

Search for Essential Constituents of Matter Through Methods of Particle Physics: Quantum Theory of Gravitation Leading to Unified Force Theory

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Abstract

The idea that universe is constituted of a few fundamental substances haunted the human history from earliest of times. Philosophical description of these as earth, water, fire, air and space could not satisfy the urge of scientists who tried to find a scientific description of these essential components.

At the dawn of the twentieth century, some such particles were recognized which are electron, proton and neutron. At this time Dirac combined special theory of relativity with quantum mechanics and derived the notion of anti-particles. High energy physics extended the number of constituent particles and their interactions as per Standard Model to weak, quantum electro dynamics (QED), quantum chromo dynamics (QCD) and strong interaction. It is particle physics which definitely showed the role of quantum force as the attractive force between unsymmetrical objects.

Big Bang theory of evolution of the universe was found to be inadequate for explaining the binding force of the universe. Alternative theory based on rotation and revolution of energy plasma was found suitable for the formation and binding of the universe.

Here it is shown that gravitation and gravity are the effect of quantum forces in different degrees which bind matter by push-in forces from outside and gravity is the faintest reminiscence of gravitation. This idea finds support from particle physics to solve the misconception of gravity as attraction between matter and the failure of Einstein's search for a unified field theory.

Finally, it is established that high energy physics and particle physics cannot reach so high an energy that prevailed in the early stage of the formation of the universe. However, finding ultimate particles is not solved till today.

Key words: Quantum mechanical basis for gravitation and gravity, High energy physics; Particle physics, Failure of Newton's theory, Alternative theory of creation of universe

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Introduction

Ancient Indian philosophers regarded five fundamental elements (*Panchbhutani*) viz., Earth (*Kshiti*), Water (*Aup*), Fire (*Tej*), Air (*Marut*) and Space (*Vyom*) as the ultimate constituents of all material objects. The first four were accepted by Aristotle (394 -322 BC) and the Space was considered by Einstein as the source of interconversion of field and matter. The scientists were not contented with these philosophical descriptions of fundamental particles as a result of which intense scientific search was made by European researchers. Three particles viz., electron, proton and photon were definitely recognized by the beginning of the 20th century. At this time, Einstein proposed his revolutionary special theory of relativity and quantum mechanical description of motion replaced Newtonian classical mechanics. Pauli advanced his theory of spinning electron and in 1932 Chadwick discovered neutron as a fundamental particle.

In the meantime, the British physicist P.A.M. Dirac attempted to combine the time independent basic principle of quantum mechanics with Einstein's special theory of relativity. Dissatisfied with the ad hoc nature of Pauli's principle of electron spin which is not naturally occurring along with n, l, m as quantum numbers and the non-classical concept of orbital motion and spinning of electron, Dirac made some bold propositions which were considered initially as the craziest of ideas. He proposed that:

- a) The idea of vacuum, filled with ether should be replaced by electrons
- b) The nucleus of an atom is imbedded in anti-particles of electron, proton etc.
- c) The spin and revolution of electron is a non-classical idea.
- d) There is anti-particle for each and every fundamental particle of the universe.

Dirac converted time independent Schrödinger equation into a form which could be solved for 4×4 matrix elements and imposing time dependency finally obtained 4 solutions [1]. Two of these solutions could be related to spin of electronic motion and the other two to

particle and anti-particle pair. Thus, spin became a non-classical description automatically produced without any ad hoc assumptions and the corresponding wave functions and their eigen values fully agreed with experimental observations of the fine structure of hydrogen spectrum.

Although initially Dirac's ideas were considered as crazy, soon came experimental evidences directly from

1. Observations of Carl Anderson [2] of the presence of positron or a positive electron.
2. Support also came from "vacuum polarization" [3] which recognizes slight change in electronic energy of hydrogen atom as well as deviation of magnetic moments of electrons which were carefully measured and gave expected results. Pair production and annihilation of electrons and positrons were observed for electrons with 1.02 MeV or more of energy.

Scientists were next interested if along with the lines of electron and proton, anti-proton or anti-neutron could be discovered. As the mass of proton is 1840 times more than that of electron, much higher energy would be required to produce this particle which was achieved by bombarding proton with 6.2 GeV atomic projectiles. The anti-particle of neutron as anti-neutron (also uncharged) was discovered, which could be identified by their mutual annihilation ability.

The particle neutrino with zero mass and zero charge (like photon) was suspected in β - emission from a single radioisotope which shows wide energy spread (from zero to a very high value). This violates the conservation of energy and momentum. This particle was suggested by Pauli in 1936 which carried the energy and the spin. This was indirectly shown by Cowen [4,5] for the reaction $p + \nu = n + e^+$. In 1935, Yukawa [6] suggested that nuclear binding force arises from the exchange of the particle of 200 electron mass. In 1947, Anderson discovered muons (μ^+ and μ^-) from cloud chamber photograph of cosmic radiation but these were rejected after further investigations. The pions (π^+ π^0 π^-) were discovered from cosmic radiations.

The known elementary particles up to 1947 are classified according to their mass/energy, charge, spin and helicity or spiral-ness. Particles of small mass are called Leptons which include electron, positron and their anti-particles of zero mass. Then there are heavier masses called mesons which are intermediate in mass between Leptons and Baryons (higher mass). The anti-particles are defined as having similar characteristics as particles but different in charge arising from their difference in helicity. We depict different particles and anti-particles according to their definition (Table I).

A few characteristics are notable in Table 1. Anti-particles are all produced by reflection in two dimensions. These are produced by double type of reflection which is called double inversion quite distinct from inversion operator (i) which indicates $f_{(xyz)} \xrightarrow{i} f_{(-x-y-z)}$.

In case of electron (e^-) converting to positron (e^+), it is seen that no electron with zero charge (e^0) is indicated. For all other particles (mesons and baryons) the zero charged particles are defined. It is expected that a positive (+) and negative (-) on combination will produce two particles of zero charge. This is not possible due to annihilation.

For π and k-mesons there is no problem, for both π^0 and K^0 are defined. In case of π -meson, the mass of π^- is equal to that of π^+ meson which is greater than π^0 as electromagnetic field accounts for a portion of the mass. The nuclear field is much greater, so both the π -mesons include the nuclear field with negligible contribution from the electromagnetic field (this is also supported by their decay scheme).

The mass of K^0 is higher than those of K^+ or K^- . Here the higher electromagnetic field (arising from decay scheme) is to be subtracted from the nuclear field.

Table 1: List of Lighter Particles and their Anti-particles

Class	Name	Symbol	Mass/e	Charge	Spin $h/2\pi$	Stability	Decay	Double Inversion
Leptons	Electron	e^-	1	-1	$\frac{1}{2}$	Stable		
	Positron	e^+	1	-1	$\frac{1}{2}$	Stable		
	Neutrino	ν	0	0	$\frac{1}{2}$	Stable		
	Anti-neutrino	$\bar{\nu}$	0	0	$\frac{1}{2}$	Stable		
	Photon	γ	0	0	1	Stable		
Mesons	Pi minus	π^-	273.2	-1	0	2.6×10^{-8}	$\pi^- \rightarrow \mu^- + \bar{\nu}$	
	Pi plus	π^+	273.2	+1	0	2.6×10^{-8}	$\pi^+ \rightarrow \mu^+ + \nu$	
	Pi zero	π^0	264.2	0	0	2.2×10^{-10}	$\pi^0 \rightarrow 2\gamma$	
	K minus	K^-	966.5	+1	0	1.2×10^{-8}	$K^- \rightarrow 2\pi^- + \pi^+$	
	K plus	K^+	966.5	-1	0	1.2×10^{-8}	$K^+ \rightarrow 2\pi^+ + \pi^-$	
K zero	K^0	974.2	0	0	1.0×10^{-10}	$K_0^1 \rightarrow \pi^- + \pi^+$		
Anti-K zero	\bar{K}^0	974.2	0	0	0.1×10^{-8}	$K_0^2 \rightarrow 3\pi^0$		
Baryons	Proton	p^+	1836.12	+1	$\frac{1}{2}$	Stable		
	Anti-proton	p^-	1836.12	-1	$\frac{1}{2}$	Stable		
	Neutron	n	1838.5	0	$\frac{1}{2}$	1.0×10^3	$n \rightarrow p + e^- + \bar{\nu}$	
	Anti-neutron	\bar{n}	1838.5	0	$\frac{1}{2}$	1.0×10^3	$\bar{n} \rightarrow p + e^- + \nu$	

In case of baryons, particularly for proton (p^+) the case is interesting, as the anti-particle p^- is defined by double reflection of p^+ , we arrive at n^0 and its anti-particle, anti-neutron is also defined. Thus, we see here a case where quadruple of nucleons is possible contrary to quantum mechanical principles where proton and neutron are assumed to be of same particles in two different guises.

High Energy Physics

Since 1947, with the help of high energy particle accelerators, a whole array of new particles was discovered which revealed that the fundamental particles are not stable and undergo continuous creation and destruction. Positron and electron are produced by the collision of cosmic rays with stationary targets. When electron and positron collide, they annihilate to produce two (or more) γ - rays. Behavior of other particles are similar to this. Thus, high energy physics led to the production of anti-neutron, anti-proton etc.

Classification:

These fundamental particles were initially classified according to their mass viz., leptons (small mass), mesons (intermediate mass) and baryons and hadrons (heavy mass). Further classification was made according to their electrical charges, spin, iso-spins and strangeness. These particles have also been classified depending on their interactions. For example, baryons and hadrons show strong interactions. Leptons have weak interaction; neutral particles show negligible interaction and weak interaction is responsible for β - decay. Surprisingly, gravitational interaction was considered to be of no significance. These interactions are guided by some conventional laws. Classical laws control energy, charge, momentum and angular momentum while non-classical laws control baryons number, iso-spin, parity and strangeness.

Claims of discovery of over one hundred fundamental particles in the last quarter of the 20th century, strongly suggest that not all these particles are truly fundamental. A proposal was

made by Gell-Mann [7] that a lower level of particles is to be sought (quarks) with fractional charges ($+ \frac{2}{3}$ and $- \frac{1}{3}$ of electron charge). Curiously enough, presence of such particles was anticipated by Anne Basant and Leadbeater [8] in 1908. Initially there were three quarks with up, down, and strange designated as u, d and s and their anti-particles as \bar{u} , \bar{d} , \bar{s} . Altogether six quarks are registered. These along with their characteristics are tabulated in (Table 2).

Modern theory which is usually referred to as STANDARD MODEL attempts to explain all the phenomena in terms of properties and interactions of three distinct type of particles – two spin $-\frac{1}{2}$ families of fermions called leptons and quarks and one family of spin 1 boson called *gauge* boson which acts as “force carrier”. In addition, there is one spin 0 particle called *Higgs* boson to explain the origin of the masses. All the particles are elementary without internal structure or excited states [9].

Leptons and anti-particles

One of the 3 classes of fundamental particles in standard model with spin $-\frac{1}{2}$ fermion indicates weak interaction. There are six known leptons which occur in pairs called *generation* written as doublets:

$$\left(\begin{array}{l} e^- \\ \text{chg} = (e^-) \\ \text{electron neutrino} \\ \text{chg} (0) \end{array} \right) \quad \left(\begin{array}{l} \mu^- \\ \text{muon or} \\ \text{mu lepton} (e^-) \\ \text{mu - neutrino} \\ \text{chg} (0) \end{array} \right) \quad \left(\begin{array}{l} \tau^- \\ \text{tauon or} \\ \text{tau lepton} (e^-) \\ \text{Tau neutrino} \\ \text{chg} (0) \end{array} \right)$$

where charges e^- , μ^- and τ^- are the electron, μ -lepton and τ -lepton respectively. Associated with these three neutral leptons are electron-neutrino, mu-neutrino and tau neutrino.

Table II: Quarks, Anti-particles and their characteristics:

Name of Particle	Symbol Quarks	Approx. Mass (GeV/c ²)	Electric Charge Q	Baryon number B	Strangeness S	Charm C	Bottom B	Top T
Down	<i>d</i>	0.3	-1/3	1/3	0	0	0	0
Up	<i>u</i>	0.3	2/3	1/3	0	0	0	0
Strange	<i>s</i>	0.5	-1/3	1/3	-1	0	0	0
Charmed	<i>c</i>	1.5	2/3	1/3	0	1	0	0
Bottom	<i>b</i>	4.5	-1/3	1/3	0	0	-1	0
Top	<i>t</i>	174	2/3	1/3	0	0	0	1

Name of Particle Baryons	Symbol Quark Composition	Approx. Mass (MeV/c ²)	Electric Charge Q		Strangeness S	Charm C	Bottom B	
<i>p</i>	uud	938	1		1	0	0	
<i>n</i>	udd	940	0		0	0	0	
Λ	uds	1116	0		0	0	1	
Λ_c	udc	2285	1		1	1	0	
Λ_b	udb	5624	0		0	0	1	

Name of Particle Mesons	Symbol Quark Composition	Approx. Mass (MeV/c ²)	Electric Charge Q		Strangeness S	Charm C	Bottom B	
π^+	$u\bar{d}$	140	1		0	0	0	
K^-	$s\bar{u}$	494	-1		-1	0	0	
D	$d\bar{c}$	1869	-1		0	0	0	
D^-	$c\bar{s}$	1969	1		1	1	0	
B^-	$b\bar{u}$	5279	-1		0	0	-1	
γ	$d\bar{b}$	9460	0		0	0	0	

In addition, there are three anti-leptons:

$$\begin{bmatrix} e^+ \\ \bar{\nu}_e \end{bmatrix} \quad \begin{bmatrix} \mu^+ \\ \bar{\nu}_\mu \end{bmatrix} \quad \begin{bmatrix} \tau^+ \\ \bar{\nu}_\tau \end{bmatrix}$$

The charged leptons interact both with electromagnetic and weak interaction while uncharged leptons interact only with weak interaction.

Quarks and Hadrons

Strongly interacting particles are called quarks and their bound states are called Hadrons. Weak and electromagnetic interactions are smaller in comparison to the strong interaction. Although only three quarks are initially proposed, six are now known to be existing like leptons. There are six types (colours) occurring in pairs:

$$\begin{bmatrix} u \\ d \end{bmatrix} \quad \begin{bmatrix} c \\ s \end{bmatrix} \quad \begin{bmatrix} t \\ b \end{bmatrix}$$

Each generation consists of a quark of charge of $+2/3$ (u c t) together with quarks of charge $-1/3$ (d s b) in terms of e^- . These are called down, up, strange, charm, bottom and top quarks. The corresponding anti-particles are defined as:

$$\begin{bmatrix} \bar{u} \\ \bar{d} \end{bmatrix} \quad \begin{bmatrix} \bar{c} \\ \bar{s} \end{bmatrix} \quad \begin{bmatrix} \bar{t} \\ \bar{b} \end{bmatrix}$$

with charge of $-2/3$ ($\bar{u} \bar{c} \bar{t}$) and $+1/3$ ($\bar{d} \bar{s} \bar{b}$) in units of e^- .

Despite many attempts, free quarks were never been observed. Approximate quark masses are inferred from the observed masses of their hadron bound states.

Strong interaction in the standard model is called quantum chromo dynamics (QCD). This is similar to quantum electro dynamics (QED) in that both describe interactions mediated by spin 1 boson of zero mass to conserved charges. These are called *gauze* invariance with characteristic symmetry. In QED, *gauze* bosons are photons. In QCD, these are called gluons.

While photons that couple to the electric charge are themselves neutral, gluons have non-zero values of the colour charges to which they couple.

Before considering the impact of high energy physics and particle physics on the possible search of fundamental particles, it is necessary to consider the cosmological theory (Big Bang) and the alternative [10] theory of evolution of the universe.

Cosmological theory:

In cosmological theory of evolution, spatio-temporal singularity is described as having spatial dimension of the order of 10^{-33} cm, temporal dimension of the order of 10^{-43} sec and matter density of the order of 10^{93} gm /cm³.

Einstein rejected singularity as a mathematical point from which the universe emerged but he accepted the presence of super-dense matter. It was believed that some twenty billion years ago the super-dense matter exploded. The matter then changed to a highly dense high temperature plasma which converted to particles and anti-particles. These were subjected to annihilation and as the temperature fell, a number of excess nucleons and electrons were produced. Later, formation of lighter elements like Hydrogen and Helium and still later heavier chemical elements emerged. During further expansion of matter and decrease of temperature galaxies and stars came into existence.

This version of the cosmological theory of evolution of the universe from spatio-temporal singularity leaves many a question unanswered viz., how the super-dense matter was formed, how it suddenly changed to a plasma, how on cooling the plasma condensed into different substances. Even if the sequence of formation of the matter, anti-matter, nucleus, electrons, element like H or He or heavy metals are accepted, none of them are accepted as the ultimate constituents of the universe. Moreover, it cannot explain the binding force of galaxies and stars and also the stability of the universe. So, on the whole the theory appears to be improbable, impossible and as best it can be considered as illusory.

Alternative theory:

According to the alternative theory of the evolution of the universe proposed in an earlier communication [10], the super-heated plasma (4th state of matter) at a temperature of $\sim 10^8\text{K}$ and above was in a state of violent rotation and revolution. At that time, matter was devoid of any symmetry. This resulted in a very highly pressing gravitational force which is particle (quantum) based and guided only by quantum laws. It is believed that the formation of the universe was completed in about half an hour time. It indicates that formation of stars and galaxies also resulted from gravitation. The attractive force between nucleons QCD (Quantum Chromo Dynamics) and QED (Quantum Electro Dynamics) took place leaving very faint residual force of attraction for leptons and for β -activity. Ultimately, gravitation is a spent force which has done its duty in the formation of the universe, creation of its constituent matter and passed into oblivion with little chance of reappearance during the lifetime of present heliocentric universe.

A clear distinction is to be made between the gravitational force predicted by Newton (gravity) and the force deduced from the result of the high energy physics in the last century. Newton's interpretation of gravitation was based on the conclusion that this is an attractive force between the objects of the universe. Every object is attracting every other one and this was accepted as infallible. Under the impression of this definition, Einstein failed to unify the forces into a compact theory even after trying for 8 years. Weak gravitational force could not be brought under quantum theory for which unified field theory remained unsolved.

Particle Physics

By following the methods of particle physics which is based on high energy physics, it has been possible to see that gravitational force is a quantum force in nature. This is in fine agreement with the alternative theory of evolution of the universe proposed in an earlier communication [10].

This force led to the formation of stars, galaxies and everything within the universe and the forces make the present universe stable. This force is utilized in the initial stages of the generation of the universe. It is also used up in providing the attractive force between nucleons (QCD) and electromagnetic force (QED). A very weak residual force remains in weak interactions between leptons. Thus, the gravitational force is completely used up so that no trace of fundamental particle could be derived or imagined. This picture of gravitational force fits the bill of all counts and does not contradict any accepted theories.

As we pass from low energy to high energy physics, we go down to lower depths and as the symmetry decreases we pass from a weak QED to QCD, where the realm of wave mechanics ends. We then pass to particle (quantum) physics. Particle physics is an independent subject by its own right and its methodology is based on terse quantum mechanical calculations. Our interest is to examine whether the particle physics can throw some light in the prediction of ultimate fundamental components by which the universe is supposed to be created. We make a very brief description for the technique of particle physics in which unsymmetrical objects are treated by quantum mechanics.

The presence of particles and their anti-particles are necessary consequence of combination of special theory of relativity with quantum mechanics as shown by Dirac in his relativistic wave equation. Interactions among elementary particles are shown in the particle physics by using Feynman diagram and Hole formalism. These are shown in Fig. I along with different types of scattering and exchange of particles – although this is not an exhaustive list [9].

High symmetry is mainly a property of macroscopic system. A sphere in three dimension shows infinite numbers of symmetry elements. As we go down, the symmetry also decreases and at the stage of QED and then to QCD stage only a single symmetry remains. Further down we see no symmetry and the whole attraction is governed by quantum properties.

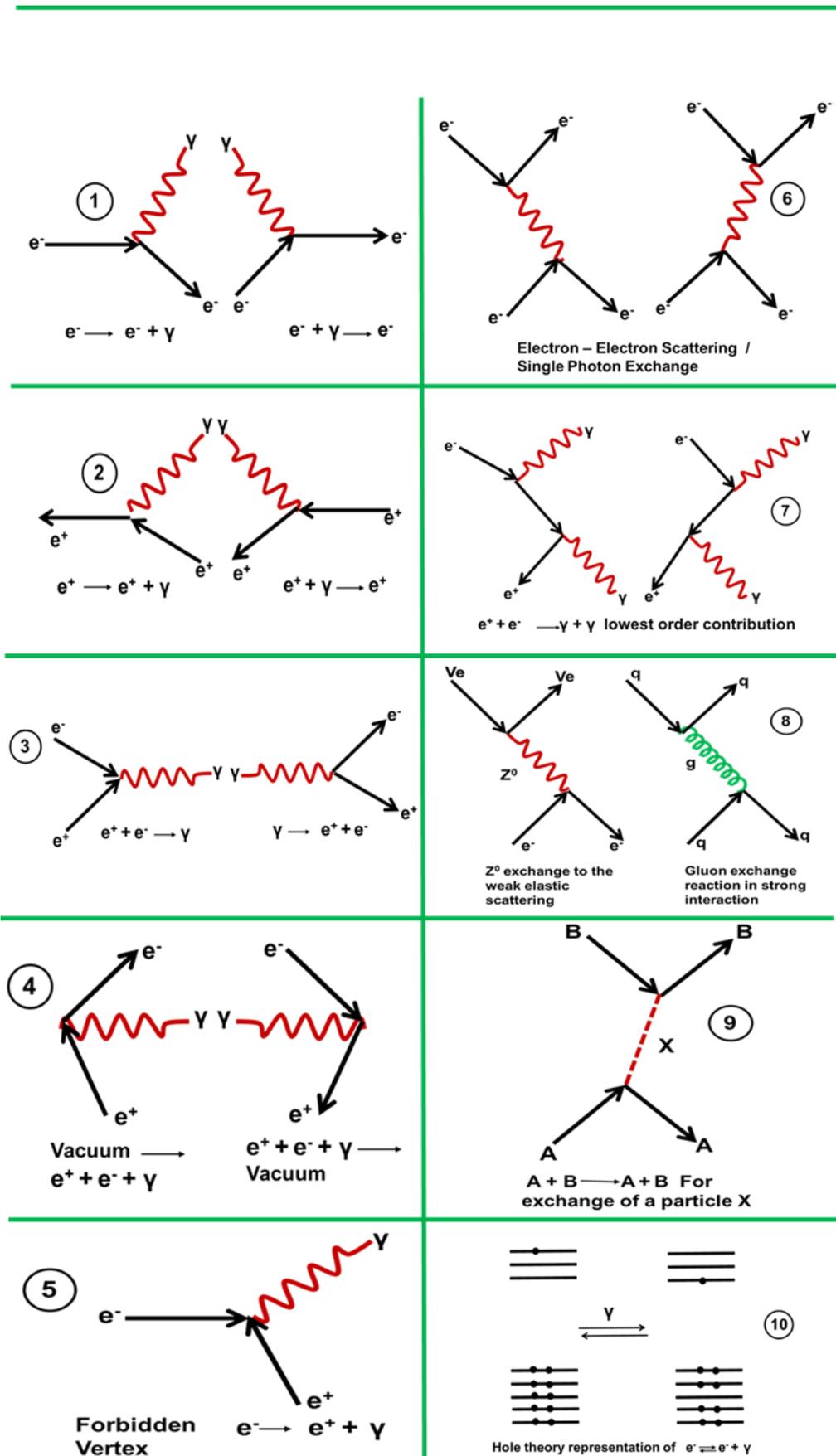


Fig. I: Feynman Diagram [Time Flows from Left to Right]

Gravitation is the most powerful quantum mechanical conglomerating force which is responsible for the creation of the universe. It is also the binding force of the universe from which originated all other types of interactions. They are nothing but different manifestation of quantum mechanical force.

From symmetry consideration, we can arrange the strength of the interactions in the following order:

Gravitation along with gravity > QED > QCD > weak interaction between leptons and β - decay process.

This order is also supported by the consideration of decrease of energy along the order. Gravity is the manifestation of a weak force between planets since the force of gravitation is mostly used up.

This description of the gravitational force and its reminiscence as gravity found support from the study of high energy physics where Seiden [11] writes “We might ask about the role of the unstable particles, the heavier leptons and quarks. Has nature just been generous with the number of possible families, or have they been crucial in the evolution of the universe? *They are like dinosaurs, remnants of an earlier age* – in this case the very early universe where temperature was huge enough to produce these objects....” “The very heavy top quark may have some special role in mass generation, in any case its very heavy mass may carry a message we do not yet understand. These kinds of questions along with whether there is a deeper relationship of the several interactions to each other (and finally gravity) are some of the exciting forefront questions in particle physics”.

It appears that Seiden hit the nail at its head although not exactly knowing the nature of gravitational force. Indeed, the nature of gravitational force, particularly the very small (negligible) binding force present in gravity in comparison to other forces was intriguing to all particle physicists [9][11-13] . This is due to the mis-interpretation of the gravitational force in

the theory of Newton which has been discussed in a previous communication [10]. Actually, gravitational attraction is the strongest of all interactions and this force is responsible for the formation and binding of the universe. Figure II depicts the inter-relationship of gravitation, gravity, QED, QCD and weak interaction.

Conclusion

- 1) Gravity is nothing different from Gravitation. It is the faintest residue of Gravitation. Misconception about gravity originated from the erroneous interpretation of Newton about mathematical vector to which Newton assigned cause while it actually indicates effect. Gravitation and gravity are both push-in forces from outside. There is no existence of gravity as an attractive force.
- 2) Moreover, gravitation and gravity, both of which resulted from quantum mechanical force are pushing-in matter in asymmetric (symmetry-less) states. This at once explains [14] the failure of Einstein to derive a unified field theory in spite of long search.
- 3) Forces of interaction between masses can be correctly arranged according to their strength as:
gravitation (and gravity) > QED > QCD > weak forces (leptons) and β - activity. This explains all the properties and justifies the alternative theory of evolution of the universe by implosion [10] of plasma state of matter.
- 4) Thus, the hope for finding the ultimate constituents of matter does not seem possible because high energy physics has not been able to reach the energy present at the start of the universe. At present high energy physics cannot reach 10^{-17} cm with 200 GeV which is the distance between the nucleons guided by QCD. With the attainment of the TeV energy new idea might be expected.

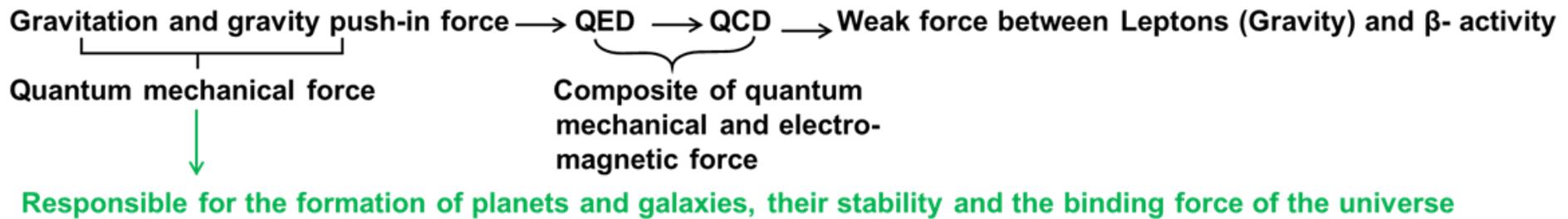
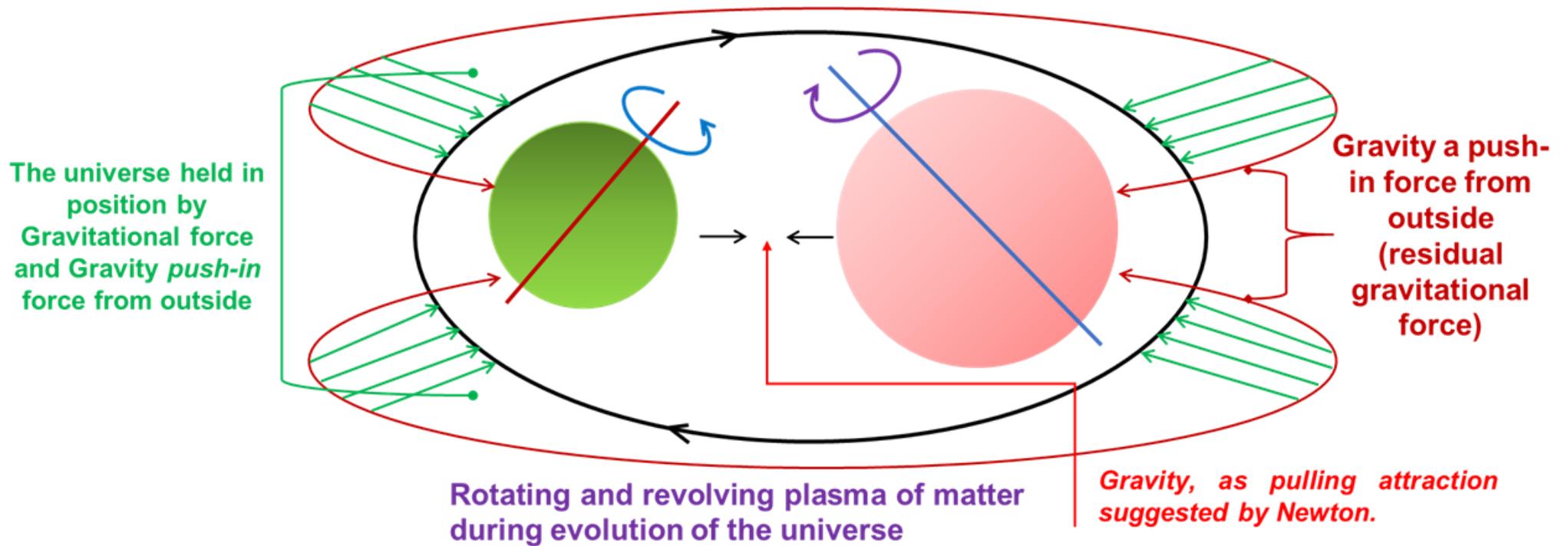


Fig.II. Gravitation, gravity, QED, QCD and their interrelationship
a simplified diagram involving only two planets

5) It has been possible to find out the real nature of gravitational force and gravity as originating from quantum mechanical force. However, for the identification of essential components of matter we must wait for a breakthrough (conceptual/experimental) from future scientists. We are now therefore back to square one in the region of the *terra incognita*.

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