The Geometry of Space-Time

The relation between the largest and the smallest components of the Universe and their relation to a negative gravitational field.

By

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ABSTRACT

The theories of General Relativity and Quantum Physics have both been immensely successful in describing the forces of nature in respect of both the very largest and the very smallest components of the universe and yet all attempts to unify the two theories have so far come to nothing. Some say it may not be possible to unify the forces and that gravity is not amenable to quantization. Others say that quantum theory is itself not a complete description of the world.

Obviously it is not possible to construct a "theory of everything" without including everything in it and therefore I propose that the forces of nature must be considered as a single coherent unit before such a theory can be formulated.

One of the principle barriers to formulating a theory of everything is the seeming incompatibility between gravitation and the other forces of nature and it would seem that to overcome this problem a new physics is required and this is the approach taken in this paper at both the large and small scales of nature. It will be shown that by introducing new aspects to gravitational theory and by applying similar ideas to the quantum world that in fact gravitation and quantum theory can be unified. Also will be shown that the dimensions and geometry of space-time are the product of a negative gravitational force which is manifested at both the quantum and the macroscopic scales.

Introduction

Are not gross bodies and light convertible into one another-------and may not bodies receive much of their activity from the particles of light which enter their composition?   Sir Isaac newton –Opticks 1704.

The changing of bodies into light and light into bodies is very conformable to the course of nature which seems delighted with the transmutation. Sir Isaac Newton – Opticks 1718.

This paper is a summary of several unpublished papers of my own which have been written or formulated over the last 25 years or so.

The work so far undertaken started out as an attempt to go some way to unifying the Gravitational force and Quantum theory.

Like many others who have travelled this path before, I cannot say that I have been entirely successful in this quest--indeed I would go so far as to say that it may be that the so-called Theory of Everything does not exist These are not questions that I shall be addressing in this paper. The questions that will be addressed are principally 1/ The Collapse of the Wave Function and 2/ The Large and Small scale structure of the Universe and their relation to each other and 3/

to propose a new view of gravitational theory and to relate that theory to quantum mechanics.

It seems to me that none of these questions can be answered in isolation but rather any attempt to address them needs to encompass very many different aspects of Physics because after all, these phenomena are all part of the universe as a whole and it is not unreasonable to think that many phenomena, being part of the whole, should be mutually influential. That is to say one cannot consider one particular phenomenon without considering the influence of other states of matter upon it. It is for this reason that I have included the well known quotations from Isaac Newton which head this introduction and as well as predicting the well known mass / energy transformation, it seems to me that Newton was also aware of the possible inter-changeability and mutual influence of other physical factors including mass and the geometrical scale of the universe. That anyway is the starting point of this paper.

I begin by first addressing the large scale structure of the universe and by describing a state whereby the Weyl tensor equates to zero, that is to say there must be a general description of a gravitational field where tidal distortion is non-existent and the field is symmetrical at all points in space. Such a description leads to the inevitable conclusion that the introduction of the cosmological constant (the lambda Λ factor) is part of the correct description of the large scale structure of the universe and from which, as will be shown, can be obtained an accurate value for Hubble's constant.

At first sight this may seem to be a strange approach by which to include the state vector reduction and other matters in quantum physics into the equation so to speak, and even stranger still when I say that I am led to conclude that the numerical relationship between the largest and smallest structures is of a very intimate nature and I pursue this theme very much along the lines already proposed by Sir Arthur Eddington and Professor P.A.M. Dirac. Indeed I have drawn very heavily on their work particularly in the use of dimensionless numbers which, though fairly unconventional, does provide some interesting outcomes.

Finally, I cannot stress strongly enough that very little of the detail of this work is my own or is original in any way. The originality, if any, is manifest in my attempt to pull together various disparate strands of conjecture in an attempt to create a coherent whole. A list of reference sources appears at the end of this paper and it is my sincere belief that I have fully acknowledged the use of those sources. If I have not, then I apologise for any omission of acknowledgement that may have occurred. Additionally and very importantly I fully acknowledge and make no attempt to deny that some passages in my text are quoted verbatim from the work of others since there seems little point in attempting to disguise the work of others as being my own. However, that being said, I must point out that this work was largely inspired by the publications “The Emperor’s New Mind” and “Shadows of The Mind” by Professor Sir Roger Penrose and by “The Accidental Universe” by Professor P.C.W Davies. Additionally the works of Bondi, Moryiasu, Rae and Sciama are worthy of special mention.

CONTENTS

Chapter 1

Negative Gravitation

This chapter describes the expansion of the universe as being the result of a negative gravitational field that is to say a field which repels rather than attracts

As the starting point of this monograph I will begin with the conditions where the tensor Weyl = 0 and the tensor Ricci = ∞ as it is from this hypothesis that further ideas can be developed which will include an investigation into the state vector reduction (or collapse of the wave function) and the application of the de Broglie –Bohm theorem. This will then lead us on to a further hypothesis which I will call gravitational electrodynamics (for want of a better title) and will subsequently lead to the inclusion of quantum coherence into general gravitational theory.

The full expression for the curvature of four dimensional space time is written in terms of the Riemann curvature tensor which itself is split into two parts, the Weyl tensor and the Ricci tensor. (Ref.26).

The Weyl tensor measures the tidal distortion and the Ricci tensor measures the the change in volume of a body in a gravitational field. The tidal effect is produced because the gravitational field is directional, that is to say it is operating in one direction only. (Ref.25). Thus for the Weyl tensor to be equal to zero the field must be one which operates uniformly in all directions at the same time. The best way to describe such a situation is to imagine a body placed in the centre of a spherical field which is acting on all parts of the body at the same time and in all directions thus there is no directional tidal effect producing a distortion in the shape of the body. There is however an increasing rate of acceleration through successive "layers" of the body as one moves from the centre of the body towards the outer "shell" of the body. This proposition can best be described by resorting to the equations of Gauss's Law by treating the universe as a whole, not exactly as a solid but as a body whose mass is uniformly distributed throughout its structure and for the sake of this exercise we can treat the universe as a solid body rather than as the dynamic expanding body which it actually is thus we can state that:-

"The gravitational flux for an arbitrarily closed surface is equal to the net mass enclosed multiplied by *g"* i.e.:-

$$\phi = \oint g.dR = \oint gdR = g\oint dR = g(4\pi r^2) \qquad \text{Equ.1.}$$

that is to say, treating the universe as a sphere the flux is a product of the gravitational force and the area of the sphere. Now Equ. 1. is derived from

$\phi = \frac{\Sigma m}{G}$ or $\oint g.dR = \frac{\Sigma m}{G}$ where G = gravitational constant and m = mass of the universe. The integral $\oint dR$ is the surface area of the universe $4\pi r^2$. By using symmetry arguments we can determine g at any point inside a uniform spherical distribution of mass M and radius R_0 by using spherical Gaussian surfaces with the same centre as the mass distribution. To find the field g inside the mass distribution we use a Gaussian surface whose radius is less than the radius of the mass distribution i.e. $R<R_{0}$. The expression for the flux of the surface is again $\phi = g(4\pi r^2)$. The mass contained within the Gaussian sphere depends on the radius R of the sphere. If we let ρ represent the mass density of the Gaussian sphere and M represents the total mass of the sphere and is given by $\frac{4\pi R_0^3}{3}$ then we can say that :- $\Sigma M = \rho\frac{4\pi r^3}{3} = \frac{M}{{}^4/_{3\pi R_0^3}}\ \frac{4\pi R^3}{3} = M\frac{R^3}{R_0^3}$. Gauss's Law $\phi\frac{\Sigma M}{G}$

for this case is $g(4\pi R^2) = \frac{M\frac{R^3}{R_0^3}}{G}$ and solving for g gives:-

$$g = \frac{MR}{4\pi G R_0^3} \qquad (R \leq R_0) \qquad \text{Equ.2}$$

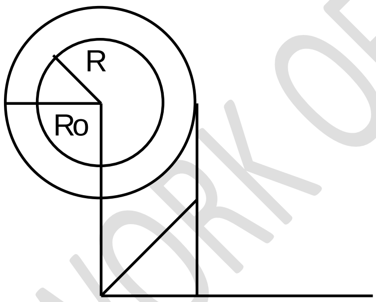

Fig. 1.

i.e. the gravitational field increases linearly with g at points inside the sphere as shown in fig.1 above and this equates to a negative gravitational field as far as a particle inside the sphere is concerned.

Referring now to Fig.2 below :-

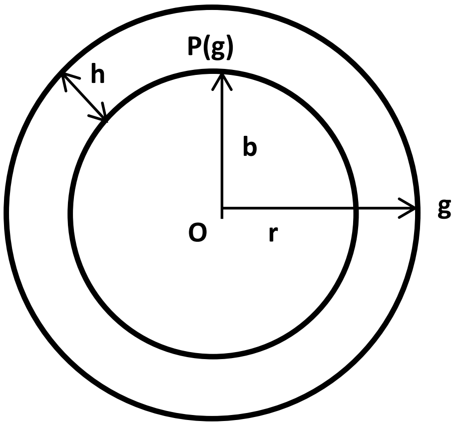

Fig.2

We can see that since the gravitational field strength increases linearly with distance it follows that the gravitational acceleration g at P is due entirely to the shell of thickness h where h = r-b. The mass of the total sphere can be expressed as :- $M = G\rho\,\frac{4\pi r^5}{3} - \frac{4\pi b^3}{3} = r^3 - b^3 G\rho$ and since $h = r - b$ and b = r-h we can write $M = 4\pi \left(\frac{r-b}{h}\right)^2 G\rho$ and we can state that the acceleration due to gravity is due entirely to the area $4\pi r^2$ and we can write $g = \Lambda = 4\pi G\rho$ because $r = b$ where $r - b/h = 1$ (Here Λ is defined as the cosmological constant to be discussed in more detail later).

Furthermore, utilising Gauss's law again we can state that the mass M can be said to be distributed uniformly over the surface of the sphere i.e:- $g = \frac{M}{4\pi G R_0^2}$

This produces the condition whereby it can be said that the gravitational force acting on any particle within the sphere is proportional to the entire mass of the universe and that the particle can be said to be lying in a symmetrical force field about the point O. There is no tidal (i.e. directional) effect here and therefore the tensor Weyl = 0.

Cosmologists will recognise the expression $\Lambda = 4\pi G\rho$ as the result obtained by Einstein as the condition for a static universe where Λ is described as the cosmological constant and for the sake of good order I describe below the derivation of the Λ term because of its importance in the development of some of the arguments to be outlined in this paper.

The reader will note that I have made little reference to the Ricci tensor so far and the reason for this is that I shall be referring to the tensor in a somewhat different context with regard to the expansion of space-time within the sphere already referred to, however I will take this opportunity to refer to Equation No.2 which is :-

$$g = \frac{MR}{4\pi G R_0^3} \qquad (R \leq R_0) \qquad \text{Equ. 2}$$

and which in effect states that the gravitational force acting on any space within the volume is proportional to the entire mass of the universe and therefore the tensor Ricci → ∞.

The fundamental equations of General Relativity as described by Einstein are written in terms of the Ricci tensor R_{uv} and are given by :-

$R_{uv} - \frac{1}{2}\, g_{uv}\, R = \left(\frac{8\pi G}{c^4}\right) T_{uv}$ Equ.3

Where T_{uv} is the energy momentum tensor of the source producing the gravitational field. The Ricci scalar is defined by $R = g^{uv}R_{uv}$ where g^{uv} is the contravariant tensor corresponding to G_{uv}. All the information about the gravitational field is contained in the covariant tensor g_{uv} and the number of indices gives the rank of the tensor. The 00 and 11 components of Equation 3 can be written as $3(\dot{R}^2 + c^2) = 8\pi G\varepsilon R^2/c^2$ and $2\dot{R}\,\dot{R}^2 = kc^2 = -8\pi G p R^2/c^2$. Here p = pressure and ε = energy mass density. The critical density at any time is $\varepsilon_c = 3H^2/8\pi G$ where $H = \dot{R}R$ and H = Hubble's constant to be evaluated later. (Ref.15)

Fortunately these equations can be expressed in Newtonian terms by referring to Fig.3 below

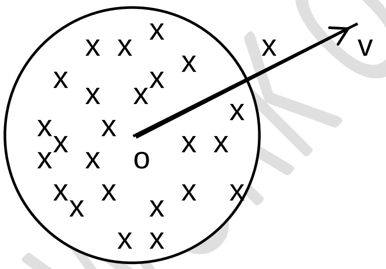

Fig. 3

The force F on x is due to all the mass within the sphere i.e. $M = 4\pi \frac{\rho(t)}{3}\, x^3(t)$ so Newton's second law for any galaxy m(x) is:-

$$F = ma = \frac{m_x\, d^2x(t)}{dt^2} = \frac{4\pi G m_x}{3}\ \frac{x(t)\rho(t)}{x^2(t)}$$

We substitute for the proper distance *x(t)* = *R(t)r* (where R = scaling factor) and for the density $\rho(t) = \frac{\rho_{m0}}{R^3(t)}$ where $\rho_{m0} = \rho(T_0)$ is the current mean density. With these substitutions Equation 3 becomes a differential equation for *R(t)* i.e:-

$$\frac{d^2R}{dt^2} = \frac{4\pi G\rho}{3}\,\frac{1}{R^2} \qquad \text{Equ.4.}$$

Integrating once yields a constant of integration $-kc^2$ and we get:-

$$\dot{R}^2 = \frac{8\pi G\rho}{3}\,\frac{1}{R} - kc^2 \qquad \text{Equ.5.}$$

which contains information about space-time geometry. The present values of the scaling factor and it's rate of change are *R=1* and $R = H_0$ respectively thus:-

$$H_0^2 = \frac{8\pi G\rho}{3}\,\frac{1}{1} - kc^2 \qquad \text{Equ.6.}$$

From Equ.6 we can write:-

$H_0^2 = \frac{8\pi G}{3}\,\frac{3H_0^2}{8\pi G}\,\Omega - kc^2$ and here we note that $1 - \Omega = H_0^2\,c^2$ and

$\Omega = \frac{\rho_{m0}}{\rho_c}$ and $\rho_c = \frac{3H_0^2}{8\pi G}$. Lastly using Equation 6 and inserting it into Equation 5 we can write $\dot{R}^2 = \frac{8\pi G\rho}{3}\,\frac{1}{R} - H_0^2\,(\Omega - 1)$ (Ref.35)

Moving on, we return now to the expression for lambda i.e :- $\Lambda = 4\pi G\rho$ which is derived from the negative gravitational field as already described. Of course it is well known that the Λ term can fulfil the conditions for a static universe. Similarly the Λ term can modify the equations of General Relativity when applied at large distances into a repulsion proportional to distance i.e:- $r = \Lambda r$ with Λ constant. The Λ term is consistent with Einstein's field equations and we will therefore adopt this term to modify Equations 4 and 5 to produce the required repulsive effect so Equation 4 becomes:-

$$\ddot{R} = -4\pi \frac{G}{3} \rho R_0^3 + \frac{\Lambda}{3} R \qquad \text{Equ.7.}$$

and Equation 5 becomes:-

$$\dot{R}^2 = 8\pi \frac{G}{3} \rho\, R_0^3 \frac{1}{R} - kc^2 + \frac{\Lambda}{3}\, R^3 \qquad \text{Equ.8}$$

That is to say the Λ term has negligible effect near $R=0$ and the universe is in a steady state. If $k=1$ there is a critical value of Λ i.e.Λ_c such that $R=0$ and $\dot{R}=0$ can be satisfied simultaneously. From Equation 7, $\ddot{R}$=0 implies that :-

$R = R_0 \left(\frac{4\pi G \rho_0}{\Lambda}\right) = R_c$ and Equation 8 implies that $0 = (4\pi G \rho_{m0})^{\frac{2}{3}} \sqrt{\Lambda} - kc^2$ so that $\Lambda_c = \frac{(kc^2)^3}{R_0^6 (4\pi G \rho_{m0})^2}$ This means that there is a possibility of a static model of the universe with $R = R_c$, $\Lambda = \Lambda_c$ for all time *t* provided that ;-

$$\Lambda = 4\pi G \rho_c = {kc^2}/{R_c^2} \qquad \text{Equ.9.}$$

and since $\rho_c \geq 0$ it follows that *k* must be positive for this to happen. (Here we note that $R_0 = R(T_0) = 1$ i.e. the scale factor is chosen to be unity at the present epoch.) (Ref.30)

From the foregoing the conclusion is that not only is the gravitational attraction between the galaxies cancelled by the repulsive effect of the Λ factor but that the expansion of the universe is the result of a repulsive or negative gravitational force, some of the geometry of which is described in the foregoing paragraphs. As previously pointed out, part of the purpose of this paper is to consider various aspects of physics as a single coherent unit and not under separate headings so to speak, because it seems to be so obvious that there is an intimate connection between both the largest and the smallest components of nature. To this end and what will be shown to be very pertinent to our later discussion regarding the state vector reduction we now consider the question of gravitational potential within an expanding universe driven by a negative gravitational field.

To this end we can say that each galaxy is in effect, falling in a gravitational field and can therefore be described in terms of the gravitational potential of this field. As will be seen this will enable us to establish the radius and consequently the size and mass density of the universe with some degree of accuracy in the following manner.

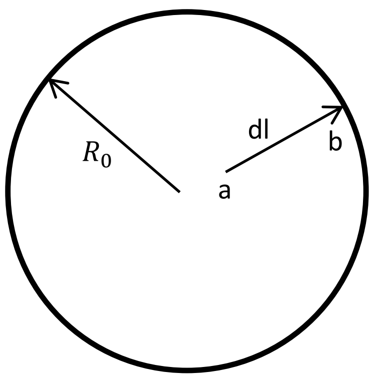

Fig.4

From Figure 4 we can imagine that a test galaxy is falling in a gravitational field inside the mass M which represents the entire mass of the universe and its associated gravitational field both of which are expressed by $\bar{g} = \frac{Mr}{4\pi G R_0^3}$. Figure 4 illustrates schematically a spherically symmetrical uniform volume mass and we can find the potential difference inside the mass by integrating along a radial path as follows:-

$$V_b - V_a = -\int_{r_b}^{r_a} \left(\frac{Mr}{4\pi G R_0^3}\, \hat{r} \right) . (dr\, \hat{r})$$

$$= -\frac{M}{4\pi G R_0^3} \int_{r_a}^{r_b} r\, dr$$

$$= \frac{M}{8\pi G R_0^3} \ (r_a^2 - r_b^2) \qquad \text{Equ.10}$$

To find the potential at any point inside the mass distribution we can say that the potential V_0 evaluated at any point on the surface of the sphere is given by $V_0 = \frac{M}{4\pi G R_0}$ and from Equation 10 we can let r_a correspond to a point inside the sphere i.e. $\left(r_a = R, V_a = V(R)\right)$ and let r_b correspond to a point on the surface of the sphere i.e $(r_b = R_0, V_b = V_0)$ and this gives :-

$$V(R) - V_0 = \frac{M}{4\pi G R_0^3} \quad (R_0^2 - R^2) \qquad (R \leq R_0) \qquad \text{Equ. 11}$$

Thus the potential varies within the sphere and each galaxy (or point in space) can be said to be lying on an equipotential surface within the sphere. The gravitational field lines are perpendicular to the equipotentials and point from a lower to a higher potential. From Equation 11 we note that the potential is highest when *R* is smallest and decreases with increasing *R*. This means that a galaxy is moving from a higher to a lower potential thus the galaxy gains kinetic energy expressed by the familiar $KE = \frac{1}{2}mv^2$ which represents the kinetic energy of any galaxy within the sphere.

From the foregoing we now have a mechanism for treating the motion of any individual galaxy of mass *m* within the larger mass *M* of the universe. Since we are treating the galaxy as a particle in a gravitational field we can say that the potential energy of the galaxy is expressed by $E_p = mgr$. A particle in a gravitational field has potential energy because the field does work moving the particle from one place to another. The gravitational potential at a point in a gravitational field is defined as the potential energy per unit mass at that point. Designating the gravitational potential by *V* and the potential energy of mass *m* by E_p we have $V = \frac{E_p}{m}$ or $E_p = mV$.

If a mass moves from one point *r* to another point *R* then the work done by the gravitational field is :-

$$W = E_{p(r)} - E_{p(R)} = m(V_r - V_R) \qquad \text{Equ. 12}$$

so the difference in potential between point *r* and *R* is $V_{(r)} - V_{(R)} = \frac{W}{m}$ or $\Delta V = -\frac{W}{m}$.

Now since *W*=*Fr* and *W*=*mgr* and since the galaxy (or particle) has effectively been accelerated from rest to some velocity *v* then in this case $v^2 = 0^2 + 2gR$ i.e. $gR = \frac{v^2}{2}$ and since *F*=*ma*=*mg* it follows that *W*=*mgr*, therefore

$W = \frac{1}{2}\, mv^2$. Noting that $W = -\Delta E_p$ and using Equation 12 we can write:-

$\frac{1}{2} mv^2 = m\left(V_{(r)} - V_{(R)}\right)$ and cancelling *m* on both sides we have

$\frac{1}{2} v^2 = V_{(r)} - V_{(R)}$.

It follows that since the maximum velocity which can be achieved by any moving particle (or galaxy) is $\approx c$ then the maximum radius of the universe is $\frac{1}{2} c^2$ and therefore $R_0 = \frac{1}{2} c^2$ light years where R_0 is the maximum possible radius of the universe.

Equation 10 describes how the gravitational potential varies within the spherical space of a universe which is expanding under the influence of a negative gravitational field and that any point within the sphere can be said to be lying on an equipotential surface.

Chapter 2

Matter in a quantised gravitational field

This chapter describes the wave function of a test galaxy in a quantised gravitational field.

Now the wave description of matter defines a natural scale for a particle through its Compton wavelength i.e. $\Lambda = h/mc$. This in turn leads to the conclusion that the Planck length $10^{-35}m$ is a limiting state of matter, that is to say it is a boundary condition at one end of the scale of structure of the universe. At the other end of the scale, the boundary condition is the limiting distance of the radius of the universe i.e. its radius of $\frac{1}{2}c^2$ light years as previously described, thus we can say that both boundary conditions take the form of potential barriers and this enables us to describe the wave function of any particle (or galaxy) in the universe by imagining that the particle (or galaxy) is moving through a quantised field and we can call this field the Quantum Gravity field.

As with any oscillator or wave function it is the boundary conditions which lead to a set of quantised energy levels. The particle cannot have zero energy. The lowest energy value occurs at *n=1*, known as the zero point energy and this is true for any particle which is confined to a region of space by the presence of boundary conditions. This is of course already well known but it is worth reminding ourselves of the boundary conditions which lead to quantisation of the wave function by referring to the familiar "particle in a box" model as this will help to lead us into a more full description of the quantised gravity field.

Now a particle in a box is confined by two impenetrable walls (or potentials) at *x* and *l*. Since a particle (or galaxy) cannot penetrate the walls then $\psi = 0$ for $x <$ 0 and $x > l$. With *ψ=0* the Schroedinger wave equation becomes :-

$\frac{\delta^2\psi}{\delta x^2} = k^2\psi = 0$ where $k = \sqrt{\frac{2mE}{\hbar}}$ and the solution to this equation is

$\psi(\mathrm{x}0 = \mathrm{A}\sin(kx = \theta)$.

The boundary conditions are *ψ=0* at *x=0* and from the condition that *ψ=0* at *x=l* we find that *(kl)=0* which means that *kl=nπ* where *n* is an integer. Thus we have a wave function which satisfies the boundary conditions in the form of a standing wave i.e :- $\psi(x) = \left(\frac{n\pi x}{L}\right)$ *n=1,2,3*……..

Since $k = \frac{2\pi}{\Lambda} = \frac{n\pi}{l}$, the wavelength of the n^{th} standing wave is $\Lambda = \frac{2L}{n}$. When this is equated to de Broglie's equation $\Lambda = \frac{h}{mv}$ we find $v = \frac{nh}{2mL}$. Since *n* takes only integer values the speed is quantised. The particle's (or galaxy's) energy which is purely kinetic and is $\frac{1}{2}mv^2$ is thus also quantised. The energy of any particle moving within fixed boundary conditions is therefore quantised.

Since it is the boundary conditions of a system which produce it's quantised properties we can say that any galaxy is moving in a quantised field which is characterised by potential field lines as already described and whose centre is located at the position of the observer. Thus we can imagine each field line to be quantised in terms of $\hbar$ and an integer where integer *1* occurs at the point where the field is strongest (i.e. on the outermost circumference of the sphere). Thus the galaxy is moving from a position of high potential to a position of low potential.

Furthermore we can say that the equipotential field lines are arranged in a manner which exhibits spatial periodicity and the potential gaps can be described in a manner similar to that of a solid structure and this enables us to hypothesise further as to how the universe might be structured on the large scale.

Within our model of the spherical potential field, any area of space can be described as being in the form of allowed energy bands separated by regions which are forbidden and we note that the onset of forbidden bands corresponds to the condition $ka = n\pi,\ n = \pm1, \pm2, \pm3, \dots\dots$ which is the condition for Bragg reflection with normal incidence. Thus with our particle in a box" analogy we have two wave functions propagating in opposite directions and which are of opposite parity. Clearly this indicates a condition of broken symmetry which occurs in the following way.

Schroedinger's equation can be written as :-

$$-\frac{\hbar^2}{2m}\nabla^2\psi - V\psi = ih\frac{\delta\psi}{dt}$$ Equ. 14

Where in Cartesian co-ordinates the wave function of the galaxy is given *as* $\psi = (x, y, z, t)$ and : −

$$\nabla^2\psi = \frac{\delta\psi^2}{\delta x^2} + \frac{\delta\psi^2}{\delta y^2} + \frac{\delta\psi^2}{\delta z^2}$$ Equ. 15

In the foregoing the potential energy of the galaxy is given by *V=(x,y,z,t)* and $i = \sqrt{-1}$. If *V* is independent of time, we can separate space and time variables by setting $\psi = \psi(x, y, z)T(t)$. Substituting into Equation 14 and dividing by ψT

We find:-

$$-\frac{\hbar^2}{2m}\frac{\nabla^2\psi}{\psi} + V = \frac{i\hbar}{T}\frac{dT}{dt}$$ Equ. 16

From the R.H.S. of Equation 16 we then obtain $T = Ce^{-i\left(\frac{E}{\hbar}\right)t}$ and the L.H.S of Equation 16 can be written as :-

$$-\frac{\hbar^2}{2m}\nabla^2\psi + V\psi = E\psi$$ Equ.17

Now from Equations 15 and 17 we can see that the substitutions $x \rightarrow -x, y \rightarrow -y, z \rightarrow -z$ (abbreviated by $\bar{r} \rightarrow -\bar{r}$ below)will not alter the solution of Schroedinger's equation if:-

$$V(-x, -y, -z) = V(x, y, z)$$ Equ.18

The substitution $\bar{r} \rightarrow -\bar{r}$ is called the parity operation and a potential which has the property expressed in Equation18 is said to be conservative under the parity operation. For a potential of the form of Equation18, the wave function ψ in Equation 17 must have the property:-

$$\psi(-\bar{r}) = +\psi(\bar{r}) \qquad \text{Equ.19}$$

or

$$\psi(-\bar{r}) = -\psi(r) \qquad \text{Equ.20}$$

The wave function described in Equation 19 is said to possess even parity and the wave function described in Equation 20 is said to possess odd parity. Further if any system has a wave function of a given type it can never change over to the wave function of the other type as long as all the interactions in the system remain the same.

We recall the Cosmological principle which permits us to use the concept that any point in the universe can be described as a central reference frame of the universe. With this in mind we now take the somewhat unconventional step of treating a galaxy in our spherical universe in the same way as we would treat a particle in a closed cubical box. Now if the universe was indeed a closed cubical box the parity of the wave function given by $\psi = \left(\frac{2}{L}\right)^{\frac{3}{2}} \frac{\sin n_x \pi_x}{L} \frac{\sin n_y \pi_y}{L} \frac{\sin n_z \pi_z}{L}$ is not a definite quality (since $\psi = 0$ outside the box we can see that $\psi(x) \neq \psi(-x)$ for $0 < |x| < L).T)$. This occurs because the location of the box causes V not to have the property as in Equation 18 because the origin starts at the end of the box. But if the origin is moved to the centre of the box as permitted in our universal model (because the Cosmological principle allows any point to be considered as a central reference frame) then *V* will have the property as in Equation 18 and the wave function has the form:-

$$\psi = \left(\frac{2}{L}\right)^{3/2} sin\left(\frac{n_x \pi x'}{L} + \frac{n_x \pi}{2}\right) sin\left(\frac{n_y \pi y'}{L} + \frac{n_y \pi}{2}\right) sin\left(\frac{n_z \pi z'}{L} + \frac{n_z \pi}{2}\right)$$

Where x',y',z', are the co-ordinates measured with respect to the central box $\left(x' = x - \frac{1}{2}\ etc.\right)$ For any odd value of n, the first sine function becomes $\pm\cos n_x \pi x'$. Hence the overall parity of the wave function is even or odd depending on whether or not $\left(n_x + n_y + n_z\right)$ is an odd or even integer.

Essentially what is happening is that the potential is generating a rotation in internal symmetry space. To generate this rotation we define the potential in the language of a rotation group. A three dimensional rotation $R(\theta)$ of a wave function is written as $R(\theta) = e^{-i\theta L}\psi$ where θ is the angle of rotation and L is the angular momentum operator. This rotation is comparable with the phase change of a wave function after a gauge transformation. The rotation has the same mathematical form as the phase factor of the wave function. But this does not mean that the potential itself is a rotation operator like $R(\theta)$. The amount of the phase change must be proportional to the potential to ensure that the Schroedinger equation remains gauge invariant. To satisfy this condition the potential must be proportional to the angular momentum operator L. The most general form of the Yang-Mills potential to which of the angular momentum operators to which the barrier potential is exactly similar is a linear combination of the angular momentum operators:-

$$A_\mu = \sum_i A_\mu^i(x) L_i \qquad \text{(Ref.20)} \qquad \text{Equ.21}$$

where the coefficients $A_\mu^i(x)$ depend on the space-time position. This relation indicates that the potential is not a rotation but is the generator of a rotation. The relation in Equation 21 displays the dual role if the potential is both a field in space time and an operator in the isotopic spin space. The potential acts like a raising operator L_x and can, for example transform a down state into an up state. Thus a total internal reflection has induced a phase change in space time. This is because the phase of a wave function can be described a new local variable. Instead of a change of scale a gauge transformation can be re-interpreted as a change in the phase of a wave function i.e:-

$$\psi \to \psi e^{-ie\Lambda} \qquad \text{Equ. 22}$$

And the familiar gauge transformation for the potential A_μ becomes:-

$$A_\mu \to A_\mu - \delta_\mu \Lambda \qquad \text{Equ. 23}$$

Thus the wave equation is left unchanged after the two transformations in Equations 22 and 23 are applied.

The non-relativistic wave equation for the test galaxy can be written as:-

$\left[\frac{1}{2m}(-i\hbar\nabla - gA)^2 + g\phi + V\right]\psi = i\frac{\hbar\delta\psi}{\delta t}$ where the canonical momentum now appears as the quantum operator for $-i\hbar\nabla - gA$. After the phase change in Equation 22 there will be a new term proportional to $e\nabla\Lambda$ from the operator $i\hbar\Lambda$ acting on the transformation wave function. This new term will be cancelled exactly by the gauge transformation of the potential according to Equation 23. (Ref.20)

The foregoing describes the nature of the negative gravitational field and hypothesises about the possible internal reflection of the general wave function of the universe on the large scale. Following this I now return to the more familiar Newtonian expressions with the intention of developing further hypotheses concerning the structure of the universe and to develop further ideas regarding the use and power of potentials with particular regard to the state vector reduction.

Chapter 3

Negative gravitation and the physical constants

This chapter describes the derivation of Hubble's constant from the negative gravitational field and the relationship of all the physical constants to each other and to the Hubble constant.

It will be recalled that we have shown that the maximum radius of the universe is given by $R_0 = \frac{1}{2}c^2$ light years. Now the static model of the universe, although not actually representing the truly dynamic universe as it actually exists, does enable us to take a snapshot so to speak, of the point of view of any particular observer at position *0* at time *T* and we can use this model to develop several further interesting ideas. Firstly, since the volume of the universe is static and the radius is known we can utilise the Schwarzchild solution to write $R_0 = \frac{2GM}{c^2}$ and solving for G we have $G = \frac{R_0 c^2}{2M}$ which implies that *G* varies with distance and therefore with time. Referring again to Figure 4, any observer at point *0* with a view radially outwards into the universe is looking backwards into time. This implies that time *T* increases from the point T_0 situated at the position R_0 towards the observer at point *O*. This implies that $G(t) \propto \frac{1}{T}$ and from this we deduce that the gravitational constant *G(t)* is proportional to Hubble's constant *H(t)* which is again proportional to $\frac{1}{T}$ and we can further infer that since *T*∝*R* we can state that:-

$G \propto \frac{1}{R}$ and $H(t)$ (Ref.31) Equ. 24

At this stage I would point out the rather obvious conclusion that the galactic red shift is the product of a negative gravitational field.

I now move on to a more arithmetical approach to cosmology and while I fully understand that such methods do not find much favour in the scientific community at present, as will be seen, the methods I intend to apply do in fact produce a series of interesting calculations which enable us to write the values of all the principle physical constants in terms of each other.

It will be recalled that Sir Arthur Eddington produced dimensionless ratios of the order of 10^{40} and various derivatives of this number and I intend to use Eddington's work incorporated into our steady state model of radius $\frac{1}{2}c^2$ light years. Eddington's work is particularly useful in this respect because we have been able to define precisely the radius and volume of the universe.

Eddington's "magic number" is in fact $\sqrt{10^{80}}$ which is described as an expression for the total number of baryons in the universe and therefore by implication the bulk of the mass *M* of the universe and the following paragraphs describe Eddington's derivation of this value.

N is described as the total number of elementary particles in the universe and was defined by Eddington as an effective number of degrees of freedom of the Universe. Wave mechanics defines *N* as the number of independent wave systems in the universe and is therefore equal to the number of separate constituents of energy of the universe. In classical theory each of *N* particles would have several degrees of freedom, but the exclusion principle limits the freedom of a particle by forbidding it to enter an orbit already occupied by another particle.

Present observations suggest that for matter the density is $\rho_m \approx 10^{-11} Jm^{-3}$ from which we can deduce *N*. The actual form Eddington gives the argument arises by considering not one number but a sequence i.e:-

$N_r = n_r(n_r + 1)2^{n^2 r}, r = 1,2,3 \ldots \ldots .where\; n_1 = 2, n_r = n_{r-1}^2$

The first few values of n_r are *2,4,16,256 ……* from which can be obtained :-

$N_1 = 2x3x2^4 = 96$

$N_2 = 4x5x2^{16} = 2x10x2^{16} = 1310720$

$N_3 = 16x17x2^{256} = 2x136x256 \approx 10^{18}$

And thus for future reference we can define the number p as $p = \sqrt{N} = 10^{40}$ (Ref. 16)

Furthermore we note that present observations of matter density indicate that the amount of cosmic material inside the Hubble radius is of a very similar order i.e**.** $\rho \approx Jm^{-3} \approx 10^{80}$ protons. (Ref. 4)

It will be recalled that in our cosmological model, every particle is surrounded by a symmetrical gravitational field and we can describe this field as acting over the whole surface area of each individual particle contained within the sphere. By nominating the Planck length 1×10^{-35} m. as our lowest boundary condition and by introducing a gravitational force equal to the universal mass M, we can define the ration of the mass of the proton and the inter-relationship of the other physical constants.

We have already defined the mass of the universe to be $M = \frac{R_0 c^2}{2G}$ and we can calculate the actual value of M by inserting the following values i.e:-

$G = 6.67x10^{-11} m^3 kg^{-1} s^{-2},\ c = 3x10^8,\ R_0 = \frac{1}{2} c^2\ light\ years =$ $4.26x10^{32} m.$ from which it follows that $M = \frac{4.26x10^{32} \times 9x10^{16}}{1.33x10^{-10}} = 2.88x10^{59}\ kg.$ and now having established the values of M and p we can move on. From Equation 24 we have shown that Hubble's constant varies with time and this bears out Eddington's original hypothesis if:-

$$\frac{GH_0}{\hbar \varepsilon_0 / e^2 m_p^3} \approx 1 \qquad \text{Equ. 25}$$

then one of the fundamental constants $G, \hbar, m_p$ and e must change with time (here m_p and e are the mass of the proton and the charge on the electron respectively).

Now the average density of matter in space expressed in protons per unit atomic volume (e^2/mc^2) turns out to be a number of the order p^{-1}. Using *R(t)* as the scale factor of expansion and assuming mass to be conserved $(\rho R^3 = const.)$ The identification of the density and Hubble's constant $(\dot{R})/R$ leads to the relation $R(t)^3 \approx p^{-1} \approx \dot{R}/R$ and we get $\frac{G(t)}{H(t)} = \frac{G(t)R(t)}{\dot{R}} = const.$ and $\frac{\rho(t)G(t)}{H^2(t)} \approx \frac{1}{T(t)^3}\ x\, G(t) x\ \frac{G(t)}{R(t)\dot{R}^2(t)} = const.$ Now *G(t)* can be eliminated to obtain $R^2(t)\dot{R}(t) = const.$ so that:-

$$R(t) \propto \frac{1}{3}t \qquad \text{Equ. 26}$$

In the atomic units *e* and *m* are constant but e^2/Gm^2 is a number of the order *p* and is proportional to T_0 therefore *G* must be proportional to t^{-1}. Furthermore as *R* increases so *H* decreases. Clearly the value of *H* is of vital importance to establishing the value of T_0.

To establish the value of Hubble's constant for a universe of radius $\frac{1}{2}c^2$ light years we can proceed as follows:-

$$T_0 = \frac{1}{H_0} \frac{10^6 parsecs.}{H_0} = 1.4x10^{18} secs.$$

$$= \frac{3.09x10^{19} kms.}{H_0} = 1.4x10^{18} secs.$$

$$\therefore H_0 \approx \frac{3.09x10^{19} kms.}{4.74x10^{17} secs.} = 65.18$$

$$(i.e. 1.5x10^{10} yrs\ x\ 4.74x10^{17} secs.)$$

$$\therefore H_0 = \frac{3.09x10^{19} kms.}{1.4x10^{18} secs.} = 22.07\ kms. per\ sec.$$

i.e.$\frac{1}{2}c^2$ light years $= \frac{9x10^{10}}{2} = 4.5x10^{10}$ years and $4.5x10^{10}y. = 1.4x10^{18}s.$

But from Equation 30 we have shown that $H_0 = \frac{1}{3}t$ so that $T_0 = \frac{1}{3}H_0$ and

$\therefore T_0 = \frac{4.5x10^{10}}{3}yrs.$

$= 1.5x10^{10}yrs.$

This results in a new value for H_0 i.e.$H_0 = \frac{3.08x10^{19}kms.}{4.74x10^{17}secs.} = 65.18\ kms\ per\ sec.$

A well known cosmological model is that produced by Paul Dirac in the 1930's. The drawback with this model was its unfortunate implication that the universe as a whole was younger than some of its component parts. The foregoing derivation of H_0 solves this problem and enables us to study his work with greater confidence.

Dirac considered the ratio of the reciprocal of Hubble's constant to an atomic unit of time $\frac{e^2}{4\pi\epsilon_0 m_e c^3}$. Now $\frac{1}{H_0} = T_0$ so we can write:-

$$\frac{4.74x10^{17}}{2.57x10^{-38}/4\pi x 8.5x10^{-12}\ x\ 9.11x10^{-31}\ x\ 2.7x10^{25}} \approx 10^{40} = p \qquad \text{(Ref.2)}$$

A further proposition by Dirac was that the value of G would change with time and we have previously shown this to be the case. Dirac's theorem went on to compare the ratio of the electrostatic force to the gravitational force in the following manner:- $\frac{F_E}{F_G} = 10^{40}$ where $F_E = \frac{e^2}{r^2}$ and $F_G = G\frac{m_e m_p}{r^2}$ where the radius of the electron is expressed as $r = \frac{e^2}{m_e c^2}$ Dirac then compared the radius of the electron r with the radius of the universe R_0 and found the relationship $\frac{R_0}{r} = 10^{40}$ where the radius of the universe is expressed as $cT_0 = \frac{c}{H} = R_0$ and to explore these relationships further we can begin by writing:- $\frac{R_0 c^2/2G}{Gmr_p^2} = 10^{40} = p$ and $\frac{1/H_0}{e^2/4\pi\varepsilon_0 m_e c^3} = 10^{40}$ where $\frac{e^2}{4\pi\epsilon_0 m_e}$ is the atomic unit of time and $\frac{cT_0}{e^2 e^2 c^2} = 10^{40}$ where cT_0 is the radius of the universe and $\frac{e^2}{m_e c^2} = 10^{40} = p$ is the classical electron radius and $\frac{e^2}{4\pi\epsilon_0 G m_e m_p} = 10^{40} = p$ where e^2 is the electromagnetic force between the electron and the proton and $\frac{\rho(cT_0)^3}{m_p} = 10^{40} = p$ where $\rho = 6.67x10^{-26}\ kg.m^{-3}$.

In a similar manner we can establish the link between the electromagnetic force and the gravitational force. The link between electromagnetism and the weak force is manifested by the weak coupling constant α_w by writing :-

$\alpha_w = \alpha \frac{e^2}{4\pi\epsilon_0 \hbar c} = 7.3x10^{-3} = 137^{-1}$ and noting that m_w is the mass of the ω particle. Now gravitation and the weak coupling constant are linked by :-

$$\alpha_w = g_w(m_e^2 c/h^3) = \sqrt[4]{p} \qquad \text{(Ref.4)}$$

and $\alpha_w^4 = \alpha_g$ where α_g is the gravitational fine structure constant i.e:-$\alpha_g = \frac{Gm_p^2}{\hbar c} = 5.9x10^{-39}$ and the relation between electromagnetism and gravitation is given by $\frac{\pi}{p\alpha_G^{-1}} = \alpha^{-1}$ where $p = 10^{40}$ thus we can write the following :- $\sqrt[4]{\frac{1}{Gr_p^2}} = \sqrt{\alpha_g} = \alpha_w = \sqrt[4]{p} = \alpha(m_e/m_w)^2 = \left(\frac{\alpha_g^{-1}\alpha^{-1}}{\pi}\right)^4$ and here we note that $\alpha_w = (m_e^2 c/h^3) = \sqrt[4]{p}$ and $g_w m_e^2 c/\hbar^3 = (Gm_e^2/\hbar c)^{1/4}$ where g_w is the weak force constant i.e:- $g_w = 1.43x10^{-62}$. This leads to the further relationships:- $\sqrt[4]{\frac{t_H}{t_n}} = \sqrt[4]{p} = \sqrt[4]{\alpha_g{}^{-1}} = \sqrt[4]{\left(\frac{t_n}{t_p}\right)}$ where:-

t_n =nuclear time scale= $\frac{h}{m_p c^3}$ (Compton time)

t_p =Planck time $\left(\frac{G\hbar}{c^5}\right)^{1/2}$

t_H = Hubble time H^{-1}

Lastly to solve the problem of whether or not the universe is bound or unbound we can proceed as follows. If ρ_{m0} is the present value of the average matter density of the universe, the total mass inside our model sphere can be written as $M = \frac{4\pi\rho_{mo}R_0^3}{3}$ $\therefore M = 2.88x10^{59}$ kg. and $R_0 = 4.26x10^{32}$ m. so we can write :-

$$\rho_{m0} = \frac{3M}{4\pi R_0^3} \quad = \frac{8.64x10^{59}}{1.1328x10^{99}} \quad = 7.63x10^{-4} \text{ kg.m}^{-3}$$

The critical mass density is given by $E = \frac{1}{2}mH_0^2R_0^2 - \frac{Gm}{r}\frac{4\pi\rho_c R^3}{3} = 0$ which in our case gives the result $\rho_c = \frac{1.335x10^{-35}}{1.7x10^{-9}} \quad = 7.85x10^{-27}$ kg.m^{-3}

If $\rho_{m0} \geq \rho_c$ the universe is bound and if $\rho_{m0\leq}\rho_c$ the universe is unbound. Therefore we can conclude that our universe is unbound but finite.

The constants used in these calculations are as follows:-

G=$6.72x10^{-11}m^3kg^{-1}s^{-2}$

$H_0 = 2.109x10^{-18}s.$

$\epsilon_0 = 8.85419x10^{-12}F.m^{-1}$

$m_p = 1.67265x10^{-27}kg.$

e =$1.60219x10^{-19}C.$

$r_p = 10^{-15}m.$

$T_0 = 4.74x10^{17}s.$

$c = 3x10^8m.s^{-1}$

m_e= 9.1095x$10^{-31}kg.$

As is apparent from the foregoing there would seem to be an intimate relationship between the values of the Hubble constant on the large scale an Planck's constant on the small scale and as will be seen later, these relationships enable us to make further hypotheses relating the very largest structure in nature to the very smallest in the quantum world.

Chapter 4

Negative gravitation and the state vector reduction

This chapter describes the state vector reduction and its relationship to the quantum gravitational potential and the influence of that potential on the geometry of space-time at the quantum level

Before exploring these relationships further I will touch briefly on the subject of " quantum weirdness " and the still unresolved philosophical questions raised by current interpretations of the theory.

Probably the most bizarre aspect of quantum theory is that it can lead to differing conclusions about the nature of reality itself which are in direct conflict with our everyday experience and appear to defy any " common sense" approach which would produce a result more in accordance with the deterministic propositions of our everyday existence. Perhaps this is best illustrated by the work of John Bell (1964) and his famous Inequality Theorem and a version of the theorem as outlined by Andrew Whittaker in Physics World in 1998 can best be used to illustrate how it is that quantum theory can appear to defy common sense.

If we take a two wing quantum apparatus, the spin component of a quantum particle can be measured in on wing in direction *a* and in the other wing in direction *b*. The probability of both results being the same and the probability of both results being different can be described by defining $E(a,b)$ as the difference between two probabilities i.e :-

$E(a,b) \equiv P(up,up;a,b) + P(down,down;a,b) - P(up,down;a,b) -$

$P(down,up;a,b)$.

If we now take four experiments with direction a and a' in one wing of the apparatus and b and b' in the other wing we obtain the result:-

$X(a.b,a',b') \equiv |E(a,b) - E(a',b') + E(a',b) - E(a',b')| \leq 2$

This is the famous Bell's inequality which appears to show that both quantities a and b have "exchanged information at the outset of the experiment as what the results (i.e. direction of spin) will be on examination of the individual spin states. However Bell's inequality is violated by quantum theory because in quantum theory $E(a,b) = -\cos(a-b)$. For example if $a = 0^0, a' = 90^0, b = 45^0, b' = -45^0$ then $X(a,b,a',b') = 2\sqrt{2}$ which is a clear violation of Bell's inequality. This finding has been borne out by the practical demonstrations in experiments carried out by Alain Aspect and others. Briefly, in classical physics the act of measurement has no effect on the system being examined, whereas in quantum mechanical physics the opposite is true and the wave function of the system is influenced by the act of measurement. This phenomenon would be resolved if it could be shown that the predictions of quantum mechanics were in fact deterministic in nature and this could be achieved if those predictions were determined by factors which cannot be observed directly and are known in the jargon as hidden variables and that these must be added to quantum mechanics to explain quantum entanglement without action at a distance being manifest. It is important to define the meanings of both local and non-local hidden variables.

It will be recalled that in 1935 the Einstein, Podolsky, Rosen (EPR) thought experiment was published which appeared to show that a measurement on either one of a pair of quantum entangled particles instantaneously fixed the quantum state of the other particle, no matter the distance between the particles at the time of measurement. The results of this experiment appeared to imply two possible alternatives; either there was an exchange of information between the particles at a velocity faster than light- a state which is described as the non-local hidden variable model and which is a result not permitted by relativity theory, or there is some other unknown influence known as the local hidden variable model which intervenes at the outset of the experiment to resolve the outcome of the entangled state of a pair of quantum particles. However, despite all the discussion which has taken place with regard to the merits or de-merits of either model, neither interpretation is satisfactory and that either causality is violated in the quantum world or that the world is fundamentally indeterminate and is subject to the influence of the observer. Clearly the two descriptions are both contradictory and mutually exclusive and both descriptions contain difficulties which have not yet been explained.

The Aspect experiment referred to previously was designed in part at least, to verify that there are no pre-set conditions which can produce quantum mechanical probabilities in the classical world, however one way to account for the dichotomy between the local hidden variable and the non-local hidden variable models would be to show that the predictions of quantum theory were statistical and this could be achieved if those predictions were demined by factors which cannot at present, be directly observed.

To illustrate this point, we can utilise the apparatus featured in the Aspect experiment to account for the local/non-local conundrum by showing that the predictions of quantum theory are statistical and deterministic and this could be achieved if those predictions are determined by factors which cannot be directly observed.

In addition to the direction of measurement, the two armed apparatus can be used to define the direction of the flow of time in an experiment described by Roger Penrose and which I re-produce below. This experiment demonstrates conclusively that it is the act of observation which introduces time a-symmetry into the classical world from the time symmetric quantum world.

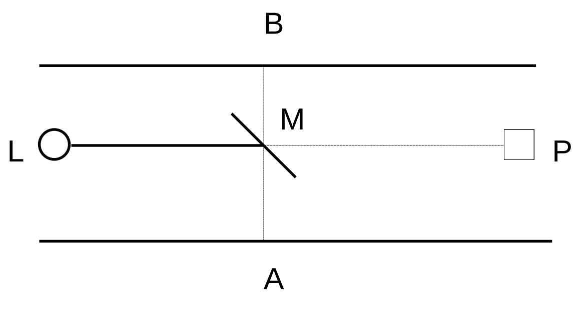

Fig. 5

The experiment shown above illustrates the time irreversibility of a quantum experiment. Let us see why. Here we have lamp L and photocell P. Between L and P there is a half silvered mirror at an angle of 45^0 to the line LP. A photon is emitted at L. The photon's wave function strikes the mirror and the wave function splits into two. There is an amplitude of $\frac{1}{\sqrt{2}}$ for the reflected part of the wave and an amplitude of $\frac{1}{\sqrt{2}}$ for the transmitted part of the wave and the probability given by the square of the moduli of these two amplitudes i.e. $\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{1}{2}$ defines the alternatives. Therefore we can answer the question "Given that L registers, what is the probability that P registers?" And the answer we get is "one half". However the time reverse of this question is "given that P registers, what is the probability that L registers?" and the answer to this question is not one half------------ it is one! Thus in the case of our time reversed question, the quantum mechanical calculation gives completely the wrong answer. In other words, the making of an observation is associated with an irreversible process and it is this irreversibility which can be said to produce three effects 1/ it provides us with the arrow of time 2/ it shows that it is not possible to make a macroscopic observation which is time reversed (i.e. we are not able to view events running backwards in time) and most importantly 3/ the macroscopic world will only admit solutions which are time a-symmetric in the forward direction. More properly, the eigenstate which is detected when the wave function collapses can only be a state which is moving forward in time. This being the case we must conclude that there exists a macroscopic world into which the wave function can collapse and from which we can infer that the macroscopic world is not a product of the quantum world but rather that the reverse is true. Of course, the foregoing is in complete contrast to quantum theory which is totally time symmetric. This is because the wave equation gives a completely deterministic solution to the wave function once the wave function is specified at any one time and this appears to establish that quantum theory is totally time symmetric, that is to say there is no preferred direction of time. Clearly this is not our experience of the world. The reason for this is that the wave equation is largely misunderstood. It is very often considered even by many well established physicists that quantum theory is a probabilistic theory. In fact this is not the case and the reverse is true. The theory is mathematically precise and probability free and what is more, completely deterministic. It is however, entirely reversible in time. So why do some people consider the theory to be probabilistic in its nature? It is because when the wave function collapses , the description of the system changes from the entangled quantum level state to a state where the system occupies one or another of the classical level alternatives open to it. However, and here is the difference, whatever state the system now adopts, it adopts a state which is forward moving in time and is now non-time reversible. Thus it is evident that at this point a causal relationship between space- time events has occurred. Now the only way physical phenomena which can influence the causal relationships between space time events is gravitation, but at the quantum level the gravitational force is not strong enough to have induced this effect. Clearly something is wrong and one would assume that the gravitational causal relationship must be incorrect. Fortunately it is not incorrect and I shall return to this point later.

The time symmetry of quantum mechanics refers only to that part of the wave equation where the wave function ψ is governed by the deterministic Schroedinger equation evolution and which is expressed in the form of probability amplitudes governed by complex numbers. For a quantum event to become manifest in the macroscopic world in which we all live, the complex numbers are replaced by the moduli of the complex amplitudes of the wave function which result in the admission of only one of the many available quantum states surviving into the macroscopic world. In other words, at this point the collapse of the wave function manifests itself and becomes a description of the world as we know it and it is here where the direction of time manifests itself and takes on its forward direction.

Finally, there is one other well known quantum experiment that we should note before continuing with our search for an answer to the questions posed by the collapse of the wave function and that is the Double Slit experiment. This experiment clearly shows that a particle only comes into existence at the superposition of two wave functions and then only when those two wave functions are in phase. A particle does not register when both wave functions are out of phase with each other. Therefore it follows that any detection of any quantum particle and the determination of its state can only take place when the two wave functions are in phase with each other. Thus when we make a detection of say a spin up condition, that spin up wave function must be in phase with some other spin up wave function. Likewise its spin down partner must be in phase with some other spin down wave function in order to be detected. The wave function of these two states must be in phase with the wave function of the macroscopic world or more particularly, the observers wave function must be in phase with the observed wave function.

The foregoing describes the principal experiments which give rise to a description of the time symmetric quantum universe and the time a-symmetric macroscopic universe of every day experience. Clearly there is a dichotomy between the two world views and we are forced to ask some very fundamental and probing questions about both the nature of time and of the validity of the laws of physics as they are generally accepted. Indeed we can make the observation that both world views cannot be correct, either time has a direction or it does not. In fact we can go further and say that if time does not have a direction then it cannot exist as a separate parameter in the laws of physics for the simple reason that time reversed events cause such nonsensical results as, for example a person's death occurring before his conception. Clearly something is wrong and I believe we are forced to conclude that there exists an objective world separate from and independent of the quantum world and that there exists an objective reality outside of quantum theory.

If it is indeed the case that an objective deterministic universe exists and that this universe will only admit those quantum solutions which are a-symmetric in time, then we must set about creating a description of this universe and describing the method by which the collapsing wave function is admitted into it.

It seems to me that the indeterminacy of the quantum state has been resolved by the intervention of the macroscopic world. This is not the same as saying that the macroscopic world is not defined until a measurement is made but rather I am saying that it is the macroscopic world which defines the outcome of the observation.

The outcome of the observation in Penrose's experiment is twofold. Firstly the quantum state is one which evolves into a state that is moving forward in time------the other solution of time reversibility is not allowed. Secondly the superposition of the spin state of the photon is resolved and it is resolved by measuring the spin states at points A and P. That is to say that a measurement of spin up at point P results in a measurement of spin down at point A.

Now if the mirror was an ordinary reflector (i.e. not a half silvered mirror) the photon would certainly register at A. It is the half silvered mirror which has split the wave function from probability 1 into two amplitudes of $\frac{1}{\sqrt{2}}$ each. In this sense it is the half silvered mirror which becomes an operator and has the effect of squaring the moduli and the mirror is the point in space at which the wave function splits. Therefore at any point along the lines MP or MA a measurement can be made which will resolve the spin state of either one of the $\frac{1}{\sqrt{2}}$ spin states. Now let us imagine that A and P are exactly equidistant from M and that the results of the measurements taken simultaneously at A and P are reflected simultaneously back to M. In this way neither one of the spin states will have been established before the other (at least not as far as an observer at M would say). What will be the outcome of this experiment? The answer is that we cannot know what the outcome of the experiment will have been other than the fact that one arm will have been in a spin up state and one arm will have been in a spin down state. Thus as far as an observer at M is concerned there is no spooky action at a distance. Action at a distance only manifests itself when A tries to measure the spin state of B. The resolution of one spin state defines the other. Therefore we conclude that the wave description detected by an observer at M is not the same wave description detected by observers at L or P. In other words, a single wave function is not a complete description of quantum theory. Two wave functions are required, one for the originator of the system and one for the observer and this is in accordance with the hypothesis already described where two wave functions are in phase with each other. Action at a distance is not an instantaneous effect. The outcome of the second measurement can only be decided after the first observation has been made. There is therefore a time interval between the two observations. The spin state recorded at point M is therefore $|E\rangle = |\uparrow\rangle + |\downarrow\rangle = 1$ and this tells us two things. The first is the obvious one that a quantum observation has been made but more importantly that the total outcome of the experiment is unity. In other words the whole experiment is one single entity and should be viewed as such and not in its component parts because evaluating its outcome by examining its component parts will produce an overall outcome which is incorrect. In fact the whole experiment comprises a system which is acting as one coherent unit but I will return to this most important aspect in more detail later. Accordingly it would appear that there is a preferred reference frame from which the experiment can be viewed as a whole and not just in its component parts, that is to say that any observation at points B and A occurs after the decision about quantum up-ness or down-ness has been made but there can be no communication between points A and P and the various components and the results of the experiment are best described as acting in unison or coherently.

Nevertheless, the common perception of this part of quantum theory is that quantum entanglement and collapse of the wave function in some way define the nature of reality, so how do we attempt to resolve these questions especially if we are not prepared to accept that there is no solution to the problem.

A good place to begin is to return to the Bell theorem and examine exactly how it is that the indeterminacy of the quantum state arises as described by Penrose.

Because quantum probabilities are given by the squared modulus of two complex numbers w and z, we do not get the sum of their squared moduli separately but simultaneously and the result of that sum is $|w + z|^2 = |w|^2 + |z|^2 + 2|w||z| \cos\theta$.

The term $2|w||z| \cos\theta$ defines the probability of the quantum state at z+w. The value of $\cos\theta$ between -1 and 1, thus when $\theta = 0^0$ then $\cos\theta = 1$ and the alternatives re-enforce one another so that the total probability is greater than the sum of the individual probabilities (constructive interference). When $\theta = 180^0$ then $\cos\theta = -1$ and the total probability is less than the sum of the individual probabilities resulting in destructive interference. It is this phenomenon which lies behind the result of Bell's theorem. To illustrate this point more clearly, the spatial probability of an entangled quantum state is more clearly defined by the Argand diagram below. It should be noted that the structure of this diagram is exactly of the form of a real two armed experiment taking place in the laboratory reference frame. In other words any experimental apparatus designed to test the outcome of a two armed experiment is the "solid form" of an Argand diagram. That is to say that the $+Re$ axis resolves the alternative state in the $-Re$ axis of the experiment.

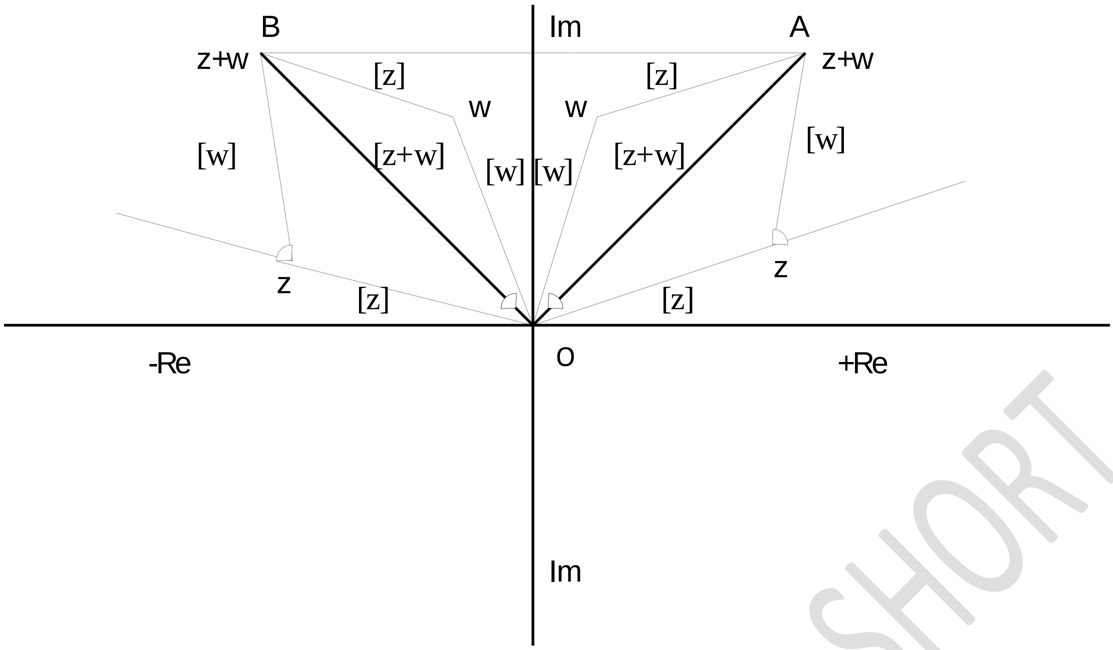

Fig.6

Generally the quantum state defined at the point z on an Argand diagram is the squared distance $|z|^2$ from the origin o and becomes an actual probability when magnified to the classical level, in other words the quantum state $z+w$ is the squared modulus of $z+w$ i.e. $|z+w|^2$. Going on from here it follows that the squared modulus in the negative $(-Re)$ arm of the experiment is equal but opposite to the squared modulus in the positive arm $(+Re)$ thus, both possibilities are raised to realities by the intervention of the potential at O, the difference being that they are each of opposite parity. Classically it is considered to be the act of observation which resolves the quantum state, but this is not a precise description. In fact it is the existence of a potential which decides the resolution of the state of entanglement. It is most important that we understand that the quantum state defined at the points A and B in a two armed experiment is the squared modulus of the sum of two complex numbers i.e. $|z+w|^2$ and that the quantum state at *A* and *B* is defined by a distance in space time *OA* or *OB* and that both states are real numbers but of opposite sign as demonstrated in Fig 6 above. Furthermore it is the existence of the potential at *O* which has resolved the entangled state into its component parts and it is the existence of a further potential at either *A* or *B* which provides information to the observer about which precise state, up or down it is that he is examining and thus we note that it is the existence of potentials which resolve quantum probabilities into classical actualities. In this regard Equation 25 demonstrates that the potential acts like a raising operator in that it instigates a total internal reflection and induces a phase change in space-time. Furthermore, in the diagram the line *AB* represents a distance in space-time between an observer at *A* who defines a quantum state and the *instantaneous* resolution of the quantum state at *B* no matter how far apart from each other *A* and *B* may be. Now if the observation at *A* was produced by the intervention of a potential at A then it is reasonable to conclude that the observation at B has been produced by a potential of some kind at B (because it cannot have been resolved without the intervention of a potential). But what kind of potential?

In his book Shadows of the Mind, Roger Penrose points out correctly that the gravitational force between the electron and the proton in a hydrogen atom is

smaller than the electric force between those particles by a factor of some $\frac{1}{2.85x10^{40}}$. In other words gravity is not noticed by either particle at inter-orbital distances and can thus have no effect and can be disregarded as having any influence on the state vector reduction and yet as pointed out earlier the only physical phenomenon which can influence causal relationships between space time events is gravitation. To sum up then the collapse of the wave function is at once (1) a causal gravitational effect, but the gravitational force involved is too weak the cause by a factor of billions or (2) a non-causal, non-physical effect which propagates at superluminal speeds. Both of these descriptions are outside the laws of physics as presently understood so where do we look for an answer? My suggestion would be that we should look for further new laws of physics which are applicable to both gravitational theory and quantum theory.

I have already described the features of a negative gravitational field and now turn to the question of finding a similarly structured phenomenon in the quantum world. The prime requirements for such a phenomenon would be threefold, firstly to account for the dichotomy between the local hidden variable and the non-local hidden variable models, secondly to provide a background quantum gravitational potential field and thirdly to account for the effects of that potential field which should increase in influence with distance from the quantum event.

One way to account for the dichotomy between local hidden variable and non-local hidden variable models would be to show that the predictions of quantum theory were statistical and this could be achieved if those predictions were determined by factors which cannot, at present, be directly observed.

One theory which will serve to account for the hidden variables is known as the de Broglie-Bohm theory which describes a situation whereby sub-atomic particles such as electrons which always possess a real position and velocity are accompanied by a matter wave which acts as a guide or pilot to the motion of the particles so that their statistical properties are as predicted by quantum theory.

The de Broglie-Bohm theory is a non-local hidden variable theory and the non-local hidden variable produced by the theory is called the quantum potential which we will define as *U* and which is described in the following text taken from Rae (Ref.27). Here it is important to note that the quantum potential produced in any two armed experiment is produced simultaneously throughout space at the point where the two arms diverge and therefore the potential field serves to connect the two arms at any distance between them. (Ref.25)

The de Broglie-Bohm theory begins from the Schroedinger equation governing the motion of a particle of mass m in a potential V(**r**) as follows:-

$$i\hbar/\delta t = -(\hbar^2/2m)\nabla^2\psi + V\psi \qquad \text{Equ.26.1}$$

We now define quantities R and S as real functions of **r** such that:-

$$\psi = R\ exp(iS/\hbar) \qquad \text{Equ.26.2}$$

Substituting from (26.2) into (26.1) we get :-

$i\hbar(\delta R/\delta t)exp(iS/\hbar) - R(\delta S/\delta t)exp(iS/\hbar) = -(\hbar^2/2m)[\nabla^2 R + 2i(\nabla R) \cdot$

$(\nabla S/\hbar + iR\nabla^2 S/\hbar - R(\nabla S)^2\hbar^2)]exp(iS/\hbar) + VRexp(iS/\hbar)$ Equ.26.3

We now cancel the common factor $exp(iS/\hbar)$ and separate the real and imaginary parts to get two equations:-

$\delta S/\delta t + \left(\frac{1}{2}m\right)(\nabla S)^2 + V - (\hbar^2 2m)(\nabla^2 R/R) = 0$ Equ.26.4A

$\delta R/\delta t + (\nabla R) \cdot \left(\frac{\nabla S}{m}\right) + R\nabla^2/2m = 0$ Equ.26.4B

If we multiply26.4B by 26.4A and re-arrange we get:-

$\delta R^2/\delta t + \nabla \cdot (R^2 \nabla S/m) = 0$ Equ.26.5

We can also re-write the first part of Equ.26.4A as:-

$\delta S/\delta t + \left(\frac{1}{2}m\right)(\nabla S^2) + V - U = 0$ Equ.26.6

Where U is defined as:-

$U = (\hbar^2/2m)\nabla^2 R/R$ Equ.26.7

What has been done so far is to re-write the Schroedinger equation in terms of the new functions R and S which represent the amplitude and spin respectively of the wave and its accompanying particle.

However we can now see that this re-casting leads to the physical ideas underlying the de Broglie-Bohm theory. First we note that R^2 equals $|\psi|^2$ which is the probability density of finding a particle in the vicinity of r If we make the further assumption that the particle at the position r has velocity V where $V = \nabla S/m$ then Equation 30.5 is simply the equation of continuity which states that the rate of increase (or decrease) of the probability density in any element of volume must equal the average net flow of particles into (or out of) it. Secondly, in re-writing the Schroedinger equation in this manner we have thrown up the existence of U which is the quantum potential.

The de Broglie-Bohm theory has not gained universal acceptance for two reasons. Firstly because of the existence of the quantum potential which essentially “drops out” of the de Broglie-Bohm model and is generally thought to have no classical analogue. Secondly the theory is not widely accepted because it is a non-local theory. That is to say that the particle may be influenced not only at the point where the particle is but also by the values of the quantum potential at other points in space. In the case of two interacting particles, the wave function and hence the quantum potential are functions of the co-ordinates of of both particles. Any change in the real potential $V(r_1 r_2)$ in the vicinity of one particle produces an *immediate* change in the joint wave function and hence the quantum potential of the other particle even though the two particles may be a very large distance apart. The potential is a field in space-time and as such has the capacity to instantaneously resolve the quantum state at any point in space-time.

One cannot over emphasise the importance of the simultaneity of the change in the joint wave functions as described above. This joint function means that the two wave functions and the quantum potential act completely as if they were one single component and this simultaneity is more commonly described as quantum coherence.

Having postulated the existence of the quantum potential and noting its intimate relationship to the concept of quantum coherence, it is now necessary to describe the influence of this potential on the geometry of space time. It has been said that there is no classical analogue for this potential, however, as will be shown, the quantum potential does have an analogue when compared with the repulsive gravitational field as already described and it will be seen that, as with the repulsive gravitational field, the quantum potential field acts in a similar manner to the gravitational field in shaping the geometry of space time.

As has already been noted, the geometry of space time is directly influenced by the presence of matter and both are therefore inter-dependent. Therefore we can postulate the geometry of space time can be described as a gravitational phenomenon and that therefore we can reiterate that there is a classical analogue for the quantum potential U and we can go further and say that U is in fact a gravitational potential and that this potential permeates all space within any given quantum experiment in the form of a field which accompanies the motion of any particle. In the case of any multiple of particles moving in the field, then the potential acts on all the particles because the field, the particles and the potential are all parts of the same coherent wave function.

Since the field and the particles are all emitted at the same time and at the same point they propagate through space in the form of a spherical wave and this being the case we can use Gauss' law to describe the geometry of space time within the spherical wave.

Although the de Broglie-Bohm theorem concerns a particle of mass m in a potential, we can develop the concept of the potential U by imagining a point charge emitting a spherical electromagnetic wave.

The quantum potential produced at the point of origin of the wave permeates all space within the spherical distribution of radius r_0 and charge ϕ .

The electric field and its accompanying quantum potential U in exactly the same way as a normal electric potential as follows:-

Let ρ represent the volume charge density i.e :- $\rho = \frac{\phi}{4\pi r_0^3/3}$ where ϕ is the total charge on the sphere and $4\pi r_0^3/3$ is the volume of the sphere. The charge inside the sphere of radius r_0 is the product of the charge density and the volume of the sphere and Gauss's law for this case is $E(4\pi r^2) = \frac{\phi r^3/r_0^3}{\epsilon_0}$ and solving for E gives :-

$$E = \frac{\phi r}{4\pi\varepsilon_0 r_0^3} \qquad (r < r_0) \qquad \text{Equ. 27}$$

From Equation 27 we know that the field distribution within the charge is radial and therefore we can calculate the value of the potential inside the charge as follows :-

The potential U_0 at any point on the surface of the sphere is:-

$$U_0 = \frac{\phi}{4\pi\varepsilon_0 r_0} \qquad \text{Equ. 28}$$

If r_b corresponds to a point inside the sphere and r_0 corresponds to a point on the surface of the sphere we can write:-

$$U_b - U_0 = \frac{\phi}{8\pi\epsilon_0 r_0^3}\ (r_0^2 - r_b^2) \qquad [r_b \leq r_0] \qquad \text{Equ. 29}$$

Substituting U_0 from Equation 32 into equation 33 and solving for U_b we find:-

$$U_b = \frac{\phi}{8\pi\varepsilon_0 r_0^3}\ (3r_0^2 - r_b^2) \qquad [r_b \leq r_0]$$

This then establishes the value of the gravitational potential U within an electromagnetic field and the same potential will apply to any other quantum event.

Since we have now identified the existence of a gravitational field produced within the coherent wave function of a quantum event we can now examine the effects of that gravitational field on the geometry of space time contained within the coherent wave function and it will be shown that there is an interchangeable equivalence between the negative gravitational field and the frequency and wavelength of any given wave function.

It is well known that a gravitational field can have the effect of changing the frequency and wave length of an electromagnetic wave but our proposition now is to examine how it is that an electromagnetic wave has the reciprocal effect of producing a negative gravitational field.

If electromagnetic radiation of frequency f_1 is emitted at a point where gravitational potential is low and is symbolised by ϕ_1 then frequency f_2 when measured at a place where gravitational potential is high and is symbolised by ϕ_2 is given by :-

$f_2 = f_1\left(1 + \frac{\Delta\phi}{c^2}\right)$ where $\Delta\phi = \phi_2 - \phi_1$ and $f_1 = \frac{f_2}{1+\frac{\Delta\phi}{c^2}}$ and solving for $\Delta\phi$

we can write $\Delta\phi = -c^2\left(1 - \frac{f_2}{f_1}\right)$.

Since $\Delta\phi = \phi_2 - \phi_1$ represents a change in gravitational potential energy caused by a change in frequency of an electromagnetic wave, so we can describe this change as being the work done by the change in frequency on the gravitational potential of the system as follows:-

$W = \int_{\phi_1}^{\phi_2} F_x(x)\,dx$ thus $\phi_2 - \phi_1 = -\int_{\phi_1}^{\phi_2} F_x(x)\,dx$

That is to say that the change in potential is the manifestation of a force $F_x(x)$ which is caused by the change in frequency of the electromagnetic wave and we can note that $\Delta\phi$ represents the distance between the areas of high and low potential within the spherical wave.

Given the equivalence between electromagnetism and a negative gravitational field we can surmise that the point of origin of an electromagnetic wave is an area of high gravitational potential and that any other point on the expanding surface area of the wave is at a lower gravitational potential because areas of shorter wavelength correspond to areas of high gravitational potential and vice versa.

The properties of an electromagnetic wave can be described in terms of gravitation because the gravitational force within the wave is a product of the gravitational potential difference within the wave and can be described in terms of the redshift i.e. the changing frequency of the emitted wave with distance from the source. Since the photon is a massless particle we can define the dimensionless redshift parameter z of a photon as being $z = \frac{gr}{c^2}$ where r is the distance between points *a* and *b* and solving for g we note that $g = \frac{c^2 z}{r}$ and that z is equivalent to the potential difference $\Delta\phi$ and these relationships will be discussed in the final pages of this chapter.

The solution for g describes the properties of an electromagnetic wave in terms of its gravitational effects in a very similar manner to the negative gravitational field as previously described whereby within the spherical wave front the Weyl tensor = 0 and the Ricci tensor = ∞. Therefore at this point it will be as well to re-state in brief those principles which are common to electromagnetism and gravitation.

Firstly if we treat the charge Ω in a similar manner to the mass density of a body we can express the gravitational force exerted by the electromagnetic wave as $g = \frac{\Omega R}{4\pi G R_0^3}$ $(R \leq R_0)$ i.e. the gravitational field increases linearly with R at points inside the wave and thus we can infer that the gravitational force is distributed uniformly over the surface of the wave i.e. $g = \frac{\Omega}{4\pi G R_0^2}$ and therefore the point of origin of the wave is lying in a symmetrical force field and consequently there is no tidal (i.e. directional) effect and therefore the tensor Weyl =0. Since the acceleration due to gravity is due entirely to the area $4\pi R^2 \rho$ thus $g = \Lambda = 4\pi G\rho$. As previously described the Λ term is an expression for a repulsive gravitational field which modifies the laws of general relativity at large distances into a repulsion proportional to distance i.e. $R = \Lambda R$ with Λ constant and this applies equally to the gravitational field produced by a spherical electromagnetic wave and by any coherent quantum wave function. The Λ term is consistent with Einstein's field equations as previously described and enables us to again write $\ddot{R} = -\frac{4\pi G \rho_{mo} R_0^3}{3}\frac{1}{R^2} + \frac{\Lambda R}{3}$ which is equally applicable to both the macroscopic universe as to the electromagnetic wave and as before the Λ term has negligible effect near $R = 0$ but its effect increases with distance from $R = 0$ and again we can conclude that the expansion of the spherical wave front is due to the gravitational repulsive effect of the Λ factor and its accompanying gravitational quantum potential U. As the area of the expanding wave front increases so does the volume of the space enclosed within the spherical wave front and therefore the dimensions of any particular volume of space time change proportionally with distance from the origin, for example the dimensions of a light cone within a repulsive gravitational field manifest themselves in a manner similar to Fig. 7 below.

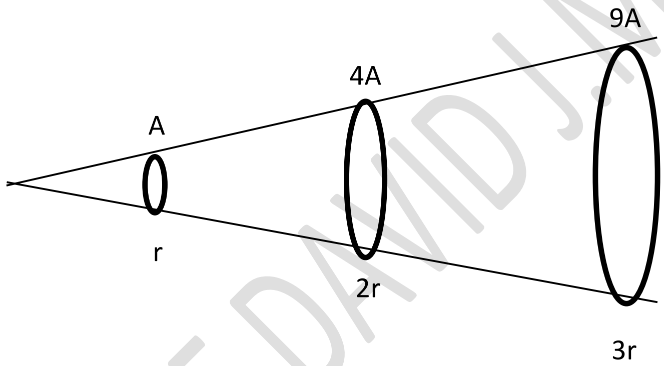

Fig. 7

In the diagram the area A of the face of the cone increases as the square of the distance from the source and therefore the curvature of space time at any point within the cone decreases with distance from the source and the relative curvature at any particular point can be calculated.

The quantum potential U within the cone is accompanied by an energy density $U_{(E)}$ so that we can again use Gauss's law to calculate g due to a plane area of $U_{(E)}$ at point in the cone by treating the plane area as a very thin slice of a long cylinder or a "disc" of energy density. Around the curved surface of the disc the gravitational acceleration is perpendicular to the outward normal unit vector $\boldsymbol{n}$ so that the curved sides of the disc contribute nothing to the integral. At each side of the disc g is anti-parallel to $\boldsymbol{n}$ so $g \cdot \boldsymbol{n} = -g$ at each side and therefore we can write:-

$$\oint g \cdot n dA = -4\pi G U_{(E)}$$

$$\therefore -g \oint dA = -4\pi G U_{(E)}$$

The integral in this case is the area of the two sides of the disc *2A* therefore $-g(2A) = -4\pi G U_{(E).}$ Since the disc is very thin it can be treated as a circle of area A and energy density $U_{(E)}A$ and cancelling $-2A$ on both sides we get:-

$$g = 2\pi G U_{(E)} \qquad \text{Equ.30}$$

thus at any point on the area A, $U_{(E)}A$ is proportional to the square of the distance r from the source. Additionally we note that the intensity of the wave decreases as the inverse square of the distance from the source and therefore the reduction in intensity is proportional to the change in gravitational potential energy within the system and we can write:-

$U_{(E)f} - U_{(E)i} = -\rho g r_f - \rho g r_i$ (where ρ is the mass energy density) and this is the negative of the work done by the gravitational force manifested in the potential *U*. This then establishes the general form of the repulsive gravitational field within the spherical wave and its effects on the structure and geometry of space time at the macroscopic level, but it is at the quantum level that the effects and the magnitude of the potential *U* can be quantified.

The expression already referred to relating to the change in frequency of an electromagnetic wave which is under the influence of a gravitational field is $= \frac{gr}{c^2}$. Now while *z* itself is a dimensionless number both *r* and *g* can be calculated and as the change in frequency is proportional to the change in gravitational potential of the field, then a numerical value can be placed on the potential difference *z* and to achieve this we can resort to the familiar Planck units.

It will be recalled that Planck units (also known as natural units) represent the point at which relativistic space time dimensions and quantum conditions share an interface and therefore can react with one another. The Planck units we shall be using are as follows:-

Planck time $t_p = \sqrt{\frac{G\hbar}{c^5}} \quad = 5.4x10^{-44}$ secs.

Planck length $l_p = \sqrt{\frac{G\hbar}{c^3}} \quad = 1.6x10^{-35}$ mtrs.

Planck mass $m_p = \sqrt{\frac{\hbar c}{G}} \quad = 2.1x10^{-5}$ grams.

Planck energy $E_p = \sqrt{\frac{\hbar c^5}{G}} \quad = 2.0x10^{9}$ joules

And here we note that the constants *ħ*, *c* and *G* are all normalised to *1*.

Bearing in mind the fact that we are examining the gravitational conditions inside a spherical electromagnetic wave and that the nature of those conditions is that the gravitational field is repulsive and not attractive we can examine the expression for *z* as applied to the quantum state within the sphere. Taking the expression for *z* we can calculate the value for *g* (the acceleration due to gravity) within the sphere by writing $g = \frac{c-0}{t_p}$ i.e. the particles (photons) have been accelerated from rest to *c* and since the value of *c* is constant therefore $g = \frac{3x10^8}{5.4x10^{-44}}$ therefore $g = 5.6x10^{51}\ m.s^{-2}$.

Subsequent to this a value can be placed on *z*. As previously stated *z* is an expression for the change in frequency of an electromagnetic wave under the influence of a gravitational field and similarly it is an expression for the change in potential in a gravitational field. In expressing a value for *z* at the quantum level we can again write $z = \frac{gr}{c^2}$ and knowing the value of *g* and substituting l_p for r we can write :-

$$z = \frac{5.6x10^{51}\ x\ 1.6x10^{-35}}{9x10^{16}}$$

$$= \frac{9x10^{16}}{9x10^{16}}$$

$$= 1.$$

We have previously noted that the values of Λ and g are related on the macroscopic scale via $g = \Lambda = 4\pi G\rho$ so thus if both *G* and *z* are normalised to 1 we can write:-

$$\Lambda = \frac{c^2 z}{r} = \frac{c^2}{l_p} = \frac{9x10^{16}}{1.6x10^{-35}} = 5.6x10^{51}$$

$$\therefore \Lambda = g$$

The force required to initiate the expansion of the spherical wave at the quantum level can be calculated in the conventional way i.e:-

$$F = m_p g \quad = \ 2.1x10^{-8} \ x \ 5.6x10^{51}$$

$$= 1.18x10^{44} \ N.$$

And the energy required is given by :-

$$W = E = Fl_p \ = \ 1.2x10^{44} \ x \ 1.6x10^{-35}$$

$\approx 2x10^9$ joules

which is equivalent to the Planck energy as previously described. Having noted from Equation 34 that $g = 2\pi GU_{(E)}$ but with $2\pi G$ normalised to 1 and that $g = 5.6x10^{51}m.s^{-2}$ we are faced with the proposition that there exists at the quantum level, a gravitational potential which does, for all practical purposes, cause information to be transferred within the system, literally instantaneously and which accounts for the instantaneous collapse of the wave function as described on pages 45, 53 and 58. Similarly it is this potential which must account for the phenomenon of quantum coherence which is in effect the manifestation of simultaneous group activity at the quantum level.

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