there is no evidence whatsoever for its very existence. The strong nuclear force acts only on the hadrons.Why should there be four forces in nature? Einstein, after unifying space and time intLo spacetime, tried to unify the gravitational force and the electromagnetic force into a single force. Although he spent a lifetime trying, he did not succeed. The hope of a unification of the forces has not died, however. In fact, we will see shortly that the electromagnetic force and the weak nuclear force have already been unified theoreticexperimentally confirmed by Rubbia. A grand unification between the electroweak and the strong force has been proposed.

Finally an attempt to unify all the four forces into one superforce is presently underway (3).

Electricity	Electromagnetism			
Magnetism		Electroweak force		
Weak force			Grand unified theories (GUT)	
Strong force				Superforce
Gravity				

Table (2-2) the forces and unification

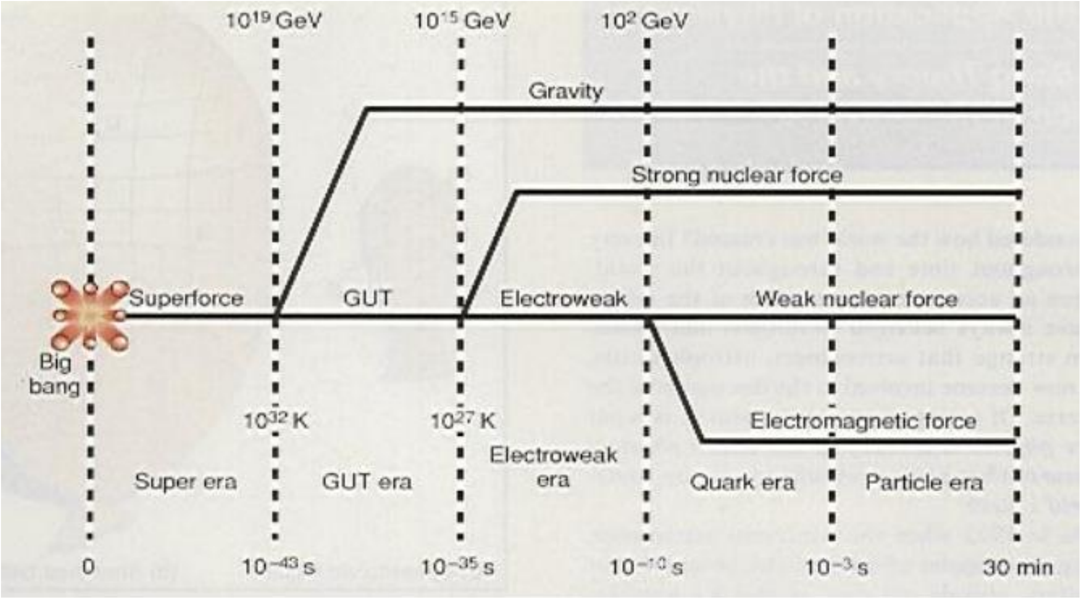
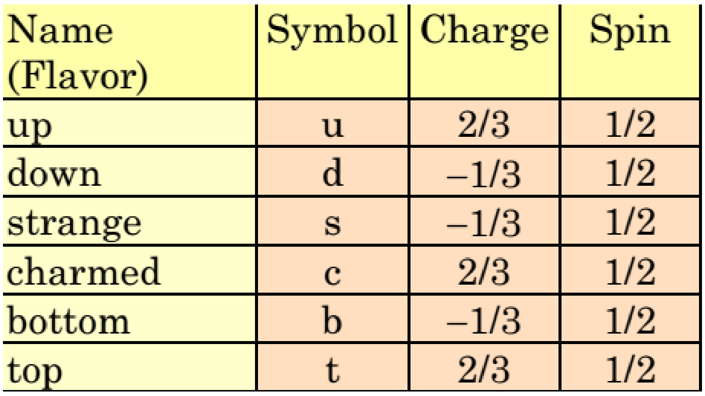


Figure (2-4) creation of the forces from the superforce.

(2-3) Quarks:-

In the attempt to make order out of the very large number of elementary particles, Murray Gell-Mann and George Zweig in 1964, independently proposed that the hadrons were not elementary particles but rather were made of still more elementary particles. Gell-Mann called these particles, quarks. He initially assumed there were only three such quarks, but with time the number has increased to six. The six quarks are shown in table (2-3). The names of the quarks are: up, down, strange, charmed, bottom, and top. One of the characteristics of these quarks is that they have fractional electric charges. That is, the up, charmed, and top quark has 2/3 of the charge found on the proton, whereas the down, strange, and bottom quark has 1/3 of the charge found on the electron.



Name (Flavor)	Symbol	Charge	Spin
up	u	2/3	1/2
down	d	–1/3	1/2
strange	s	–1/3	1/2
charmed	c	2/3	1/2
bottom	b	–1/3	1/2
top	t	2/3	1/2

Table (2-3) the six quarks.

quarks is that they have fractional electric charges. That is, the up, charmed, and top quark has 2/3 of the charge found on the proton, whereas the down, strange, and bottom quark has 1/3 of the charge found on the electron. They all have spin 1/2, in units of ħ. Each quark has an antiquark, which is the same as the original quark except it has an opposite charge. The antiquark is written with a bar over the letter,

that is q.

all of the hadrons are made up of quarks. The baryon are made up of three quarks:

$$\text{Baryon} = qqq \qquad \textbf{(2-3)}$$

While the mesons are made up of a quark-antiquark pair:

$$\text{Meson} = qq \qquad \textbf{(2-4)}$$

As an example of the formation of a baryon from quarks, consider the proton. The proton consists of two up quarks and one down quark, as shown in figure (2-3) (a).

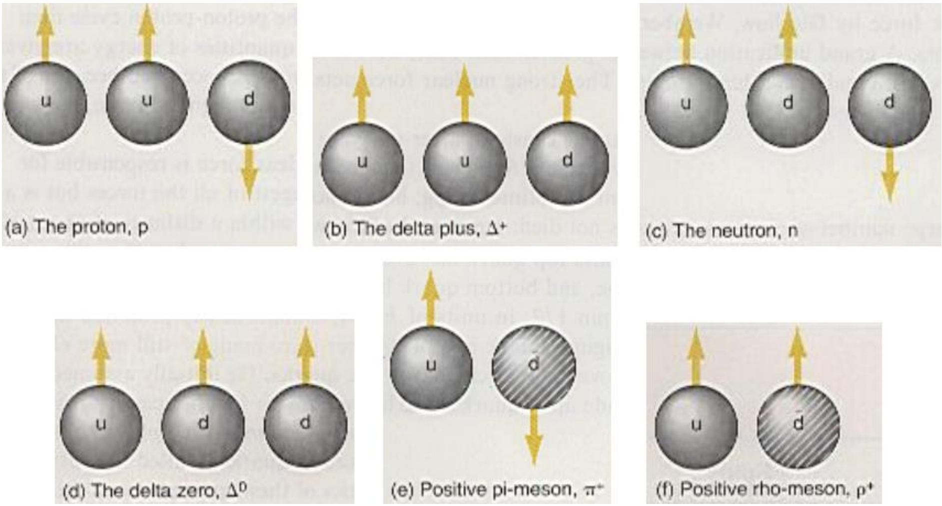


Figure (2-5) some quark configuration of baryon and mesons.

The electric charge of the proton is found by adding the charges of the constitutive quarks. That is, since the u quark has a charge of 2/3, and the d quark has a charge of -1/3, the charge of the proton is

$$2/3 + 2/3 = 1 \qquad \textbf{(2-5)}$$

The quark structure of some of the baryons, quark structure for some mesons. Particles that contain the strange quark are called strange particles. The reason for this name is because these particles took so much longer to decay than the other elementary particles, that it was considered strange (1,2,3,4,5,7) .

Chapter Three

Cosmology

(3-1) Introduction

Cosmology is the study of the history of the Universe as a whole, both its structure and evolution. The study assumes that over large distances the Universe looks essentially the same from any location (the Universe is homogeneous) and that the Universe looks essentially the same in all directions (the Universe is isotropic). The assumptions are known as the cosmological principle. In addition, it is assumed that the same laws of physics hold everywhere in the Universe.

Reliable astronomical records are available for the last 100 years or so. This time interval is minute by astronomical scales, which are typically on the order of 10 billion years. To study the evolution of the Universe, astronomers rely on observations of distant objects. For example, the Andromeda Galaxy (M31) is about 2 million light years away. This means that our photographs of M31 show the galaxy as it was 2 million years ago, and the information presently received by our telescopes describe the state of the cluster as it was 50 million years ago. Information received from galaxies that are billions of light years away pertains to the state of these objects as they were billions of years ago (8,9,10,11,12,14,15) .

(3-2) Hubble’s Law

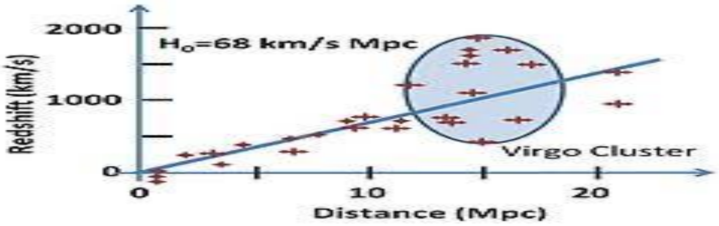
Edwin Hubble determined that there is a relation between the distance of various galaxies and their radil velocity, derived from the Doppler shift of absorption lines in the spectrum of the galaxies. The spectral lines appear red-shifted for all galaxies. This result is very significant: all galaxies are moving away from us.

The amount of red shift in the absorption is proportional to the distance of the galaxy. The relation, known as Hubble's Law, is given by

$$\upsilon = Hd \qquad \textbf{(3-2)}$$

where υ is the radial recession velocity, d is the distance, and H is the Hubble constant. Current best estimates of H are around 65 km/s/Mpc. Note that the units of H are actually inverse time. The only galaxies that deviate from Hubble's Law are those so close that gravity dominates their behavior (8,9,13).

Figure (3-1) explain Hubble's law



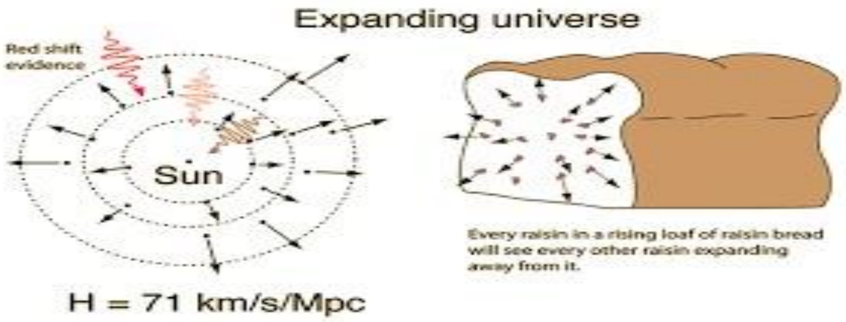
(3-3) Hubble's Law and the Expansion of the Universe

If the galaxies are just moving randomly through space, some near ones would move rapidly and some distant ones would move slowly. About half as many would approach as recede. The fact that all the galaxies are moving away from us does not mean that we are in a special place in the Universe (8,12) .

Hubble's Law could be measured at any location in the Universe, with the same result. This means that space itself is expanding, because the more distant the galaxies are, the faster they are moving away.

A two-dimensional analog is the surface of an expanding balloon. If you blow up a balloon part way, and mark little dots on it to indicate galaxies, then continue to blow it up, you will find that the distance between the dots that were most separated increased more than the distance between dots that were close together.

In the same way, more distant galaxies move away faster, and so we know that the space in between grew. Fortunately, there is more evidence than simply the Hubble Law, and this evidence has con- vinced astronomers that the Universe is expanding (8,9,13). **Figure (3-2) expanding universe**



(3-4) Hubble’s Law and the Age of the Universe

According to Hubble’s Law, the recession velocity v divided by the distance d is equal to the constant 1/*H*, the same for all galaxies. The ratio v/d gives the time it took for the Universe to expand to the present state. This implies that 1/*H* is the age of the Universe.

An important assumption in this estimate is that the rate of expansion is constant. The gravitational interaction between galaxies would tend to slow down the expansion. On the other hand, observations of Type Ia supernovae in very distant galaxies indicate recession speeds lower than predicted by Hubble’s Law. But for very distant galaxies, the measured speed corresponds to their speeds in the distant past when the observed spectrum was emitted (,13,14,15).

(3-5) The Big Bang

One implication of Hubble's Law is that the entire Universe was once much denser than it is now, so that all the mass was much closer together. But Hubble's Law is not the only piece of evidence.

1. The Universe contains mass, and gravity is the only force acting on the large scale of distances, and tends to pull mass together. This observation implies that at least one of three things is true:

(i) The Universe is of finite age. Gravity hasn't had enough time yet to collapse the Universe.

(ii) The Universe is infinite in extent. There's no center for all of the mass to fall to.

(iii) The Universe is expanding faster than its own escape velocity. All the galaxies have enough speed to overcome their mutual gravitational attraction.

2. The infinite Universe, the night sky ought to be as bright as the day.

(i) The Universe is of finite age. Light hasn't had enough time yet to get here from the most distant places.

(ii) The Universe is of finite extent. There aren't actually enough objects out there to fill up the sky.

(iv) Stars are a ‘‘new’’ phenomenon. The Universe only recently started to produce light.

The Universe is expanding. This implies that

(i) The Universe is of finite age.

(ii) Because we can measure this, we know that 1(iii) and 2

(iii) above are incorrect Universe does not have a ‘‘center,’’ whether or not it is infinite.

Note also that this means that there is no ‘‘outside.’’

1. There is no center. The Universe is not expanding ‘‘away’’ from anything.

2. There is no ‘‘before.’’ Time began at the Big Bang.

3. The Universe is not expanding ‘‘into’’ anything. Space is created by the expansion of the Universe (13).

Reference :-

1. David Griffiths (2008). Introduction to Elrmrntary Particles, particle, Second Edition, printed in the Fedral Repubic of Germany.

2. W. N. Cottingham and D. A. Greenwood (2001). The Standard Model of Particle Physics, Second Edition, published in the Unite State of America by Cambridge Univeristy Press.

3. Peter J. Nolan (2014). Fundamental Particle of Modern Physics, First Edition, printed in United state University of New –York Farmingdale.

4. Alessandro Bettini (2012). Introduction to Elementary Particle Physics, Second Edition, printed in United Kingdom by MPG Books Group.

5. Williom B. Rolink (1994). The Fundamental Particle and Their Interaction, First Edition, printed United State of America.

6. Paul A. Tipler and Ralph A. Llewellyn (2008). Modern Physics, Fifth Edition, printed in United States of America.

7. H. Kavttunen & P. Kroger & H. Oja & M.Poutanen & K.J. Donner (2007). Fundamental Astronomy, Fifth Edition, Printed springer Berlin Heidelberg New York.By McGraw-Hill Companies (2008). Astronomy, Printed in United stated.

8. By McGraw-Hill Companies (2008). Astronomy, 2007 Edition, Printed in United stated.

9. STACY E. PALEN (2002). Theory and Problems of Astronomy, second Edition, Printed in United States.
10. John D. Fix (2008). Astronomy, Fifth Edition, Printed in United States.
11. Michael A. Seeds (2008). Foundation of Astronomy, Tenth Edition, Printed in United States.
12. John F. Hawley & Katherine A. Holcomb (2005). FOUNDATION OF MODERN COSMOLOGY, Second Edition, Printed in Great Britain.
13. F. Combes & P. Boisse & A. Mazure & A. Blanchard (1998). Galaxies and Cosmology, Second Edition, Translated by Mark Seymour.
14. P.J.E. PEEBLES (1971). Physical Cosmology, First Edition, Printed by Princeton University Press.
15. Mitchell A. Berger(2004). Cosmology, First Edition, Printed by Mathematics University College London.