Exploring the Possibility of New Physics
Part II
Clashing with General Relativity near Black Holes

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Abstract

The first section of this paper (Quantum mechanics and the Warping of Spacetime) attempted to show that the fundamental particles of the Standard Model can be built from infinite superpositions borrowing mass from a Higgs type scalar field and energy from zero point fields. As zero point energy densities are limited, especially at cosmic wavelengths, this requires space to expand exponentially with time to make the zero point energy available, equal to that required. There is a minimum graviton wavenumber $k_{\min}$ at which this balance occurs. The density of these $k_{\min}$ gravitons is $\rho_{Gk\min} = K_{Gk\min} dk_{\min}$ where $K_{Gk\min}$ is a constant scalar, in any coordinates, at all points in spacetime. The value of $k_{\min} \approx R_{Horizon}^{-1}$ decreases with cosmic time T, but increases around mass concentrations, inversely to the value of g_{00} in the local metric. These borrowed cosmic wavelength quanta are Planck energy zero point modes redshifted from a holographic horizon receding at light velocity. We suggested that an infinitesimally modified General Relativity is consistent with this. This paper extends these arguments to include angular momentum and the Kerr Metric. In the first paper to keep things simple we used the fact that the vast majority of $k_{\min}$ gravitons around mass concentrations is due to $\left[\psi(\text{Universe})*\psi_m + \psi_m*\psi(\text{Universe})\right]$. We ignored the relatively smaller number of $k_{\min}$ gravitons emitted by mass concentrations themselves ($\psi_m * \psi_m$). This paper includes their effect and proposes that as well as the usual $2m/r$ term, the metric also includes an m^2/r^2 term (in Planck units) causing insignificant changes in the solar system ($\approx 10^{-16}$ at Earth radius versus $\approx 10^{-8}$ for the normal $2m/r$ metric term). The effect of this extra term however is more significant close to Black Holes. The radius of a non-rotating Black Hole increases $\approx 27\%$ from $r = 2m$ to $r \approx 2.54m$, but a maximum spin Black Hole remains at $r = m$. These changes should only significantly affect the fine details of the last two or three cycles of gravitational waves from black hole mergers, and will probably only be possible to test for after further accuracy improvements in the future. Depending on the degree of spin, these changes may reduce slightly the maximum possible neutron star mass before a black hole forms. The T_{00} component of the Stress Energy tensor is based on mass densities and does not appear to naturally relate with an m^2/r^2 term in the metric. This may introduce a tension with General Relativity in its current form, but only in the extreme region near black holes. It may also possibly question the validity of the Equivalence Principle in these regions.

1 Introduction

The universe we live in is currently described by two models: “The Standard Model of Particle Physics” and “The Standard Model of Cosmology”. An excellent summary of these models, their problems and possible solutions, can be found in the popular science magazine “New Scientist” 24 September 2016. It very succinctly describes: “Six Principles, Six Problems and Six Solutions.” While the Standard Model of Particle Physics is remarkably accurate in its predictions, and apparently complete, it is also as they say in this article “strangely incomplete”. Supersymmetry, proposed to solve some of its issues, is not panning out as expected, and increasingly particle physicists are facing the uncomfortable prospect that it may not be the hoped for answer. Nuetrinoes have a small mass when they shouldn’t, without supersymmetry there is no force unification, and gravity is not included.

In the first paper [7] we attempted to show that the fundamental particles of the Standard Model can be built from infinite superpositions apart from infinitesimal but important differences. They all had mass which naturally divided into two sets. Spin 2 gravitons, spin 1 photons and gluons, all had infinitesimal mass approximately the inverse of the causally connected horizon radius or $\approx 10^{-33} eV$. They all travel at virtually light velocity.The rest had finite masses of micro electron volts upwards. The fundamental forces all related with each other, at the Planck energy cutoff of superpositions; but in a manner that seemed to fit nicely with the Standard Model. In the final third of this first paper we tried to fit infinite superpositions with General Relativity and The Standard Model of Cosmology. Because these infinite superpositions borrow energy from zero point fields, which are in very limited supply at cosmic wavelengths, we found that space has to expand exponentially with time. It all only worked if space was flat on average. The equations we derived looked the same for all comoving observers. Regardless of an observer’s position in the universe this expansion looked the same apart from the effect of initial quantum fluctuations at the start. This removes one of the key reasons for inflation. The universe in this proposed scenario always looks the same and is flat on average for all observers with or without inflation. Even to observers near the horizon or outside it. The properties and equations controlling distant universes should be identical to ours and there would be no metaverses which are a natural endpoint of inflation. We connected these equations with an infinitesimally modified GR equation locally, but with profound implications at cosmic scale.

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = \frac{8\pi G}{c^4} \left[T_{\mu\nu} - T_{\mu\nu}(\text{Background}) \right]$$

In comoving coordinates $T_{\mu\nu}(\text{Background})$ has just one component $T_{00} = \rho_U$ the average density of the universe.

This modification limits the range of GR to scales smaller than the radius of the universe and guarantees flatness on average regardless of the value of Ω. The overall exponential expansion of space is controlled by equations balancing the zero point energy available to that borrowed by infinite superpositions. Dark Energy is not required for this accelerating expansion, but Dark Matter is still required inside galaxies to hold them together against centrifugal forces due to their fast rotation. We found a spin 2 massive graviton type infinite superposition as a possible dark matter candidate that would not show up in current weak interaction type searches. Spacetime has to warp in accord with GR around mass concentrations to make available the zero point energy required by their extra cosmic wavelength gravitons. To keep things simple we looked only at the long range gravitons emitted by this mass that interact with the rest of the mass in the universe $\left[\psi(\text{Universe})*\psi_m + \psi_m*\psi(\text{Universe})\right]$ while ignoring the relatively smaller number of long range gravitons emitted by the mass interacting with itself ($\psi_m*\psi_m$). This paper looks at the $(\psi_m*\psi_m)$ term which is only significant close to black holes. It unfortunately messes up a nice agreement with the Schwarzchild solution by adding an m^2/r^2 term (in Planck units). In the solar system this is insignificant, where at Earth radius $m/r \approx 10^{-8}$ & $m^2/r^2 \approx 10^{-16}$, but a non rotating black hole radius increases approximately 27% from $r = 2m$ to $r \approx 2.54m$. With angular momentum this becomes the modified ergosphere maximum diameter, but the radius of a maximum spin black hole is unchanged at $r = m$. These changes may possibly introduce a tension with the field equations of General Relativity, but only close to Black holes. The T_{00} component, based on mass/energy density, does not seem to naturally relate with an m^2/r^2 term. The Riemannian tensor however, that controls the curvature of spacetime would remain king, always controlling the metric. This will hopefully become clearer as we proceed. These changes would only be seen as small changes in the last few cycles of the gravitational waves from black hole mergers recently observed. The accuracy of these observations will almost certainly improve with time and these changes may be detected. They may also change slightly the maximum mass at which neutron stars form black holes depending on their angular momentum.

At the risk of some repitition with the above we repeat some of the abstract and introduction of that earlier paper:

“In a different approach, it proposes fundamental particles formed from infinite superpositions with mass borrowed from a Higgs type scalar field. However energy is also borrowed from zero point vector fields. Just as the Standard Model divides the fundamental particles into two types…those with mass and those without, with the Higgs mechanism providing the difference…infinite superpositions seem also to divide naturally into two sets: (a) those with “infinitesimal” mass, and (b) those with significant mass (from micro electron volts upwards). In the infinitesimal set (a), photons, gluons and gravitons (so that gravitons in particular can span the cosmos) all have $\approx 10^{-33}$ eV mass, approximately the inverse of the *radius of the causally connected, or observable universe* $R_{OU} \approx 46\times10^{9}$ light years. This mass is also close to some recent proposals [8] giving gravitons a mass of $<10^{-33} eV$ to explain the accelerating expansion of the universe. These infinitesimal mass values are so close to zero the symmetry breaking of the Standard Model remains essentially valid. These particles travel so close to the speed of light they have virtually fixed helicity, with the Higgs mechanism increasing their mass from infinitesimal type (a) to significant or measureable type (b) values."

In that earlier paper infinite superpositions are always built in some rest frame in which they had no nett momentum $\mathbf{p}$ but only $\mathbf{p}^2$ terms. In the "infinitesimal" mass set this rest frame can be, and usually is, travelling at almost light velocity, as seen from our usual (nearly) comoving frame. We also divided the world of all interactions into two sets.

(a) **Primary Interactions** are only virtual. They build all the fundamental particles in the form of infinite superpositions.

(b) **Secondary Interactions** are all the others that occur between fundamental particles, both virtual and real. They are the real world of experiments that the Standard Model is all about.

The rules for borrowing energy from zero point fields can be different for both (a) & (b).

Primary interactions are between spin zero particles borrowed from a Higgs type scalar field and the zero point vector fields. In the 1970's models were proposed with preons as common building blocks of leptons and quarks [10] [11] [12] [13] In contrast with the spin zero particles in this paper, most of these earlier models used *real spin ½* building blocks. As in earlier models this paper also calls the common building blocks preons, *but here the preons are both virtual, and spin zero bosons.* There are only three preons; red, green and blue, all with positive electric charge. There are also three anti preons; antired, antigreen and antiblue, all with negative electric charge. As preons are spin zero there can be no weak charge involved in primary interactions. This is all explained more fully in the first paper. These preons build all spin ½ leptons and quarks, spin 1 gluons, photons, W & Z particles, plus spin 2 gravitons. This is in contrast to only leptons and quarks in the earlier models.

In the *rest frame* in which the particles are built the spin zero preons are born with *zero momentum*. This means they are *born with infinite wavelength* allowing the possibility that they *can borrow zero point energy from an infinite distance*. We proposed that they borrow redshifted Planck energy zero point quanta from a holographic horizon receding at light like velocities relative to comoving coordinates instantaneously on that horizon. This is necessary because at cosmic wavelengths of $\approx R_{OU}$ the density of zero point modes is almost zero and insufficient to build all the fundamental particles; gravitons in particular. We also found that there is always some minimum wavenumber $k_{\min} \approx R_{OH}^{-1}$ where the density of this redshifted supply of zero point quanta is equal to that required to build gravitons which are the largest user of these cosmic wavelength quanta. At minimum wavenumber $k_{\min}$ the probability density of gravitons is $\rho_{Gk\min} = K_{Gk\min} dk_{\min}$ where $K_{Gk\min}$ is a constant scalar, in any coordinates, at all points in spacetime. The value of $k_{\min} \approx R_{Horizon}^{-1}$ however depends on the cosmic time T, but also on the value of g_{00} in the local metric. The Riemannian spacetime curvature tensor is controlled by the need to keep what we call "The $k_{\min}$ Graviton Constant $K_{Gk\min}$" invariant.

For the sake of clarity, and to avoid continually referring to the earlier paper this paper repeats (with some changes and corrections) some of the final third (of the earlier paper), but now includes cosmic wavelength gravitons emitted by the mass interacting with itself $(\psi_m * \psi_m)$, and also includes the effects of angular momentum.

Einstein published his General Theory of Relativity [1] 100 years ago. There have been many attempts over the intervening years to modify it with different goals in mind. A dissertation by Germanis [2] discusses some of these modifications [3] [4] [5] [6] . If we ignore the possible tension with General Relativity close to black holes, the main modification proposed in these papers, $T_{\mu\nu} - T_{\mu\nu}$(Background) versus simply $T_{\mu\nu}$, has an infinitesimal effect locally, but significant implications at cosmic scale. The current Standard Model of Cosmology is based on unmodified General Relativity. It requires Dark energy to accelerate the expansion, it requires $\Omega \approx 1$, it requires Inflation so that regions initially out of causal contact can have (almost) uniform properties and to produce the observed average flatness. The modification in red above, proposed in these two papers, should eliminate the need for these requirements. If $K_{Gk\min}$ is *invariant at all points in spacetime*, the equations controlling the expansion of space and the warping of spacetime around mass concentrations are the same for all observers in this universe and should also be for those far away. There should be no metaverses and no need for anthropic arguments. The original arguments behind the Cosmological Model, of uniformity on average everwhere, should be absolutely true.

While the arguments proposed in these papers are radical, and will no doubt contain many errors, the principles behind them may well suggest a possible different path forward.

It is probably to our evolutionary advantage that what we call established or collective knowledge, or paradigms particularly in science, changes slowly; and only after evidence for change builds to a tipping point. In the end however, science, as it always has in the past, slowly but surely progresses towards the simplest explanations regardless.

2 The Expanding Universe and General Relativity

2.1 Zero point energy densities are limited

If the fundamental particles can be built from energy borrowed from zero point fields and as this energy source is limited, (particularly at cosmic wavelengths) there must be implications for the maximum possible densities of these particles. In section 2.2.3 in [7] we discussed how the preons that build fundamental particles are born from a Higg's type scalar field with zero momentum in the laboratory rest frame. In this frame they have an infinite wavelength and can thus be borrowed from anywhere in the universe. This would suggest that there should be little effect on localized densities, but possibly on overall average densities in any or all of these universes. So which fundamental particle is there likely to be most of? *Working in Planck, or natural units with $G=1$ we will temporarily assume the graviton coupling constant between Planck masses is one.* (We will modify this later but it helps to illustrate the problem.) As an example there are approximately $M \approx 10^{61}$ Planck masses within the causally connected or observable universe. They have an average distance between them of approximately the radius R_{OH} of this region. Thus there should be approximately $M^2 \approx 10^{122}$ virtual gravitons with wavelengths of the order of radius R_{OH} within this same volume. No other fundamental particle is likely to approach these values, for example the number of virtual photons *of this extreme wavelength* is much smaller. (Virtual particles emerging from the vacuum are covered in section 2.5.4) If this density of virtual gravitons needs to borrow more energy from the zero point fields than what is available at these extreme wavelengths does this somehow control the maximum possible density of a causally connected universe?

2.1.1 **Virtual Particles and Infinite Superpositions**

Looking carefully at section 3.3 in [7] we showed there that, for all interactions between fundamental particles represented as infinite superpositions, the actual interaction is between only single wavenumber k superpositions of each particle. *We are going to conjecture that a virtual particle of wavenumber k for example is just such a single wavenumber k member*. Only if we actually measure the properties of real particles do we observe the properties of the full infinite superposition. The full properties do not exist until measurement, just as in so many other examples in quantum mechanics. We will use this conjectured virtual property below when looking at the probability density of virtual gravitons of the maximum possible wavelength. These virtual gravitons would be a superposition of the three modes $n=3,4,5$ of a single wavenumber k, as in Table 4.3.1 in [7]. Time polarized or spherically symmetric versions would be a further equal $(1/\sqrt{5})$ superposition of $m=-2,-1,0,+1,+2$ states of the above $n=3,4,5$ mode superpositions. A spin 2 graviton in an $m=+2$ state is simply a superposition of the three modes $n=3,4,5$ as above but all in an $m=+2$ state. This is explained in the first paper section 3.2.2 page 30 [7] .

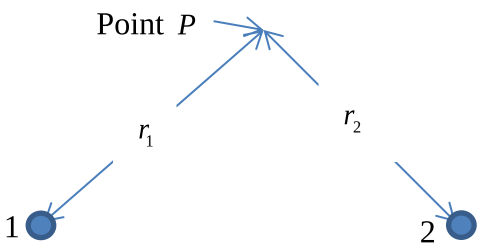
2.1.2 **Virtual graviton density at wavenumber k in a causally connected Universe**

From here on we will work in natural or Planck units where $\hbar = c = G = 1$.

General Relativity predicts nonlinear fields near black holes, but in the low average densities of typical universes *we can assume approximate linearity*. The majority of mass moves slowly relative to comoving coordinates so we can ignore momentum (i.e. $\beta << 1$), provided we limit this analyses initially to comoving coordinates. Spin 2 gravitons transform as the stress tensor in contrast to the 4 current Lorentz transformations of spin 1, but, at low mass velocities the only significant term is the mass density T_{00}. In comoving coordinates the vast majority of virtual gravitons will thus be *time polarized or spherically symmetric* which we will for simplicity call scalar. We should be able to simply apply the equations in sections 3.4 & 3.5 in [7] to spin 2 virtual graviton emissions, as they should apply equally to both spins 1 & 2 at low mass velocities. (This is not necessarily so near black holes.) We will assume spherically symmetric $l = 3$ wavefunctions emit both spins 1 & 2 scalar virtual bosons, and $l = 3, m = \pm 2$ states can emit both $m = \pm 1$ spin 1 bosons and $m = \pm 2$ spin 2 gravitons. Section 3.4 in [7] derived the electrostatic energy between infinite superpositions. In flat space we looked at the amplitude that each equivalent point charge emits a virtual photon, and then focused on the interaction terms between them. Thus we can use the same scalar wavefunctions Eq's. (3.4.1) in [7] for virtual scalar gravitons as we did for virtual scalar photons. Using $(\psi_1 + \psi_2)*(\psi_1 + \psi_2) = (\psi_1 * \psi_1) + (\psi_1 * \psi_2 + \psi_2 * \psi_1) + (\psi_2 * \psi_2)$ we showed in section 3.4.1 in [7] that the interaction term for virtual photons is

$$\psi_1 * \psi_2 + \psi_2 * \psi_1 = \frac{4k}{4\pi r_1 r_2} e^{-k(r_1 + r_2)} \cos k(r_1 - r_2) \tag{2.1. 1}$$

Figure 2.1. 1



Where r_1 & r_2 are the distances to some point P from two charges or masses 1 & 2, and we are looking at the interaction at point P as in Figure 2.1. 1. Equation (2.1. 1) is strictly true *only in flat space* but it is still approximately true if the curvature is small or when $2m/r <<<< 1$, *which we will assume applies almost everywhere throughout the universe except in the infinitesimal fraction of space close to black holes*. In both sections 3.4 & 3.5 in [7] for simplicity and clarity, we delayed using coupling constants and emission probabilities in the wavefunctions until necessary. We do the same here. There will also be some minimum wavenumber k which we call $k_{\min}$ where for all $k < k_{\min}$ there will be insufficient zero point energy available. We want Eq.(2.1. 1) to still apply at the maximum wavelength whe

$k_{\min} \approx 1/R_{OU}\,(=1/R_{ObsevableUniverse})$. In section 6 in [7] we found gravitons have an infinitesimal rest mass m_0 of the same order as this minimum wavenumber $k_{\min}$. At these extreme k values this rest mass must be included in the wavefunction negative exponential term. It is normally irrelevant for infinitesimal masses. Section 6.2 in [7] looks at $N=2$ infinitesimal rest masses finding $\langle K_{k\min}\rangle^2 \approx 1$. Using Eq. (3.1.11) in [7] with $\hbar = c = 1$

$$\langle K_{k\min}\rangle^2 = \frac{s\langle n^2\rangle k_{\min}^2}{2m_0{}^2} \approx 1 \text{ and for spin 2 gravitons } \frac{\langle n^2\rangle k_{\min}^2}{m_0{}^2} \approx 1 \text{ or } m_0 \approx k_{\min}\sqrt{\langle n^2\rangle} \tag{2.1. 2}$$

From Table 4.3.1 in [7] we find

$$\text{For } N=2 \text{ spin 2 gravitons } \langle n^2\rangle \approx 11.644 \text{ so that } m_0 \approx k_{\min}\sqrt{11.644} \approx 3.412k_{\min} \tag{2.1. 3}$$

This virtual mass m_0 increases the negative energy of the virtual graviton from $-k$ to $-\sqrt{k^2+m_0^2}$. The exponential decay term e^{-kr} in its wavefunction becomes $e^{-r\sqrt{k^2+m_0^2}}$.
Using Eq. (2.1. 3) we can define a k' such that

$$k' = \sqrt{k^2+m_0^2} \approx \sqrt{k^2+11.644k_{\min}^2} \text{ and } k'_{\min} \approx \sqrt{k_{\min}^2+11.644k_{\min}^2} \approx 3.556k_{\min} \tag{2.1. 4}$$

A normalized virtual massles graviton wavefunction is $\psi = \sqrt{\frac{2k}{4\pi}}\frac{e^{-kr+ikr}}{r}$ see Eq. (3.4.1) in [7] and for infinitesimal mass gravitons this becomes using Eq. (2.1. 4)

$$\text{A massless } \psi = \sqrt{\frac{2k}{4\pi}}\frac{e^{-kr+ikr}}{r} \quad \text{becomes with infinitesimal mass } \sqrt{\frac{2k'}{4\pi}}\frac{e^{-k'r+ikr}}{r} \tag{2.1. 5}$$

Thus the massless interaction term in Eq. (2.1. 1) becomes with this infinitesimal mass m_0

$$\psi_1{}^*\psi_2 + \psi_2{}^*\psi_1 = \frac{4k'}{4\pi r_1 r_2} e^{-k'(r_1+r_2)} \cos k(r_1-r_2) \tag{2.1. 6}$$

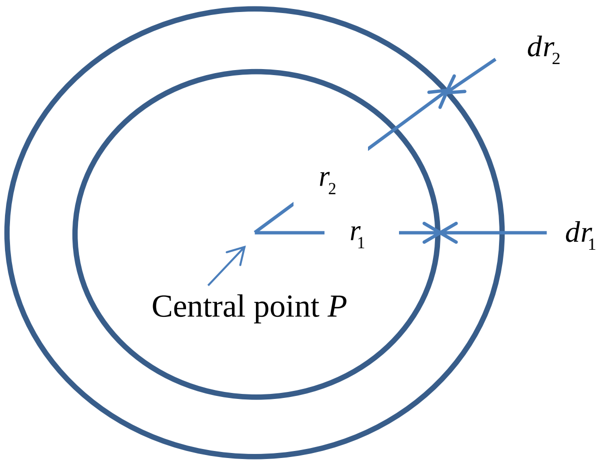


Figure 2.1. 2

Let point P be anywhere in the interior region of a typical universe as in Figure 2.1. 2. Let the average density be ρ_U (subscript U for homogeneous universe density) Planck masses per unit volume. Consider two spherical shells around the central point P of radii $r_1 \,\&\, r_2$ and thicknesses $dr_1 \,\&\, dr_2$ with masses $dm_1 = \rho_U dv_1 = 4\pi r_1^2 dr_1 \rho_U$ & $dm_2 = \rho_U dv_2 = 4\pi r_2^2 dr_2 \rho_U$. Now we expect the graviton coupling constant α_G to be $=1$ between Planck masses but because we do not really know this let us define

$$\text{The Secondary graviton coupling constant between Planck masses } = \alpha_G \tag{2.1. 7}$$

In section 3.4.1 in [7] Eq. (3.4.3) used a scalar emission probability $(2\alpha/\pi)(dk/k)$ which becomes $(2\alpha_G/\pi)(dk/k)$ between Planck masses. (We return to this in section 2.4.2) Now quantum interactions are instantaneous over all space but distant galaxies recede at light like and greater velocities. However at the *same cosmic time T in all comoving coordinate systems, clocks tick at the same rate, and a wavenumber k (or frequency) in one comoving coordinate system measures the same in all comoving coordinate systems*. Thus as we integrate over radii $r_1 \,\&\, r_2 = 0 \to \infty$ we can still use the same equations as if the distant galaxies are not moving. (The vast majority of mass is moving relatively slowly in these comoving coordinate systems and we return to this important comoving coordinate property in section 2.4.1). Using this proposed coupling probability between Planck masses $(2\alpha_G/\pi)(dk/k)$ we can now integrate over both radii $r_1 \,\&\, r_2$; but to avoid counting all pairs of masses $dm_1 \,\&\, dm_2$ twice, we must divide the integral by two. The total probability density of virtual gravitons at any point P in the universe at wavenumber k is using Eq. (2.1. **6**)

$$\rho_{Gk} = \frac{\rho_U^2}{2}\alpha_G \frac{2}{\pi} \iint_{0\to\infty} 4\pi r_1^2 dr_1 \cdot 4\pi r_2^2 dr_2 \cdot \frac{4k'}{4\pi r_1 r_2} e^{-k'(r_1+r_2)} \cos k(r_1 - r_2)$$
$$= 16\alpha_G \rho_U^2 \frac{k'}{k} dk \iint_{0\to\infty} r_1 r_2 e^{-k'(r_1+r_2)} \cos k(r_1 - r_2)$$

Expanding $\cos k(r_1 - r_2) = \cos kr_1 \cos kr_2 + \sin kr_1 \sin kr_2$, then using:

$$\int_{r=0}^{r=\infty} rExp(-k'r)\cos(kr)dr = \frac{k'^2 - k^2}{(k'^2 + k^2)^2} \quad \text{and} \quad \int_{r=0}^{r=\infty} rExp(-k'r)\sin(kr)dr = \frac{2k'k}{(k'^2 + k^2)^2}$$

$$\text{finally yields } \rho_{Gk} = 16\alpha_G \rho_U^2 \frac{k'}{k} dk \frac{(k'^2 + k^2)^2}{(k'^2 + k^2)^4} = 16\alpha_G \rho_U^2 \frac{k'}{k} dk \frac{1}{(k'^2 + k^2)^2} \tag{2.1. 8}$$

From Eq.(2.1. 4) $k' = \sqrt{k^2 + m_0^2} \approx \sqrt{k^2 + 11.644k_{\min}^2}$ and we can write Eq.(2.1. 8) as

$$\rho_{Gk} = 16\alpha_G \rho_U^2 \frac{\sqrt{k^2 + 11.644k_{\min}^2}}{k} dk \frac{1}{\left(2k^2 + 11.644k_{\min}^2\right)^2} = 16\alpha_G \frac{\rho_U^2}{k_{\min}^4} dk \frac{\sqrt{x^2 + 11.644}}{x\left(2x^2 + 11.644\right)^2} \quad \text{where } x = \frac{k}{k_{\min}}$$

$$\text{Wavelength } k \text{ Graviton Probability Density } \rho_{Gk} \approx \frac{0.3056\alpha_G \rho_U^2}{k_{\min}^4} dk \left[\frac{52.35}{x} \frac{\sqrt{x^2+11.644}}{\left(2x^2+11.644\right)^2} \right] \qquad (2.1.\ 9)$$

$$\text{Maximum wavelength Probability Density } \rho_{Gk\min} \approx \frac{0.3056\alpha_G \rho_U^2}{k_{\min}^4} dk_{\min} \text{ when } \frac{k}{k_{\min}} = x = 1$$

As we think $K_{G\min}$ will prove to be a universal constant scalar we will write this as follows.

$$\text{Maximum wavelength Probability Density } \rho_{Gk\min} = K_{Gk\min} dk_{\min} \text{ where } K_{Gk\min} \approx \frac{0.3056\alpha_G \rho_U^2}{k_{\min}^4} \qquad (2.1.\ 10)$$

2.2 Can we relate all this to General Relativity?

The above assumes a homogeneous universe that is essentially flat on average. At any cosmic time T it also assumes there is always some value $k_{\min}$ where the borrowed energy density $E_{Gk\min} = E_{ZP\min}$ the available zero point energy density @ $k_{\min}$. It is also in comoving coordinates. At the same cosmic time T, all comoving observers measure the same probability density $\rho_{Gk\min} = K_{Gk\min} dk_{\min}$ as in Eq. (2.1. 10). So what happens if we put a small mass concentration $+m_1$ at some point? The gravitons it emits must surely increase the local density of $k_{\min}$ gravitons upsetting the balance between borrowed energy and that available. However General Relativity tells us that near mass concentrations the metric changes, radial rulers shrink and local observers measure larger radial lengths. This expands locally measured volumes lowering their measurement of the background $\rho_{Gk\min}$. But clocks slow down also, increasing the measured value of $k_{\min}$. Let us look at whether we can relate these changes in rulers and clocks with the $\rho_{Gk\min} = K_{Gk\min} dk_{\min}$ of Eq. (2.1. 10).

2.2.1 Approximations with possibly important consequences

Let us refer back to Eq. (3.4.2) in [7] and the steps we took to derive it; but now including $k' = \sqrt{k+m_0} \approx \sqrt{k^2 + 11.644 k_{\min}^2}$ as in Eq. (2.1. 4)

$$\psi_1 {*} \psi_2 + \psi_2 {*} \psi_1 = \frac{4k'}{4\pi r_1 r_2} e^{-k'(r_1+r_2)} \cos[k(r_1 - r_2)] \qquad (2.2.\ 1)$$

And assume that *space has to be approximately flat* with errors $\propto 1-(1-2m/r)^{1/2} \approx m/r$. If we now focus on Figure 2.1. 1, equation (2.2. 1) is the probability that an infinitesimal mass virtual graviton of wavenumber k is at the point P *if all other factors are one*. Let us now put a mass of m_1 Planck masses at the Source 1 point in Figure 2.2. 1. Also assume that the *point P is reasonably close to mass* m_1 *(in relation to the horizon radius)* at distance r_1 as in Figure

2.2. 1 and *the vast majority of the rest of the mass inside the causally connected or observable horizon* R_{OH} is at various radii r, equal to r_2 of Eq.(2.2. 1) where $r_2 = r >> r_1$ and thus $\cos[k(r_1 - r)] \approx \cos(-kr)$. *Only under these conditions can we approximate Eq.* (2.2. 1) *as*

$$\psi_1 {}^*\psi_2 + \psi_2 {}^*\psi_1 \approx \frac{4k'}{4\pi r_1 r} e^{-k'r} \cos(-kr) \tag{2.2. 2}$$

(We will later find that this approximation is consistent with limiting the range of GR to well inside the horizon but to vast scales)

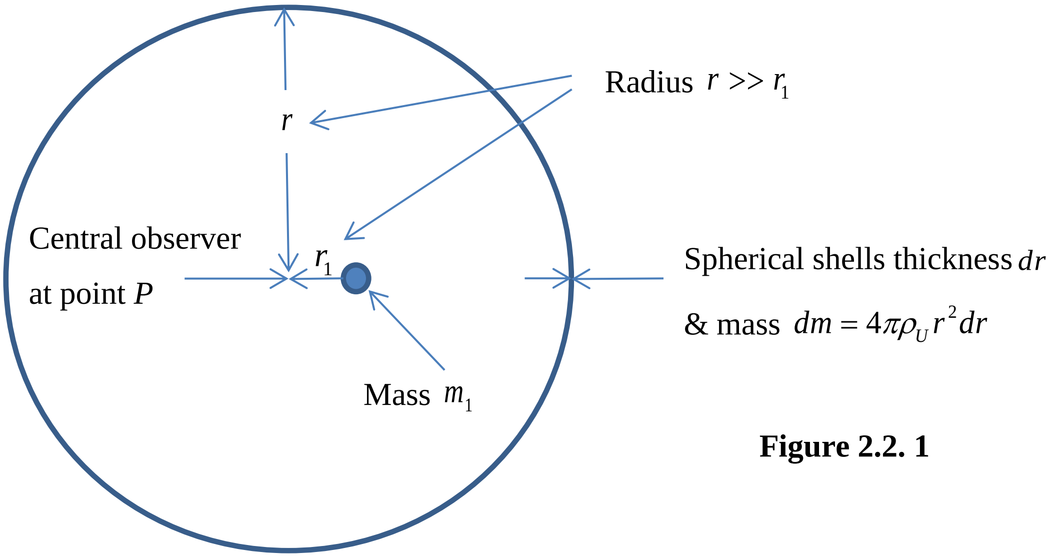


Figure 2.2. 1

As we have assumed average particle velocities are low (relative to comoving coordinates) this is *a time polarized or scalar interaction* and as *there are no directional effects* we can consider simple spherical shells of thickness dr and radius r around a central observer at the point P which have mass $dm = \rho_U 4\pi r^2 dr$. At each radius r the coupling factor $(2\alpha / \pi)(dk / k)$ using Eq. (2.1. 7) again is $(2\alpha_G / \pi)(dk / k)$ between Planck masses *and again we use the fact that all instantaneously connected comoving clocks tick at the same rate*.

$$\text{Coupling factor } = \frac{2\alpha_G m_1}{\pi} dm \frac{dk}{k} = \frac{2\alpha_G m_1}{\pi} \frac{dk}{k} \rho_U 4\pi r^2 dr \tag{2.2. 3}$$

Including this coupling factor in Eq. (2.2. 2)

$$\left(\frac{2\alpha_G m_1}{\pi} \frac{dk}{k} \rho_U 4\pi r^2 dr\right)(\psi_1 {}^*\psi_2 + \psi_2 {}^*\psi_1) \approx \left(\frac{2\alpha_G m_1}{\pi} \frac{dk}{k} \rho_U 4\pi r^2 dr\right)\left(\frac{4k'}{4\pi r_1 r} e^{-k'r} \cos(-kr)\right) \tag{2.2. 4}$$
$$\approx \alpha_G \frac{m_1}{r_1} \frac{8\rho_U}{\pi} \frac{k'dk}{k} r e^{-k'r} \cos(-kr) dr$$

This is virtual graviton density at point P due to each spherical shell. (ignoring the relatively *small number of particularly* $k_{\min}$ gravitons emitted by mass m_1 itself $(\psi_{m_1} * \psi_{m_1})$ see section 2.6.1). Integrating over radius $r = 0 \to \infty$ the virtual graviton density at wavenumber k using Eq's. (2.1. 4 & (2.2. 4)

$$\Delta\rho_G = \alpha_G \frac{m_1}{r_1} \frac{8\rho_U}{\pi} \frac{k'dk}{k} \int_0^\infty re^{-k'r} \cos(-kr)dr$$

$$= \alpha_G \frac{m_1}{r_1} \frac{8\rho_U}{\pi} \frac{k'dk}{k} \left[\frac{(k'^2 - k^2)}{(k'^2 + k^2)^2} \right] \qquad (2.2.\ 5)$$

Now $k'^2 = k^2 + m_0^2 \approx k^2 + 11.644 k_{\min}^2$ and if $k = k_{\min}$ then $k'^2_{\min} \approx 12.644 k_{\min}^2$ & so when $k = k_{\min}$:

$$\Delta\rho_{Gk\min} \approx \alpha_G \frac{m_1}{r_1} \frac{8\rho_U}{\pi} \frac{\sqrt{12.644 k_{\min}^2}\, dk_{\min}}{k_{\min}} \left[\frac{(12.644 k_{\min}^2 - k_{\min}^2)}{(12.644 k_{\min}^2 + k_{\min}^2)^2} \right] \qquad (2.2.\ 6)$$

$$\Delta\rho_{Gk\min} = (\psi_{\text{Universe}} * \psi_{m_1} + \psi_{m_1} * \psi_{\text{Universe}}) \approx \alpha_G \frac{m_1}{r_1} 0.566 \frac{\rho_U}{k_{\min}^2} dk_{\min}$$

Equation (2.1. 10) suggests $\rho_{Gk\min} = K_{Gk\min} dk_{\min}$. In comoving coordinates in a metric far from masses & $g_{\mu\nu} = \eta_{\mu\nu}$, $k_{\min}$ has its lowest value. As we approach any mass $k_{\min}$ increases to $k''_{\min}$ where we use green double primes when $g_{\mu\nu} \neq \eta_{\mu\nu}$ to avoid confusion with the $k' \,\&\, k'_{\min}$ of Eq. (2.1. 4). At a radius r from mass m the Schwarzchild metric is $(1 - 2m/r)^{\pm 1/2}$ for the time and radial terms. Radial rulers shrink and clocks slow, measured volumes and frequencies both increase locally as $\approx 1 + \dfrac{m}{r}$ .Thus using $\rho_{Gk\min} = K_{Gk\min} dk_{\min}$

$$\text{If } r >>> m\,; \quad 1 + \frac{m}{r} \approx \frac{V + \Delta V}{V} = 1 + \frac{\Delta V}{V} \approx \frac{k''_{\min}}{k_{\min}} = \frac{dk''_{\min}}{dk_{\min}} = \frac{\rho''_{k\min}}{\rho_{k\min}} \qquad (2.2.\ 7)$$

So in this metric the total number of $k_{\min}$ gravitons is the original $(g_{\mu\nu} = \eta_{\mu\nu})$ $\rho_{Gk\min}$ of Eq. (2.1. 10) plus the extra due to a local mass of Eq. (2.2. 6), but we have to divide this number by the increased volume to get the new density $\rho''_{Gk\min} \approx (1 + \dfrac{m}{r})\rho_{Gk\min}$. Thus using Eq. (2.2. 7)

$$\text{The new} \quad \rho''_{Gk\min} \approx \frac{\rho_{Gk\min} + \Delta\rho_{Gk\min}}{1 + \Delta V / V} \approx \frac{\rho_{Gk\min} + \Delta\rho_{Gk\min}}{(1 + m/r)} \approx (1 + m/r)\rho_{Gk\min}$$

$$\rho_{Gk\min} + \Delta\rho_{Gk\min} = (1 + m/r)^2 \rho_{Gk\min} \approx (1 + 2m/r)\rho_{Gk\min} \qquad (\text{if } r >>> m)$$

$$\frac{\rho_{Gk\min} + \Delta\rho_{Gk\min}}{\rho_{Gk\min}} \approx 1 + \frac{2m}{r}$$
$$\frac{\Delta\rho_{Gk\min}}{\rho_{Gk\min}} \approx 2\frac{m}{r} \qquad (2.2.\ 8)$$

We can now put Eq's. (2.1. 9), (2.2. 6) & (2.2. 8)) into this, and dropping the now unnecessary subscripts the graviton coupling constant α_G cancels out:

$$\frac{\Delta\rho_{Gk\min}}{\rho_{Gk\min}} \approx \frac{\alpha_G \left[\frac{m}{r}\right] 0.566 \frac{\rho_U}{k_{\min}^2} dk_{\min}}{\alpha_G 0.3056 \frac{\rho_U^2}{k_{\min}^4} dk_{\min}} \approx \left[\frac{m}{r}\right]\left[\frac{1.853 k_{\min}^2}{\rho_U}\right] \approx 2\frac{m}{r} \qquad (2.2.\ 9)$$

(Strictly speaking we should be using $dk''_{k\min}$ in the top line of this equation but the error is second order as we are approximating with $r >>> m$. We will do this more accurately below for large masses.) For the above to be consistent with General Relativity this suggests that:

"At all points inside the horizon, and at any cosmic time *T*, the red highlighted part is ≈ 2 in Planck units. This is simply equivalent to putting $G/c^2 = 1 = G = c$".

Thus we can say

The average density of the universe $\rho_U \approx (0.9266) k_{\min}^2 \approx 0.9266 \frac{\Upsilon^2}{R_{OU}^2}$ (2.2. 10)

Where the parameter $\Upsilon = k_{\min} R_{OH}$ is in radians, and Υ is close to 1.

Putting Eq. (2.2. 10 the average density ρ_U into Eq.(2.1. 10) gives $\rho_{Gk\min}$ & $K_{Gk\min}$.

Maximum Wavelength Graviton Probability Density $\rho_{Gk\min} \approx \frac{0.3056 \alpha_G \rho_U^2}{k_{\min}^4} dk_{\min}$

$$\rho_{Gk\min} \approx \frac{0.3056 \alpha_G (0.9266 k_{\min}^2)^2}{k_{\min}^4} dk \approx 0.262 \alpha_G dk_{\min} = K_{Gk\min} dk_{\min} \qquad (2.2.\ 11)$$

Where we label $K_{Gk\min} \approx 0.262 \alpha_G$ as "The $k_{\min}$ Graviton Constant".

If our conjectures are true, this is the number density of maximum wavelength gravitons excluding possible effects of virtual particles emerging from the vacuum. In section 2.5.4 we argue these do not change the $K_{Gk\min}$ of Eq. (2.2. **11**). However $K_{Gk\min}$ does depend on the graviton coupling constant α_G between Planck masses, but α_G cancels out in Eq.(2.2. 9). It does not affect the allowed universe average density ρ_U in Eq. (2.2. 10).

2.2.2 The Schwarzchild metric near large masses

At a radius r from a mass m (dropping the now unnecessary subscripts) the Schwarzchild metric is $(1-2m/r)^{\pm 1/2}$ for the time and radial terms which can be written as

$$\sqrt{g_{rr}} = \frac{1}{\sqrt{1-2m/r}} = \frac{1}{\sqrt{g_{tt}}} = \frac{1}{\sqrt{1-\beta_M^2}} = \gamma_M \tag{2.2. 12}$$

Velocity β_M ($c=1$) is that reached by a small mass falling from infinity and $\gamma_M^{\pm 1}$ is the metric change in clocks and rulers due to mass m. We are using green symbols with the subscript M for metrics $g_{\mu\nu} \neq \eta_{\mu\nu}$ as we did for $k''_{\min}$ above. The symbols $\gamma_M^{\pm 1}$ help clarity in what follows.

$$\beta_M^2 = \frac{2m}{r}$$

$$\gamma_M^2 = \frac{1}{1-2m/r} = g_{rr} = \frac{1}{g_{00}}$$

Using these symbols $k''_{\min} = \gamma_M k_{\min} \rightarrow dk''_{\min} = \gamma_M dk_{\min} \rightarrow \rho''_{Gk\min} = \gamma_M \rho_{Gk\min}$ (2.2. 13)

In sections 2.1.2 & 2.2.2 we approximated in flat space. The wavelength of $k_{\min}$ gravitons span approximately to the horizon. They fill all of space. We can think of the space around even a large black hole as an infinitesimal bubble on the scale of the observable universe. The normalizing constant of a $k_{\min}$ wavefunction emitted from a localized mass is only altered very close to this mass. Over the vast majority of space it is unaltered. Only close to this mass will local observers measure $k''_{\min} = \gamma_M k_{\min}$ due to the change in clocks. There is also a local dilution of the normalizing constant due to the change in radial rulers. We will consider both these changes in two steps to help illustrate our argument. Now repeat the derivation of $\Delta\rho_{Gk\min}$ as in section 2.2.1 but with a large central mass as in Figure 2.2. 1.

At the point P consider Eq.(2.2. 2) $\psi_1{}^*\psi_2 + \psi_2{}^*\psi_1 \approx \dfrac{4k'}{4\pi r_1 r} e^{-k'r}\cos(-kr)$.

The red part is the normalizing factor discussed above where we will *initially ignore the dilution* due to the local increase in volume. The green $k'r$ & kr can be thought of as invariant phase angles. So *if we ignore the dilution factor* this equation is unaltered. However the coupling factor contains all the masses in the universe and the local mass m. But in the Schwarzchild metric this is *the mass dispersed at infinity before it comes together.* At a radius r it is measured as $\gamma_M m$. For the same reasons all the mass in the universe is increased by the same factor γ_M.

We are left with the factor $\frac{2\alpha_G}{\pi}\frac{dk_{\min}}{k_{\min}}$ which is the same as $\frac{2\alpha_G}{\pi}\frac{dk''_{\min}}{k''_{\min}} = \frac{2\alpha_G}{\pi}\frac{\gamma_M dk_{\min}}{\gamma_M k_{\min}}$ in the changed metric. Ignoring the dilution factor, and considering only clock changes Eq.(2.2. 6) becomes, dropping the now uneccesary subscripts

$$\text{With only time change and no dilution } \Delta\rho_{Gk\min} \approx \alpha_G \gamma_M^2 \frac{m}{r} 0.566 \frac{\rho_U}{k_{\min}^2} dk_{\min}$$

$$\text{But } \frac{\rho_U}{k_{\min}^2} \approx 0.9266 \text{ from Eq. (2.2. 10) so } \Delta\rho_{Gk\min} \approx \gamma_M^2 \frac{2m}{r} 0.262\alpha_G dk_{\min}$$

From Equ's. (2.2. 11) & (2.2. 13) $K_{Gk\min} \approx 0.262\alpha_G$ and $\beta_M^2 = \frac{2m}{r}$ and we finally get

$$\text{Before dilution of the normalization factor } \Delta\rho_{Gk\min} \approx \beta_M^2 \gamma_M^2 K_{Gk\min} dk_{\min} \tag{2.2. 14}$$

So the total $k_{\min}$ graviton density before dilution is the original $\rho_{Gk\min} \approx K_{Gk\min} dk_{\min}$ plus the extra $\Delta\rho_{Gk\min} \approx \beta_M^2 \gamma_M^2 K_{Gk\min} dk_{\min}$. Thus before dilution

$$\begin{gathered} \rho_{Gk\min}(\text{Total}) = K_{Gk\min} dk_{\min} + \beta_M^2 \gamma_M^2 K_{Gk\min} dk_{\min} = (1+\beta_M^2\gamma_M^2) K_{Gk\min} dk_{\min} \\ \text{But } (1+\beta_M^2\gamma_M^2) = 1 + \frac{\beta_M^2}{1-\beta_M^2} = \gamma_M^2 \\ \text{So undiluted } \rho_{Gk\min}(\text{Total}) = \gamma_M^2 K_{Gk\min} dk_{\min} \end{gathered} \tag{2.2. 15}$$

If we now increase the volume to that in the new metric, the new volume is $\sqrt{g_{rr}} = \gamma_M$ times the original volume. So in the new metric we must divide this value by γ_M .

$$\text{In the new metric } \rho''_{Gk\min} = \frac{\gamma_M^2 K_{Gk\min} dk_{\min}}{\gamma_M} = \gamma_M K_{Gk\min} dk_{\min} = K_{Gk\min} dk''_{\min} \tag{2.2. 16}$$

If for example $\gamma_M = 2$, frequencies are doubled so $k''_{\min} = 2k_{\min}$, the number density of gravitons ($\rho''_{Gk\min} = 2\rho_{Gk\min}$) is doubled, but so is the measurement of a local small volume element, which is now $V = 2$. The above equations tell us that the original $\rho_{Gk\min}$ background gravitons which occupied one unit of volume is now compressed into 1/2 a unit of volume and the remaining 3/2 units of volume is taken up by extra gravitons due to the central mass. Figure 2.2. 2 illustrates this. The metric appears to adjust itself so that $K_{Gk\min}$ *(the maximum wavelength graviton probability constant)* is an invariant scalar. (See Figure 2.5. 1 also.)

What we have done in this section is only true if the increase in measured volume is equal to the increase in measured frequency. In the Schwarzchild metric this is equivalent to saying that $g_{rr} \cdot g_{tt} = 1$. But what happens in the Kerr metric with angular momentum?

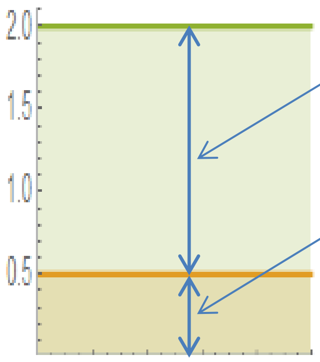


Figure 2.2. 2 An infinitesimal local volume in a Schwarzchild metric where $\sqrt{g_{rr}} = \gamma_M = 2$.

2.3 Angular Momentum and the Kerr Metric

In the Schwarzchild metric the increase in volume is the same as the frequency increase as $g_{rr} \cdot g_{tt} = 1$ and $g_{\theta\theta} \cdot g_{\phi\phi} = r^4 \sin^2\theta$ is invariant if there is no angular momentum. With angular momentum both $g_{\theta\theta}$ & $g_{\phi\phi}$ change. The volume ratio of $g_{\mu\nu} = \eta_{\mu\nu}$ space, to $g_{\mu\nu} \neq \eta_{\mu\nu}$ space in

any metric at fixed r & θ is
$$\frac{V'}{V} = \sqrt{\frac{-(g'_{rr} \cdot g'_{\theta\theta} \cdot g'_{\phi\phi})(g_{\mu\nu} \neq \eta_{\mu\nu})}{-(g_{rr} \cdot g_{\theta\theta} \cdot g_{\phi\phi})(g_{\mu\nu} = \eta_{\mu\nu})}} = \sqrt{\frac{-(g'_{rr} \cdot g'_{\theta\theta} \cdot g'_{\phi\phi})(g_{\mu\nu} \neq \eta_{\mu\nu})}{r^4 \sin^2\theta}} \qquad (2.3.\ 1)$$

Now the Kerr metric can be written as $-g_{\theta\theta} = \rho^2 = r^2 + \alpha^2 \cos^2\theta$

$$-g_{\varphi\varphi} = (r^2 + \alpha^2 + \frac{r_S r}{\rho^2}\alpha^2 \sin^2\theta)\sin^2\theta$$

$$+g_{t\varphi} = \frac{r_S r}{\rho^2}\alpha \sin^2\theta$$

$$-g_{rr} = \frac{\rho^2}{\Delta} \qquad \& \qquad +g_{tt} = 1 - \frac{r_S r}{\rho^2}$$

Where $\Delta = r^2 + r_S r + \alpha^2$ and $\alpha = \dfrac{J}{mc}$ and $r_S = \dfrac{2Gm}{c} = 2m$ is the Schwarzchild radius in Planck units where $G = c = 1$. Everything is in units of length or $(\text{length})^2$, but g_{rr} & g_{tt} are dimensionless. Because we want volume ratios as in Eq. (2.3. 1) we can write the above version of the Kerr metric in a dimensionless form, leaving the $(\text{length})^2$ or length terms $r^2, r^2\sin^2\theta$ & $r\sin\theta$ in $r^2 d\theta^2$, $r^2 \sin^2\theta d\varphi^2$ & $r \sin\theta d\varphi$ etc outside the metric tensor. This effectively gives us the denominator $r^4 \sin^2\theta$ we want in Eq. (2.3. 1) as we will see. We need to also remember that α is a length dimension.

Writing the above in dimensionless form as follows, using $+---$ for the line element ds^2:

A Dimensionless form of the Kerr metric

$$
\begin{aligned}
-g_{\theta\theta} &= \rho^2 = 1+\frac{\alpha^2}{r^2}\cos^2\theta \\
-g_{\varphi\varphi} &= 1+\frac{\alpha^2}{r^2}+\frac{A}{\rho^2}\frac{\alpha^2}{r^2}\sin^2\theta \\
+g_{t\varphi} &= \frac{A}{\rho^2}\frac{\alpha}{r}\sin\theta \\
-g_{rr} &= \frac{\rho^2}{\Delta} \\
+g_{tt} &= 1-\frac{A}{\rho^2}
\end{aligned}
\tag{2.3. 2}
$$

Where $\Delta = 1+\frac{\alpha^2}{r^2}-A$ and $A=\frac{2m}{r}$ but we may add an $\frac{m^2}{r^2}$ later (see Section 2.6) which is also dimensionless, as we have left out $G=c=1$ in Planck units. Now the space surrounding a rotating mass corotates with it. If we move in this corotating reference frame there is a new metric time component $g'_{tt} = g_{tt} - \frac{g_{t\phi}^2}{g_{\phi\phi}}$. Thus using Eq. (2.3. 2)

$$
g'_{tt} = g_{tt} - \frac{g_{t\varphi}^2}{g_{\varphi\varphi}} = (1-\frac{A}{\rho^2}) - \frac{\frac{A^2}{\rho^4}\frac{\alpha^2}{r^2}\sin^2\theta}{-\left[1+\frac{\alpha^2}{r^2}+\frac{A}{\rho^2}\frac{\alpha^2}{r^2}\sin^2\theta\right]}
$$

$$
= (1-\frac{A}{\rho^2}) + \frac{\frac{A^2}{\rho^2}\frac{\alpha^2}{r^2}\sin^2\theta}{\rho^2\left[1+\frac{\alpha^2}{r^2}+\frac{A}{\rho^2}\frac{\alpha^2}{r^2}\sin^2\theta\right]}
$$

$$
= \frac{\rho^2(1+\frac{\alpha^2}{r^2}+\frac{A}{\rho^2}\frac{\alpha^2}{r^2}\sin^2\theta) - A(1+\frac{\alpha^2}{r^2}) - \frac{A^2}{\rho^2}\frac{\alpha^2}{r^2}\sin^2\theta + \frac{A^2}{\rho^2}\frac{\alpha^2}{r^2}\sin^2\theta}{\rho^2(1+\frac{\alpha^2}{r^2}+\frac{A}{\rho^2}\frac{\alpha^2}{r^2}\sin^2\theta)}
$$

$$
= \frac{-A(1+\frac{\alpha^2}{r^2}-\frac{\alpha^2}{r^2}\sin^2\theta)+\rho^2(1+\frac{\alpha^2}{r^2})}{-\rho^2 g_{\phi\phi}}
$$

$$
= \frac{-A(1+\frac{\alpha^2}{r^2}\cos^2\theta)+\rho^2(1+\frac{\alpha^2}{r^2})}{-\rho^2 g_{\phi\phi}}
$$

$$
g'_{tt} = \frac{-A\rho^2+\rho^2(1+\frac{\alpha^2}{r^2})}{-\rho^2 g_{\phi\phi}} = \frac{\rho^2(1+\frac{\alpha^2}{r^2}-A)}{-\rho^2 g_{\phi\phi}} = \frac{\Delta}{-g_{\phi\phi}} \tag{2.3. 3}
$$

(We have explicitly gone through this to show that if $A = \frac{2m}{r}$ is dimensionless there is potentially freedom to change it, as it will not change Eq. (2.3. **3**), see Section 2.6)

We will do all our calculations in this corotating refence frame. Space is swirling around the black hole effectively at rest in this frame as clocks also tick fastest in it. If a small mass, at rest at infinity in the same rest frame as the rotating black hole, falls inwards, it will have the same circumferential velocity as the corotating rest frames at all radii. It will be falling radially through these corotating frames. As in section 2.2.2 we call this radial velocity β_M where as in the non-rotating case

$$\frac{1}{\sqrt{1-\beta_M^2}} = \gamma_M \quad \text{but now} \quad \frac{1}{\sqrt{1-\beta_M^2}} = \gamma_M = \frac{1}{\sqrt{g'_{tt}}} \quad \text{the inverse rate of clocks.}$$

In the corotating frame

$$\frac{1}{\gamma_M^2} = g'_{tt} = \frac{\Delta}{-g_{\phi\phi}} \qquad \gamma_M^2 = \frac{-g_{\phi\phi}}{\Delta} \tag{2.3. 4}$$

Frequencies measured in this corotating frame will increase as γ_M .

Similarly using Eq's. (2.3. 1) & (2.3. 4) we can get the volume element ratio

$$\text{The volume element ratio } V = \sqrt{-(g_{rr}\cdot g_{\theta\theta}\cdot g_{\phi\phi})} = \sqrt{\frac{-\rho^2}{\Delta}\rho^2 g_{\phi\phi}} = \rho^2\sqrt{\frac{-g_{\phi\phi}}{\Delta}} = \rho^2\gamma_M \tag{2.3. 5}$$

With angular momentum we no longer have the same increase in frequency as volume as in the Schwarzchild case. With no angular momentum we found that the probability density of time polarized $k_{\min}$ gravitons Eq. (2.2. 14) $\Delta\rho_{Gk\min} \approx \gamma_M^2\beta_M^2 K_{Gk\min} dk_{\min} = \gamma_M^2 \frac{2m}{r} K_{Gk\min} dk_{\min}$.

With angular momentum we can expect circularly polarized gravitons surrounding the rotation axis and transversely polarized around the equator. This will increase the time polarized $\frac{2m}{r}$ figure to some as yet unknown figure we simply label as X where $X > \frac{2m}{r}$.

We will rewrite Eq.(2.2. 14) as

$$\Delta\rho_{Gk\min} \approx \gamma_M^2 X K_{Gk\min} dk_{\min} \text{ with rotation} \tag{2.3. 6}$$

Where the factor γ_M^2 is for the same clock rate change effect in the metric as before or see section 2.3.2 and the derivation of Eq. (2.3. 13). Repeating the derivation of Eq.(2.2. 15)

$$\rho_{Gk\min}(\text{Undiluted Total}) = K_{Gk\min} dk_{\min} + \gamma_M^2 X K_{Gk\min} dk_{\min} = (1+\gamma_M^2 X) K_{Gk\min} dk_{\min}$$

As in Eq.(2.2. 16) we need to divide this undiluted total by the new volume $V=\rho^2\gamma_M$ in Eq. (2.3. 5) to get the new $k_{\min}$ graviton density $\rho''_{Gk\min}$.

If our conjectures are correct $\rho''_{Gk\min}=K_{Gk\min}dk''_{\min}$ is always true, and as our measurement of $k_{\min}$ increases to $k''_{\min}=\gamma_M k_{\min}$ in the new metric, $\rho''_{Gk\min}=K_{Gk\min}\gamma_M dk_{\min}$.

So rewriting Eq.(2.2. 16) as follows

$$\rho''_{Gk\min}=\frac{(1+\gamma_M^2 X)K_{Gk\min}dk_{\min}}{V}=\frac{(1+\gamma_M^2 X)K_{Gk\min}dk_{\min}}{\rho^2\gamma_M}=\gamma_M K_{Gk\min}dk_{\min}=K_{Gk\min}dk''_{\min}$$

$$(1+\gamma_M^2 X)K_{Gk\min}dk_{\min}=\rho^2\gamma_M^2 K_{Gk\min}dk_{\min}$$

$$1+\gamma_M^2 X=\rho^2\gamma_M^2$$

$$X=\rho^2-\frac{1}{\gamma_M^2}=(1+\frac{\alpha^2}{r^2}\cos^2\theta)-\frac{1}{\gamma_M^2}$$

$$X=(1+\frac{\alpha^2}{r^2}\cos^2\theta)-\frac{\Delta}{-g_{\varphi\varphi}}\quad \text{using Eq. (2.3. 4)}$$

$$X=1+\frac{\alpha^2}{r^2}\cos^2\theta-\frac{1+\frac{\alpha^2}{r^2}-A}{1+\frac{\alpha^2}{r^2}+\frac{A}{\rho^2}\frac{\alpha^2}{r^2}\sin^2\theta}\quad \text{using Eq's.(2.3. 2)}$$

We can write this as
$$X=\frac{\alpha^2}{r^2}\cos^2\theta+\frac{\left[1+\frac{\alpha^2}{r^2}+\frac{A}{\rho^2}\frac{\alpha^2}{r^2}\sin^2\theta\right]-\left[1+\frac{\alpha^2}{r^2}-A\right]}{1+\frac{\alpha^2}{r^2}+\frac{A}{\rho^2}\frac{\alpha^2}{r^2}\sin^2\theta}$$

$$X=\frac{\alpha^2}{r^2}\cos^2\theta+\frac{A\left[1+\frac{\alpha^2}{r^2}\frac{\sin^2\theta}{\rho^2}\right]}{1+\frac{\alpha^2}{r^2}+\frac{A}{\rho^2}\frac{\alpha^2}{r^2}\sin^2\theta}$$

$$X=\frac{\alpha^2}{r^2}\cos^2\theta+\frac{A\left[1+\frac{\alpha^2}{r^2}\frac{\sin^2\theta}{-g_{\theta\theta}}\right]}{-g_{\phi\phi}}\quad \text{using Eq's.(2.3. 2)}$$

Which we will write as $$X=\frac{\alpha^2}{r^2}\cos^2\theta\quad+\quad\frac{A}{-g_{\varphi\varphi}}\quad+\quad A\frac{\alpha^2}{r^2}\frac{\sin^2\theta}{g_{\phi\varphi}g_{\theta\theta}}\qquad(2.3.\ 7)$$

Putting $A = \frac{2m}{r}$, the *extra* $k_{\min}$ virtual gravitons $\gamma_M^2 X$ (due to a mass m rotating with angular parameter α but with dimensions of length) are the following three polarization groups (The background $k_{\min}$ virtual gravitons have been normalized to one when $\gamma_M = 1$)

Time polarized spin 2 $\qquad \gamma_M^2 \left[\frac{2m}{r} \frac{1}{-g_{\varphi\varphi}} \right]$

Transversely polarized spin 2: $\qquad \gamma_M^2 \left[\frac{\frac{2m}{r}\left[\frac{\alpha^2}{r^2} \sin^2\theta \right]}{g_{\varphi\varphi} g_{\theta\theta}} \right] \times \left[\frac{(m=+2)}{\sqrt{2}} + \frac{(m=-2)}{\sqrt{2}} \right]$

Circularly polarized spin 2: $\qquad \gamma_M^2 \left[\frac{\alpha^2}{r^2} \cos^2\theta \right] \times (m = \pm 2)$

Comparing Figure 2.3. 1 & Figure 2.3. 2 there are some parallels with spinning charged spheres in electromagnetism. The electrostatic energy density surrounding a charged sphere however, reduces with radius as r^{-4}, and magnetic energy as r^{-6}, or two more powers of radius. With gravity however we have been looking at the probability density of minimum wavenumber $k_{\min}$ gravitons surrounding a mass. With no angular momentum there are only time polarized $k_{\min}$ gravitons and their extra probability density drops as r^{-1}, as so far we have only focussed on those $k_{\min}$ gravitons (the vast majority), that interact with the rest of the mass in the universe. If a charged sphere rotates, there is a radial magnetic field of circularly polarized $m = \pm 1$ photons varying in intensity as $\cos^2\theta$ and a transverse magnetic field (of transversely polarized $m = \pm 1$ photons) varying as $\sin^2\theta$ as in Figure 2.3. 1.

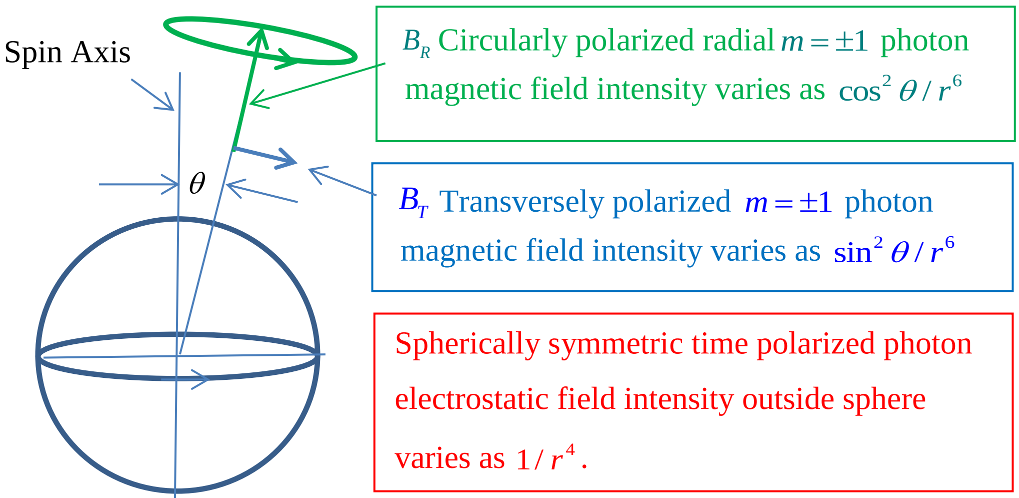


Figure 2.3. 1 Spinning electrically charged sphere. At the same radius $B_R(@\,\theta = 0)$ $= 2B_T(@\,\theta = \pi/2)$

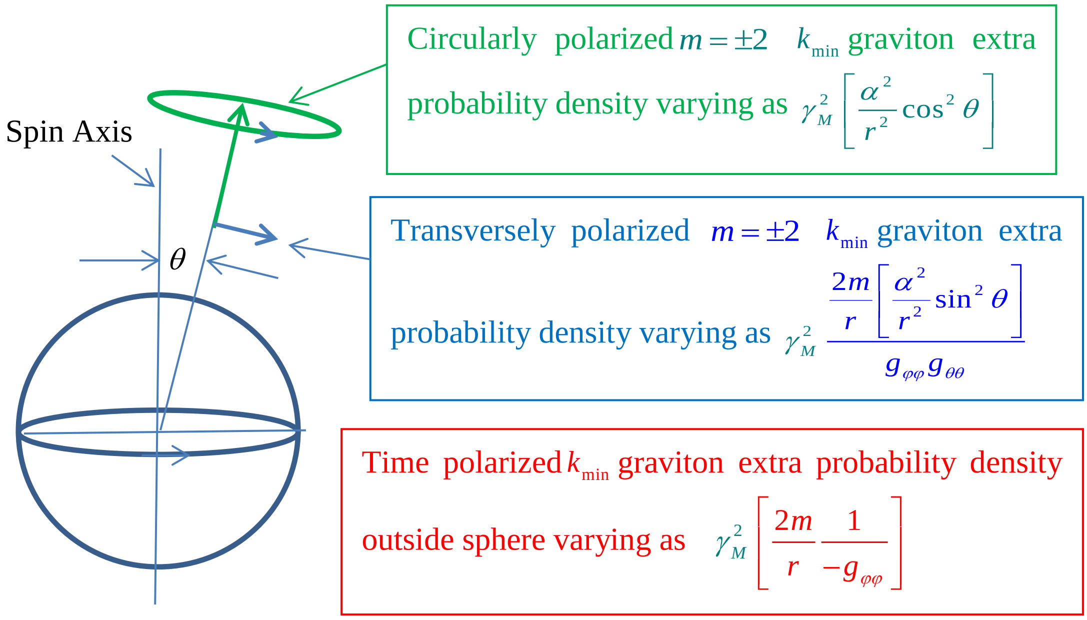


Figure 2.3. 2 Spinning mass m with angular momentum length parameter α. The time polarized $k_{\min}$ gravitons are distorted from spherical symmetry as $-1/g_{\varphi\varphi}$. For $r >> r_{Sw}$ we can ignore the effects of $g_{\theta\theta}, g_{\varphi\varphi}$ & γ_M^2, as all three rapidly tend to ± 1 when written in dimensionless form as in Equ's.(2.3. 2). These values are the extra probability densities before the density dilution due to the expansion of space around the rotating mass.

2.3.1 Stress tensor sources for spin 2 gravitons but 4 current sources for spin 1

Spin 1 particles behave like a 4 vector, transforming with velocity as in the Special Relativity transformations of Minkowski spacetime. Spin 2 gravitons, in contrast, behave differently seeming to relate with the accelerations of General Relativity or non-Minkowski spacetime. The shape of gravitational waves behaves like transversely polarized $m=\pm 2$ particles, suggesting the $k_{\min}$ gravitons surrounding mass concentrations may only consist of time polarized, plus $m=\pm 2$, transverse or circularly polarized, spin 2 particles. Time polarized versions would consist of an equal $1/\sqrt{5}$ superposition of $m=-2,-1,0,+1,+2$ states. Before we considered angular momentum we treated all $k_{\min}$ gravitons as time polarized or spherically symmetric. Unless close to black holes we only needed to think about mass sources, as the only significant term in the stress tensor near slow moving masses is T_{00}. Also there is no accepted quantum field theory relating spin 2 gravitons to General Relativity. It is generally seen however, that spin 2 gravitons can be treated as coming from a Stress tensor source in contrast to a 4 Current source for spin 1 photons.When we looked at non rotating spherical masses it appeared that, even close to black holes, the spherical symmetry of the Schwarzchild metric suggested similarly spherically symmetric, or time polarized, extra $k_{\min}$ gravitons right down to the horizon; with space expanding only radially. A stress tensor source with no angular momentum has only time polarized $k_{\min}$ gravitons. But this clearly changes when there is angular momentum in the source as above. We still have time polarized $k_{\min}$ gravitons due to the central mass but distorted from spherical symmetry as

$-1/g_{\varphi\varphi}$ which only affects the close in region and disappears as $\alpha \to 0$. There are transversely polarized $m = \pm 2\ k_{\min}$ extra gravitons that are related to the central mass and the angular momentum length parameter α. The behaviour of the circularly polarized extra $m = \pm 2\ k_{\min}$ gravitons is only related to angular momentum. These circularly polarized gravitons do not have the $2m/r$ factor that the transverse gravitons have, and thus behave very differently. As we will discuss below it appears that they are generated from the background time polarized $k_{\min}$ gravitons by the swirling velocity of corotating space.

2.3.2 Circularly polarized gravitons from corotating space

With angular momentum the transversely polarized gravitons have the same $2m/r$ factor as the time polarized gravitons. They reduce in intensity as $1/r^3$. The circularly polarized gravitons do not have this $2m/r$ factor and reduce as $1/r^2$. The Kerr metric is an exact solution to Einstein's field equations, which we claim (in an infinitesimally modified form as in Eq. (2.5. 6) are consistent with the $k_{\min}$ Graviton constant being invariant at all points in spacetime (section 2.6 changes this consistency in some respects only); or that Eq. (2.2. 11) is always true. If this is so then Eq. (2.3. 7) should be true also. We can perhaps just accept that it must be true, but at the same time look at whether it makes sense?

The angular momentum parameter α has dimensions of length, and is defined as $\alpha = \frac{J}{mc}$. Because angular momentum is the cross product of momentum by radius or $m\mathbf{v}\times\mathbf{r}$, we can think of this length parameter as a vector of length α, pointing along the axis of spin, with components $\alpha\cos\theta$ at any polar angle θ to the spin axis. Space corotates around spinning masses with angular velocity $\Omega = -\frac{g_{t\phi}}{g_{\phi\phi}}$ which in the plane of the equator simplifies to

$$\Omega = \frac{r_S \alpha c}{r^3 + r\alpha^2 + r_S \alpha^2} \approx \frac{r_S \alpha c}{r^3} \text{ when } r >>> r_S \ \&\ \alpha .$$

$$\text{At large radii the corotating velocity} \quad V = \Omega \cdot r \approx \frac{r_S \alpha c}{r^2} \tag{2.3. 8}$$

Because $r_S\ \&\ \alpha$ have dimensions of length this equation has dimensions of velocity, and if we divide it by c it is dimensionless. We will call it $\beta_{Coratating} = \beta_C$

$$\text{At large radii} \quad \beta_{Coratating} = \beta_C = \frac{V}{c} = \frac{\Omega \cdot r}{c} \approx \frac{r_S \alpha}{r^2} \tag{2.3. 9}$$

If we now think of $\alpha = \frac{J}{mc}$ as $\alpha = \frac{m}{m}\frac{\mathbf{v}\times\mathbf{r}}{c} = \frac{\mathbf{v}\times\mathbf{r}}{c}$ we can consider a similar vector along the spin axis consisting of the cross product of the corotating velocity of space $\frac{V}{c} \approx \frac{r_S \alpha}{r^2}$ by the radius r. The length along the spin axis of this cross product vector $\frac{\mathbf{V}\times\mathbf{r}}{c}$ is simply $\frac{r_S \alpha}{r}$.

$$\text{Length of vector } \frac{\mathbf{V}\times\mathbf{r}}{c} \text{ along the spin axis is } \approx \frac{r_S\alpha}{r} \text{ for } r >>> r_S \tag{2.3. 10}$$

We need this vector length to be a dimensionless number representing the amplitude that a background time polarized $k_{\min}$ graviton generates a circularly polarized $k_{\min}$ graviton around the spin axis. If we divide Eq. (2.3. 10) by the Schwarzchild radius r_S , all rotating black holes with the same percentage of maximum spin look identical and we get a dimensionless magnitude as required

$$\text{Magnitude of normalized dimensionless vector } \left|\frac{\mathbf{V}\times\mathbf{r}}{r_S c}\right| \approx \frac{r_S\alpha}{r_S r} \approx \frac{\alpha}{r} \tag{2.3. 11}$$

Now the $\Omega = -g_{t\phi} / g_{\phi\phi}$ in Eq. (2.3. 8) is measured by the clock rate at infinity. In the corotating frame clocks tick slower and it is measured as the γ_M of Eq. (2.3. 4) times greater.

$$\text{In the corotating frame this magnitude becomes } \left|\frac{\gamma_M \mathbf{V}\times\mathbf{r}}{r_S c}\right| \approx \frac{\gamma_M\alpha}{r} \tag{2.3. 12}$$

The whirling velocity of space is a maximum out from the equator, but circularly polarized gravitons generated in this region have to be distributed on this shell around the spin axis as the square of the component of angular momentum. We thus conjecture that the probability of *background* time polarized $k_{\min}$ gravitons, on a corotating thin spherical shell at large radius, generating circularly polarized $k_{\min}$ gravitons around the spin axis on the same shell is (before we expand the volume with the new spatial metric)

$$\text{Probability of } \frac{\text{Extra circularly polarized } m = \pm 2\times k_{\min}\text{gravitons}}{\text{Background time polarized } k_{\min}\text{gravitons}} \approx \frac{\gamma_M^2\alpha^2\cos^2\theta}{r^2} \tag{2.3. 13}$$

What we are suggesting here is that there is a background density of time polarized $k_{\min}$ gravitons on each corotating spherical shell. The swirling velocity of these $k_{\min}$ gravitons generates extra circularly polarized $k_{\min}$ gravitons around the spin axis with a $\cos^2\theta$ distribution around the spin axis *on the same shell,* in agreement with Figure 2.3. 2. We have only derived this approximation at large radius, but we suggest that the swirling velocity of corotating space makes this true at all radii apart from possible changes we discuss in section 2.6. Circular polarization is a result of the swirling velocity and not due to the mass.

2.3.3 Transverse polarized gravitons from a rotating mass

The mass is the cause of the extra time polarized $k_{\min}$ gravitons varying as $2m/r$. As we discussed earlier, in electromagnetism the electrostatic energy intensity drops as $1/r^4$, and the magnetic (or transverse $m = \pm 1$ polarization) intensity two powers of radius smaller, or as

$\sin^2\theta / r^6$. But the ratio of time polarized to transverse polarized photons at any radius is proportional to $\sin^2\theta / r^2$. In a similar manner the ratio of the extra transverse $m = \pm 2\ k_{\min}$ gravitons to the extra time polarized $k_{\min}$ gravitons due to a rotating mass is proportional to $\sin^2\theta / r^2$. The proportionality factor being the same α^2 as for circular polarization.

$$\text{For rotating black holes} \quad \frac{\text{Extra time polarized } k_{\min} \text{ gravitons}}{\text{Extra tranversely polarized } k_{\min} \text{gravitons}} = \frac{\alpha^2}{r^2}\sin^2\theta \qquad (2.3.\ 14)$$

As the Kerr metric is an exact solution for rotating black holes we can say that if the extra $k_{\min}$ gravitons due to a rotating mass are consistent with $\gamma_M^2 X$ where X is as in Eq. (2.3. 7) then it is also consistent with keeping the Graviton constant $K_{Gk\min}$ as in Eq. (2.2. **11**) invariant in the spacetime surrounding it. We come back to this, and potential changes to the dimensionless term $A = 2m/r$ in section 2.6. When we looked at non rotating black holes in section 2.2.2 we used simple first principles to show that the warping of spacetime around them is consistent with an invariant Graviton constant $K_{Gk\min}$. With rotating black holes we have turned the argument around and assumed this invariance to derive the extra probability densities of time, circular and transverse polarized $k_{\min}$ gravitons, before the density dilution due to the expansion of space around the rotating mass. We then tried to show that these extra probability densities (as in Figure 2.3. 2) are not too far from what might be intuitively expected. It is important to also remember that the Kerr metric is an exact solution for rotating black holes and not for rotating masses in general. We have only considered here the exact solution. We could perhaps summarize section 2.3 as follows:

Spherically symmetric "Einstein fictitious / Newtownian real" accelerations do not transform spherically symmetric, or time polarixed $k_{\min}$ gravitons.

Cylindrically symmetric "Einstein fictitious / Newtownian real" accelerations generate both transverse and cylindrically polarized $m = \pm 2\ \ k_{\min}$ gravitons.

This should not be confused with acceleration generating a thermal spectrum of real photons and gravitons (and other particles) from the virtual pair background with a temperature proportional to that acceleration. See for example [18].

We need to next include the relatively small number of $k_{\min}$ gravitons emitted by the mass itself $(\psi_m * \psi_m)$, which has effect close to black holes, but before we do that, it helps if we first look at the expanding universe. This is almost a repeat of section 5.3 in [7], but Figure 2.4. 1 & Equ's.(2.4. 12) help to make clearer the real significance of what the $k_{\min}$ graviton constant $K_{Gk\min}$ is all about, and why it has to be invariant throughout spacetime. It is the cutoff wavenumber where the zero point quanta density available equals the quanta density required by the $k_{\min}$ graviton superpositions. The value of $k_{\min}$ reduces with cosmic time T but increases around mass concentrations with the local metric clock rates. See Figure 2.5. 1. This repeated section also has a few refinements and corrections from the first paper.

2.4 The Expanding Universe

Section 2.1.1 conjectures that virtual gravitons are single wavenumber k members of superpositions, of width dk. They are thus, using Eq. (2.1.4) in [7], wavefunctions ψ_k occurring with probability $sN \cdot dk/k$, but we have aready included factor dk/k in deriving Eq's.(2.1. 9), (2.2. 6) & (2.2. **11**). The number density of ψ_k wavefunctions is simply $\rho_{\psi k} = sN\rho_{Gk} = 4\rho_{Gk}$ for spin 2 & $N = 2$ gravitons. To get the number density of gravitons at any wavenumber k we can rewite Eq. (2.1. 9) using Eq.(2.2. 10) for $\rho_U^2/k_{\min}^4$ & Eq.(2.2. **11**).

$$\rho_{Gk} \approx \frac{0.3056\alpha_G \rho_U^2}{k_{\min}^4} dk \left[\frac{52.35}{x} \frac{\sqrt{x^2+11.644}}{\left(2x^2+11.644\right)^2} \right] \approx 0.262\alpha_G dk \left[\frac{52.35}{x} \frac{\sqrt{x^2+11.644}}{\left(2x^2+11.644\right)^2} \right]$$

$$\rho_{\psi k} = Ns\rho_{Gk} = 4\rho_{Gk} \approx 4 \times 0.262\alpha_G dk \left[\frac{52.35}{x} \frac{\sqrt{x^2+11.644}}{\left(2x^2+11.644\right)^2} \right] \quad \text{where} \quad x = \frac{k}{k_{\min}} \tag{2.4. 1}$$

The blue part of Eq. (2.4. 1) is one when $k/k_{\min} = x = 1$.

From Eq.(3.2.1) in [7] the vacuum debt for a superposition is $\langle \mathbf{p}_k(debt) \rangle = -\langle \beta_k \rangle^2 \langle n \rangle \hbar \mathbf{k}$.

Using Eq's. (3.1.11), (3.1.12) & (3.2.10) in [7] $\langle \beta_k \rangle^2 = \dfrac{\langle K_k \rangle^2}{1+\langle K_k \rangle^2}$.

For $N = 2$ spin 2 $\langle K_k \rangle = \dfrac{\langle n \rangle k}{m_0}$ and from Eq. (2.1. 3) $m_0 \approx 3.33k_{\min}$ from which we can show

$$\langle \beta_k \rangle^2 = \frac{k^2}{k^2 + k_{\min}{}^2} = \frac{x^2}{x^2+1} \quad \text{where} \quad x = \frac{k}{k_{\min}}.$$

From Table 4.3.1 in [7] $\langle n \rangle \approx 3.33$ for gravitons. Each wavefunction ψ_k borrows from the zero point fields $\langle \beta_k \rangle^2 \langle n \rangle \approx (3.33)\dfrac{x^2}{x^2+1}$ wavenumber k quanta. The quanta density required @k by gravitons is:

$$\rho_{Quanta@k} \approx (3.33)\frac{x^2}{x^2+1} \times 4 \times 0.262\alpha_G dk \left[\frac{52.35}{x} \frac{\sqrt{x^2+11.644}}{\left(2x^2+11.644\right)^2} \right]$$

$$\rho_{Qk} \approx 1.745\alpha_G dk \left[\frac{104.7x}{(x^2+1)} \frac{\sqrt{x^2+11.644}}{\left(2x^2+11.644\right)^2} \right] \quad \& \text{ when } \frac{k}{k_{\min}} = x = 1 \tag{2.4. 2}$$

$$\rho_{Quanta@k\min} = \rho_{Qk\min} \approx 1.745\alpha_G dk_{\min}$$

But the density of zero point modes available @ $k_{\min}$ is $k_{\min}^2 dk/\pi^2$ (ignoring some small factors). Even if $\alpha_G << 1$ this is too small by about $k_{\min}^2 \approx 1/R_{OH}^2$. However the area of the causally connected horizon $4\pi R_{OH}^2$ suggests possible connections with Holographic horizons and the AdS/CFT correspondence [24].

2.4.1 Holographic horizons and red shifted Planck scale zero point modes

Malcadena proposed AntiDesitter or Hyperbolic spacetime where Planck modes on a 2D horizon are infinitely redshifted at the origin by an infinite change in the metric. In contrast we have assumed flat space on average to the horizon. In section 2.2.3 in [7] we defined a rest frame in which zero momentum preons with infinite wavelength build infinite superpositions. If we also have a spherical horizon with Planck scale modes, but here receding locally at the velocity of light, these Planck modes can be absorbed by infinite wavelength preons (from that receding horizon) and red shifted in a radially focussed manner inwards. We will argue in what follows, that at the centre where the infinite superpositions are built, approximately 1/6 of these Planck modes can be absorbed from that horizon with wavelengths of the order of the horizon radius. *This potential possibility only exists because zero momentum preons have an infinite wavelength.* If any source of radiation recedes at velocity $\beta = v/c$ the frequency/wavenumber reduces as $k_{observer} = k_{source}\left[\gamma(1-\beta)\right]$ where $\gamma = (1-\beta^2)^{-1/2}$. In the extreme relativistic limit $\beta \to 1$ & we can put $1-\beta = \Delta\beta = \varepsilon$.

$$\text{Putting } 1-\beta = \Delta\beta = \varepsilon \text{ implies } \beta = 1-\varepsilon \text{ and } \beta^2 \approx 1-2\varepsilon$$

$$1-\beta^2 = \gamma^{-2} \approx 2\varepsilon \text{ and } \gamma \approx 1/\sqrt{2\varepsilon} \tag{2.4. 3}$$

$$\text{Thus } \frac{k_{Observer}}{k_{Source}} = \left[\gamma(1-\beta)\right] \approx \frac{\varepsilon}{\sqrt{2\varepsilon}} \approx \sqrt{\frac{\varepsilon}{2}} \approx \frac{1}{2\gamma}$$

There is always some rest frame travelling at nearly light velocity that can redshift Planck energy modes into a $k_{\min} \approx 1/R_{OH}$ mode and also many other frames travelling at various lower velocities that can redshift Planck energy modes into any $k > k_{\min}$ mode . This is special relativity applying locally. But in sections 2.1.2 & 2.2.1 we used the fact that clocks in comoving coordinates tick at the same rate. So how does Eq.(2.4. 3) help? Space between comoving galaxies expands with cosmic or proper time t and is called the scale factor $a(t)$. It is normally expressed as $a(t) \propto t^p$.

$$\text{Thus } \dot{a}(t) \propto pt^{p-1} \text{ and the Hubble parameter } H(t) = \frac{\dot{a}(t)}{a(t)} = \frac{p}{t} \tag{2.4. 4}$$

Writing the present scale factor normalized to one so that $a(T) = 1$ implies $a(t) = t^p / T^P$, we can get the causally connected horizon radius and the horizon velocity *V*. Using Eq. (2.4. 4)

$$\text{The horizon radius } R_{OH} = \int_0^T \frac{dt}{a(t)} = T^p \int_0^T \frac{dt}{t^p} = \frac{T}{1-p} \text{ only when } p \text{ is constant.} \tag{2.4. 5}$$

$$\text{The horizon velocity } V = \frac{dR_{OH}}{dT} = \frac{d}{dT}\left[T^p \int_0^T \frac{dt}{t^p}\right] = \frac{T^p}{T^p} + \frac{R_{OH}}{T^p}(pT^{p-1}) = 1 + \frac{p}{T}R_{OH}$$

$$\text{But } \frac{p}{T} \text{ is the current Hubble constant so horizon velocity } V = 1 + H(T)R_{OH} \tag{2.4. 6}$$

Now the receding velocity of a comoving galaxy on the horizon is $V' = H(T)R_{OH}$ and thus from Eq.(2.4. 6) the horizon velocity is always $V = 1 + V'$. In other words the horizon is moving at light velocity relative to comoving coordinates instantaneously on the horizon as measured by a central observer. Now clocks tick at the same rate in all comoving galaxies but clocks moving at almost the horizon light velocity (relative to comoving coordinates instantaneously on the horizon) will tick extremely slowly or as $1/\gamma$ from Eq.(2.4. 3) as special relativity applies locally in this case. Thus Planck modes on the receding horizon will obey Eq's.(2.4. 3) as seen in all comoving coordinates. Let us now imagine an infinity of frames all travelling at various relativistic velocities relative to comoving coordinates instantaneously on the horizon and radially as seen by central observers. We can think of these as spherical shells on the horizon *all of one Planck length thickness as measured by observers moving radially with them.* Transverse dimensions do not change for all radially moving observers and the effective surface area of all these shells is $4\pi R_{OH}^2$. The internal volume of all these shells as measured in rest frames by observers moving radially with them as each of these observers measures their thickness as one Planck length is

$$\text{Rest frame internal shell volume } V = 4\pi R_{OH}^2 \Delta R = 4\pi R_{OH}^2 \qquad (2.4.\ 7)$$

We want the zero point quanta available where *these quanta have Planck energy* ΔE *lasting for Planck time* ΔT *such that* $\Delta E \times \Delta T \approx \hbar / 2$. Before redshifting, a single zero point quanta thus has Planck energy (temporarily using a single primed k' that is not the k' of Eq.(2.1. 4)) where $k' = 1$ before redshifting and k after redshifting. The density of Planck energy zero point modes in this shell is $k'^2 dk' / \pi^2$ and at energy $k'/2$ per mode this is equivalent to

$$\frac{k'^2 dk'}{2\pi^2} \text{ quanta, which we will write as zero point quanta density } \frac{k'^3}{2\pi^2}\frac{dk'}{k'}. \qquad (2.4.\ 8)$$

Now at Planck energy $k' = 1$ and we are redshifting to k where from Eq's.(2.4. 3) $k = k'\sqrt{\varepsilon / 2}$ & $dk = dk'\sqrt{\varepsilon / 2}$. Thus $dk'/k' = dk/k$. As $k = 1$ Eq.(2.4. 8) becomes

$$\text{Planck Energy Zero Point Quanta Density before redshifting} = \frac{1^3}{2\pi^2}\frac{dk'}{k'} = \frac{1}{2\pi^2}\frac{dk}{k} \qquad (2.4.\ 9)$$

Now multiply density by volume ie. Eq's. (2.4. 7) & (2.4. 9) to get the total Planck energy zero point quanta inside the rest frame shell as $4\pi R_{OH}^2 \cdot \frac{1}{2\pi^2}\frac{dk}{k}$. Two thirds of these quanta are transverse and one third radial so only $1/6$ of these quanta are available for redshifting radially inwards. Using Eq.(2.4. 6): After redshifting to wavenumber k these quanta have radius $R' \approx \lambda\!\!\!^{-}_C = \frac{1}{k} = \frac{1}{k_{\min}}\frac{k_{\min}}{k} = \frac{R_{OH}}{\Upsilon}\frac{k_{\min}}{k}$ and thus occupy spherical volume $V' \approx \frac{4\pi R_{OH}^3}{3\Upsilon^3}\left[\frac{k_{\min}}{k}\right]^3$.

Again using $\Upsilon = k_{\min} R_{OH}$ the effective quanta density becomes

$$\rho_{Quanta@k} \approx \frac{1}{6}\left[4\pi R_{OH}^3 \frac{1}{2\pi^2}\frac{dk}{k}\right]\frac{3\Upsilon^3}{4\pi R_{OH}^3}\left[\frac{k}{k_{\min}}\right]^3 \approx \frac{\Upsilon^2}{4\pi^2}dk\left[\frac{k}{k_{\min}}\right]^2 \approx \frac{\Upsilon^2}{4\pi^2}dk\cdot x^2 \text{ where } x=\frac{k}{k_{\min}}$$

These quanta are half scalar and *half the vector required to build infinite superpositions*.

$$\text{Density of vector quanta available after redshifting } \rho_k \approx \frac{\Upsilon^2}{8\pi^2}x^2 dk \tag{2.4. 10}$$

Now an observer at the centre of all this sees space being added inside the horizon at the rate of the horizon velocity $V = 1 + H(T)R_{OH}$ as in Eq. (2.4. 6). *We will conjecture that the space added in one unit of Planck time inside the expanding horizon also creates the source of these zero point quanta that we can borrow*. Thus Eq. (2.4. 10) becomes

$$\text{Density of vector quanta available } \rho_k' \approx \frac{\Upsilon^2 V}{8\pi^2}\left[\frac{k}{k_{\min}}\right]^2 dk = \frac{\Upsilon^2(1+H\cdot R_{OH})}{8\pi^2}x^2 dk \tag{2.4. 11}$$

2.4.2 Plotting available and required zero point quanta

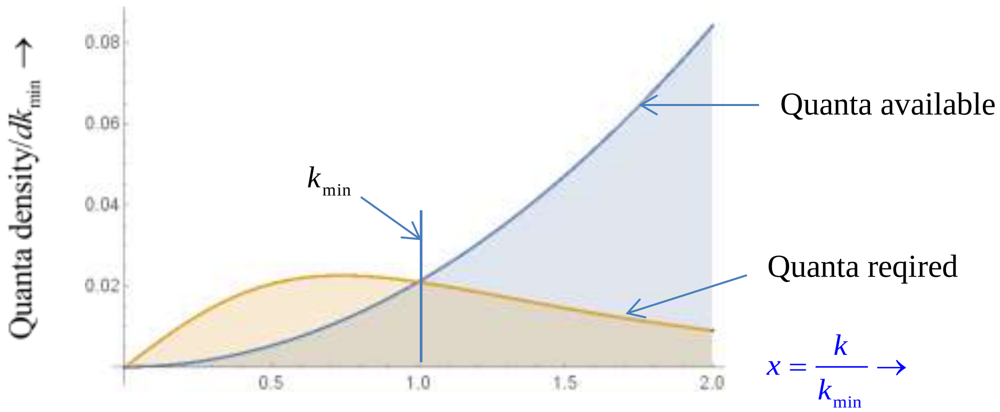


Figure 2.4. 1

Figure 2.4. 1 plots Eq's. (2.4. 2) & (2.4. 11) as a function of $x = k / k_{\min}$ and when $k = k_{\min}$ we can equate these

$$\text{Quanta available} \approx \frac{\Upsilon^2 V}{8\pi^2}dk_{\min} = \text{Quanta required} \approx 1.745\alpha_G dk_{\min} = K_{Qk\min} dk_{\min}$$
$$\text{Where } K_{Qk\min} = 1.745\alpha_G \text{ is the "Quanta required @ } k_{\min} \text{ Constant" \& } \alpha_G \approx \frac{\Upsilon^2 V}{137.8} \tag{2.4. 12}$$

Equation (2.2. 10) the average density of the universe $\rho_U \approx 0.9266\frac{\Upsilon^2}{R_{OH}^2}$ allows us to solve the present value of $\Upsilon = k_{\min} R_{OH}$. Using the 9 year WMAP (March 2013) data for Baryonic and Dark Matter density and radius $R_{OH} \approx 2.7 \times 10^{61}$ Planck lengths ($\approx 46 \times 10^{9}$ light years) puts $\rho_U \times R_{OH}^2 \approx 0.37$ in Planck units. Thus $\rho_U \times R_{OH}^2 \approx 0.9266\Upsilon^2 \approx 0.37$ yields

$$\text{The current value for } \Upsilon = k_{\min} R_{OH} \approx 0.63 \tag{2.4. 13}$$

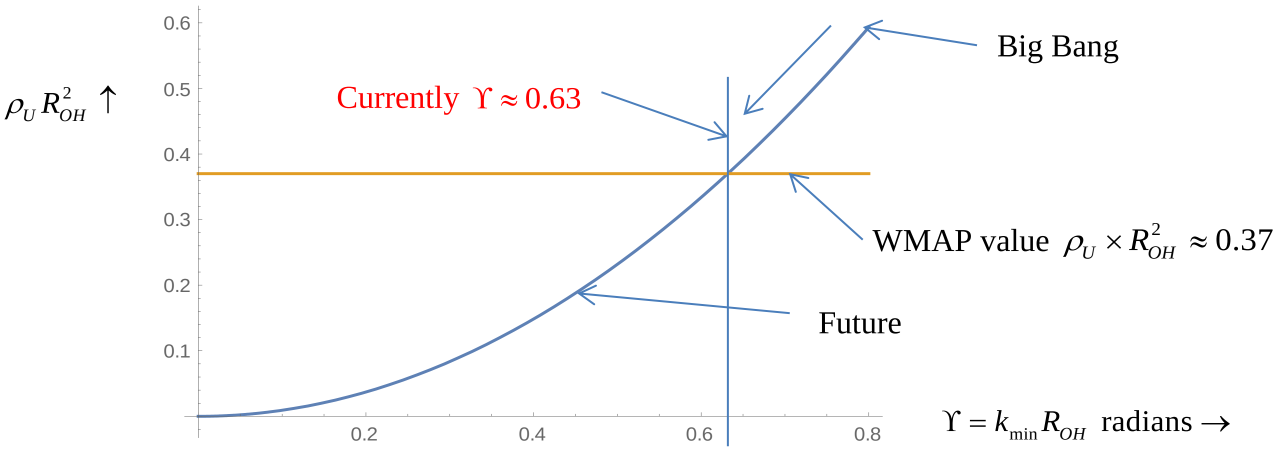


Figure 2.4. 2 plots $\rho_U \times R_{OH}^2 \approx 0.927\Upsilon^2$

Figure 2.4. 7 plots Eq. (2.4. 20) $\Upsilon \approx 0.8Exp(-0.24t)$ out to 10 times the current age of the universe showing the exponential decrease with time. The current Horizon Hubble velocity $V = 1 + H(T)R_{OH} \approx 4.35$ and putting this and $\Upsilon \approx 0.63$ into Eq.(2.4. 12) we can solve the approximate graviton coupling constant α_G.

$$\alpha_G \approx \frac{\Upsilon^2 V}{137.8} \approx \frac{1}{80} \tag{2.4. 14}$$

The actual value for α_G is less important than the form of this equation as provided Eq. (2.2. 10) $\rho_U \times R_{OH}^2 \approx 0.927\Upsilon^2$ is true (or in other words all comoving observers measure the *maximum wavelength graviton probability density* $K_{Gk\min}$ *as in Eq.* **(2.2. 11**) GR is still true locally regardless of graviton coupling α_G. The normal gravitational constant (big) G is directly related to the metric change of GR, and if GR is true locally then G will not change, as it is independent of graviton coupling α_G. Because Eq. (2.4. 14) depends on the actual present values for Υ & V it must be approximate. The above analysis is based on a receding horizon source of cosmic wavelength quanta that can only be borrowed if preons are born with zero momentum and infinite wavelength, but as we will see exponential expansion seems to follow naturally from Eq. (2.4. 14). It also strongly suggests that if fundamental particles are in fact built from infinite superpositions that borrow quanta from zero point vector fields, then graviton coupling α_G between Planck masses must be much less than 1. So are there possible consequences of this? We need to remember here that Einstein believed the forces of gravity were due to fictitious accelerations and not due to exchanged four momentum of virtual gravitons. They behave differently to all the other forces.

2.4.3 **Possible consequences of a small gravitational coupling constant**

In quantum mechanics forces between charged particles are due to the exchange of virtual bosons. All scattering crossections are calculated from the exchanged 4 momenum of these bosons. General Relativity suggests that the forces of gravity are fictitious and only seem real due to the change of the metric. This paper proposes that the change in the metric around mass concentrations is consistent with keeping the "$k_{\min}$ Graviton Constant $K_{Gk\min}$" of Eq. (2.2. **11**) invariant. These changes in the metric are about 80 times greater than the coupling constant suggests. We are suggesting in this paper that spin 2 gravitons only cause changes in the metric by the need to keep $\rho_{Gk\min} = K_{Gk\min} dk_{\min}$ invariant. The attempts to develop a quantum field theory for gravitons have difficulty with the infinities at Planck energies that are not renormalizable. They assume a gravitational coupling constant of one between Planck masses. This could change if this coupling constant is in fact about 80 times smaller, as Planck energy gravitons would no longer automatically form Black holes. However it may be irrelevant if, as Einstein believed, gravity is not due to exchanged 4 momentum.

2.4.4 **A possible exponential expansion solution and scale factors**

Let the scale factor be a then density $\rho \propto \dfrac{1}{a^3}$ and Eq. (2.2. 10) tells us the average density of the universe $\rho_U \approx 1.41 \dfrac{\Upsilon^2}{R_{OH}^2}$ so that $\rho_U = K \dfrac{\Upsilon^2}{R_{OH}^2} = \dfrac{1}{a^3}$ where $K = 1.41$ is constant.

$$\text{Thus} \quad a^3 = KR^2\Upsilon^{-2} \rightarrow a = K'R^{2/3}\Upsilon^{-2/3} \quad \text{where } R = R_{OH} \tag{2.4. 15}$$

The Hubble parameter H is

$$H = \frac{\dot{a}}{a} = \frac{(2/3)K'R^{-1/3}\Upsilon^{-2/3}\, dR/dt}{K'R^{2/3}\Upsilon^{-2/3}} - \frac{(2/3)K'R^{2/3}\Upsilon^{-5/3}\, d\Upsilon/dt}{K'R^{2/3}\Upsilon^{-2/3}} = \frac{2}{3}\left[\frac{1}{R}\frac{dR}{dt} - \frac{1}{\Upsilon}\frac{d\Upsilon}{dt}\right]$$

$$\text{Thus the Hubble Horizon velocity @ } R_{OH} \text{ is } V' = H \cdot R = \frac{2}{3}\left[\frac{dR}{dt} - \frac{R}{\Upsilon}\frac{d\Upsilon}{dt}\right] \tag{2.4. 16}$$

We can also write Eq.(2.4. 14) $\Upsilon^2 V \approx 164\alpha_G = \text{a constant}$, hence $\Upsilon^2 dV + 2\Upsilon d\Upsilon V = 0$.

Thus $\dfrac{1}{2V}\dfrac{dV}{dT} = -\dfrac{1}{\Upsilon}\dfrac{d\Upsilon}{dT}$ and Eq. (2.4. 6) tells us that the Horizon velocity $V = \dfrac{dR_{OH}}{dt} = \dfrac{dR}{dt}$.

Equation (2.4. 6) also tells us that $V' = H \cdot R = V - 1$ so we can write Eq. (2.4. 16) as

$$\left[3(V-1) - 2V = -\frac{2R}{\Upsilon}\frac{d\Upsilon}{dt} = \frac{2R}{2V}\frac{dV}{dt}\right] \rightarrow V - 3 = \frac{R}{V}\frac{dV}{dt} \quad \rightarrow \quad \frac{dV}{dt} = \frac{V}{R}(V-3) \tag{2.4. 17}$$

We will look for an exponential increase of the horizon velocity so $dV/dt > 0$ and $3 \le V \le \infty$. Let us try first a simple $V = 3Exp(bt)$ with $V > 3$ for all values of $b \,\&\, t > 0$.

Also simply put $R = \int_0^t Vdt = \int_0^t 3Exp(bt)dt$ thus $R = \frac{3[Exp(bt)-1]}{b}$.

Putting this value for R plus $V = 3Exp(bt)$ & $V - 3 = 3[Exp(bt)-1]$ into Eq. (2.4. 17)

$$\frac{dV}{dt} = \frac{V}{R}(V-3) = 3Exp(bt)\cdot\frac{b}{3[Exp(bt)-1]}\cdot 3[Exp(bt)-1] = 3bExp(bt).$$

But $V = 3Exp(bt)$ and again $\frac{dV}{dt} = \frac{d}{dt}\left[3Exp(bt)\right] = 3bExp(bt)$. Thus Eq's. (2.2. 10) & (2.4. 14) are consistent with $V = 3Exp(bt)$ for positive b regardless of the value of graviton coupling α_G

A possible expansion solution is $V = 3Exp(bt)$ & $R = \frac{3[Exp(bt)-1]}{b}$, $b > 0$. (2.4. 18)

But is this consistent with the local special relativity requirement for R_{OH}? In other words does R @ time $T = a(T)\int_0^T \frac{dt}{a(t)} = \frac{3[Exp(bT)-1]}{b}$? Now Eq. (2.4. 15) tells us the scale factor $a^3 = KR^2\Upsilon^{-2} \rightarrow a = K'R^{2/3}\Upsilon^{-2/3}$ but Eq.(2.4. 14) says $\Upsilon^2 \propto 1/V$ so the scale factor $a \propto V^{1/3}R^{2/3}$.

From Eq. (2.4. 18) ignoring the constant factors 3 & b, $V \propto Exp(bt)$ & $R \propto \left[Exp(bt)-1\right]$

The scale factor $a(t) \propto Exp(bt)^{1/3}[Exp(bt)-1]^{2/3}$ (2.4.19)

Thus $R = a(T)\int_0^T \frac{dt}{a(t)}$

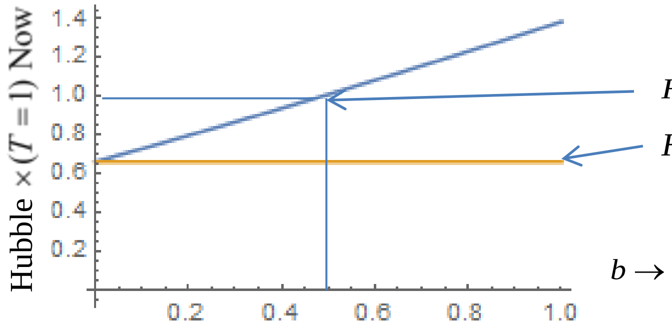
$$= Exp(bT)^{1/3}[Exp(bT)-1]^{2/3}\int_0^T \frac{dt}{Exp(bt)^{1/3}[Exp(bt)-1]^{2/3}}$$

$$= \frac{3[Exp(bT)-1]}{b}$$

And Eq. (2.4. 18) appears to be a consistent exponential expansion for both V and R.

From Eq. (2.4. 14) we showed $\frac{1}{2V}\frac{dV}{dT} = -\frac{1}{\Upsilon}\frac{d\Upsilon}{dT}$. Using Eq. (2.4. 18) $V = 3Exp(bt)$ & $\frac{dV}{dt} = 3bExp(bt)$ implies $\Upsilon = K \cdot Exp(-bt/2)$. The current value of $\Upsilon \approx 0.63$ from Eq.(2.4. 13) and our best guess of $b \approx 0.48$ from Figure 2.4. 3 yields

$$\Upsilon = k_{\min} R_{OH} \approx 0.8Exp(-0.24t) \text{ in radians} \qquad (2.4.\ 20)$$

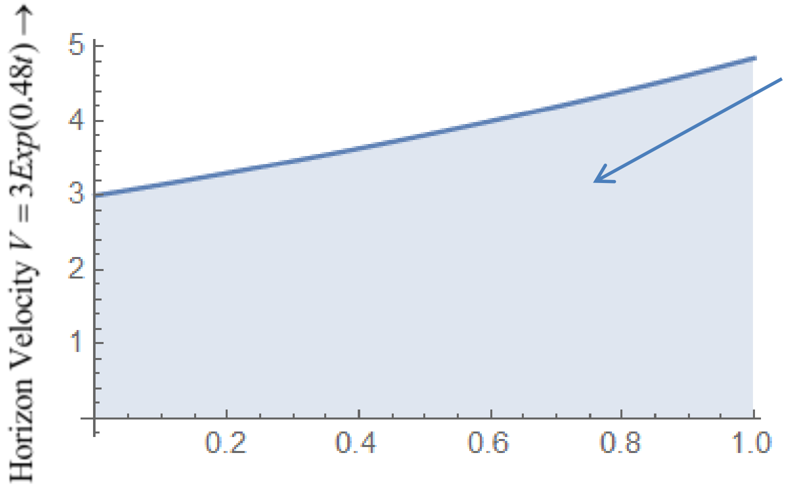


Hubble parameter

$H \approx 1/T$ now if $b \approx 0.48$

H always $2/3t$ if $b = 0$

Figure 2.4. 3



Shaded Area $R = \int_0^T V dt$

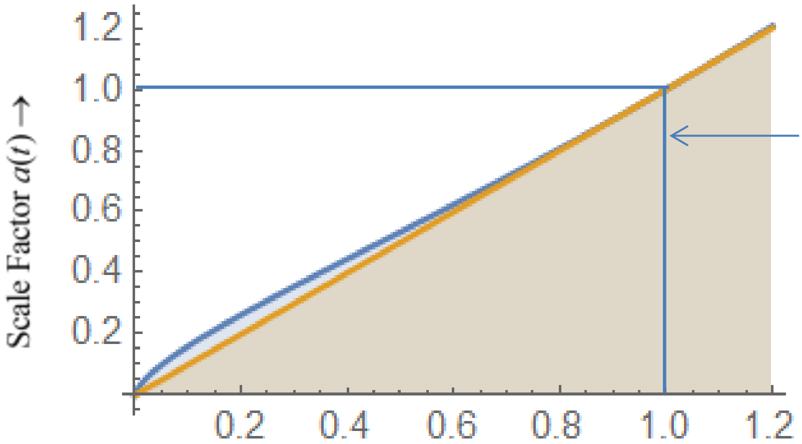
$= \int_0^T 3Exp(0.48t)dt$

$= \dfrac{3[Exp(0.48T) - 1]}{0.48}$

$= a(T)\int_0^T \dfrac{dt}{a(t)}$

Time $t \rightarrow$

Figure 2.4. 4



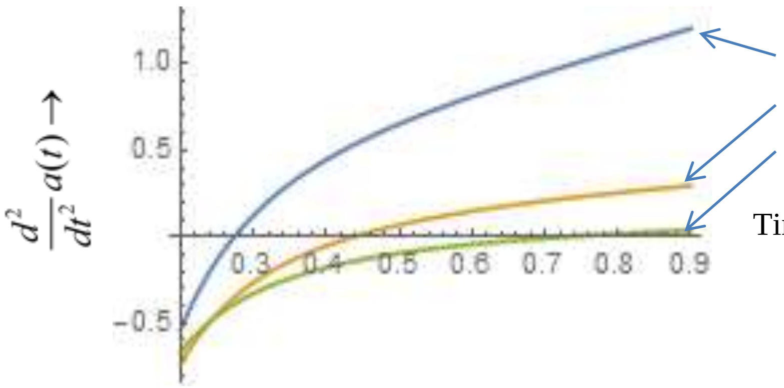
$b \approx 0.48$ is based on

Hubble $\approx \dfrac{1}{T}$ now

and is best guess.

Time $t \rightarrow$

Figure 2.4. 5



$b = 0.8$

$b = 0.5$

$b = 0.3$

Time $t \rightarrow$

Figure 2.4. 6

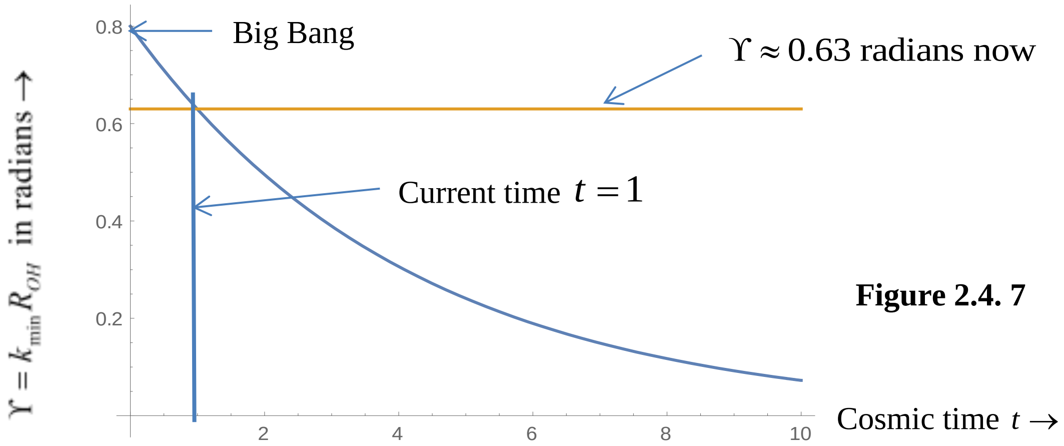


Figure 2.4. 7

2.4.5 Possible values for *b* and plotting scale factors

This simple exponential expansion starts at the Big Bang and is very different to the current cosmology models that keep a constant horizon velocity until Dark Energy starts to take effect. This continuous exponential increase could well lead to slightly different values for the radius R_{OH} and also possibly the age $T \approx 13.8 \times 10^9$ years. (Some recent observations [7] have also been questioning the leading current dark energy explanations of acceleration). Current cosmology models put the Hubble parameter as $H = \dot{a}/a \approx 1/T$ at present (based on $T \approx 13.8 \times 10^9$ years). It also simplifies the plots above if we put $T \approx 13.8 \times 10^9$ years $= 1$, with R_{OH} or radius R becoming multiples of $T = 1$. Using Eq. (2.4. 6)$V = 1 + H(T)R$, Figure 2.4. 3 plots the Hubble parameter by time$(T = 1)$now as a function of the exponential time coefficient b showing if $b = 0$ that H always $= 2/(3t)$ as in current cosmology at critical density with no dark energy. Also if $H \approx 1/T$ now the best guess is $b \approx 0.48$. This yields $R \approx 3.85T$ or $\approx 15\%$ greater than current cosmology. Figure 2.4. 4 plots horizon velocity & Figure 2.4. 5 the scale factor based on $b \approx 0.48$, but of course the actual value of *b* or rate of change with time must be in agreement with the redshifts currently observed when looking back towards the big bang. These could well change *b* and radius *R*. Figure 2.4. 6 plots the transition to positive acceleration of the scale factor showing the effect of changing the value of *b*. Figure 2.4. 7 plots Eq.(2.4. 20) $\Upsilon = k_{\min} R_{OH} \approx 0.8 Exp(-0.24t)$ out to 10 *T*.

2.5 An Infinitesimal change to General Relativity effective at cosmic scale

All we have discussed is based on the energy in the zero point fields being limited. We argued that uniform mass density throughout the cosmos has $k_{\min}$ graviton probability density $\rho_{Gk\min}$ as in Eq. (2.2. **11**). At this probability density the zero point quanta density available equals that required. To maintain this required balance as in Figure 2.4. 1 we argued that around any mass concentration the curvature of space expands space locally so as to keep the $k_{\min}$ graviton constant $K_{Gk\min} \approx 0.262\alpha_G$ as in Eq. (2.2. **11**) invariant at all points. In other words *our conjecture only works if the local curvature of space depends on the difference* *between the local mass density and the uniform background.* Compared to General Relativity this is an infinitesimal change except at cosmic scale. *GR says the curvature of space depends on local mass density* whereas we argue that it depends on the difference between local mass density and the average background (only a few hydrogen atoms per cubic metre). This automatically guarantees the universe to be flat on average. All our aguments start with flat space on average. The equations of GR would look almost identical except the Energy Momentum Tensor $T_{\mu\nu}$ in comoving coordinates requires T_{00} the mass/energy density to change from ρ to $\rho - \rho_U$ where the density of the universe ρ_U is as in Eq.(2.2. 10).

In comoving cordinates T_{00} changes from ρ to $\rho - \rho_U$ in the Energy Momentum Tensor $T_{\mu\nu}$ (2.5. 1)

2.5.1 Non comoving coordinates in Minkowski spacetime where $\mathbf{g}_{\mu\nu} = \eta_{\mu\nu}$

To this point everything we have looked at has been in comoving coordinates. Velocities relative to comoving coordinates are usually referred to as peculiar velocities, so, does what we are saying above still apply in such non comoving coordinates? In section 2.3.1 we said that spin 1 sources are 4 currents, but spin 2 graviton sources are the stress tensor. We have also been saying up to here that the background $k_{\min}$ gravitons are spherically symmetric or time polarized in comoving coordinates. We are going to conjecture that in non rotating Minkowski spacetime they are always time polarized, regardless of peculiar velocities. This may seem impossible, as we would intuitively expect something to not remain spherically symmetric if we move relative to it. But we are not talking about real particles; we are talking about virtual spin 2 gravitons. We cannot see them, or detect them directly in any way, only their consequences. We can calculate amplitudes and probabilities for their presence only. So let us look again at these background $k_{\min}$ graviton amplitudes and probabilities. In section 2.1.2 we found in Eq.(2.1. 10) the probability density of background $k_{\min}$ virtual gravitons

$$\psi_{\text{Universe}}{}^{*}\,\psi_{\text{Universe}} = \rho_{Gk\min} = K_{Gk\min}dk_{\min} \text{ where } K_{Gk\min} \approx \frac{0.3056\alpha_G\rho_U^2}{k_{\min}^4} \text{ in comoving coordinates.}$$

If we move relative to this at peculiar velocity β_P, measured volumes shrink as $\gamma_P^{-1} = (1-\beta_P^2)^{1/2}$ and all comoving mass increases as $\gamma_P = (1-\beta_P^2)^{-1/2}$. (We will use red symbols with the subscript $_P$, and triple primes for wavenumber $k'''_{\min}$ for peculiar velocities, to distinguish them from metric changes where we used green and a double primed $k''_{\min}$.) Thus $\rho'''_U = \gamma_P^2\rho_U$ .The minimum wavenumber $k_{\min}$ has its lowest value in comoving coordinates (at least far from mass concentrations where $g_{\mu\nu} = \eta_{\mu\nu}$) but at peculiar velocity β_P , $k'''_{\min} = \gamma_P k_{\min}$.

$$\frac{\rho_U'''^2}{k_{\min}'''^4} = \frac{\gamma_P^4}{\gamma_P^4}\frac{\rho_U^2}{k_{\min}^4} = \frac{\rho_U^2}{k_{\min}^4} \text{ and } K_{Gk\min} \text{ is invariant.}$$

$$\rho_{Gk\min} \approx K_{Gk\min}dk_{\min} \text{ in non comoving coordinates if } g_{\mu\nu} = \eta_{\mu\nu} \tag{2.5. 2}$$

2.5.2 Non comoving coordinates when $\mathbf{g}_{\mu\nu} \neq \eta_{\mu\nu}$

Starting with Eq. (2.1. 10) $\rho_{Gk\min} \approx K_{Gk\min} dk_{\min}$ we have just shown that this equation remains true at any peculiar velocity β_P in flat spacetime. All that happens is that the values of $k_{\min}$, $dk_{\min}$ & $\rho_{Gk\min} \approx K_{Gk\min} dk_{\min}$ all increase as $\gamma_P = (1-\beta_P^2)^{-1/2}$. In other words the probability of finding a $k_{\min}$ graviton is always proportional to whatever the value $k_{\min}$ & $dk_{\min}$ is. Also the *amplitude* to find a $k_{\min}$ graviton is always proportional to either $\sqrt{k_{\min}}$ or $\sqrt{dk_{\min}}$. We have shown in sections 2.1 & 2.2 that around mass concentrations in comoving coordinates, the $k_{\min}$ gravitons are comprised of the background due to the universe plus the interaction between the local mass and the universe as in Figure 2.2. 2 . This background $k_{\min}$ graviton probability, regardless of the local metric, is always proportional to whatever the local value $k_{\min}$ & $dk_{\min}$ is. Amplitudes are also always proportional to local values of $\sqrt{k_{\min}}$ or $\sqrt{dk_{\min}}$.

$$\text{Amplitude } \psi_{Gk\min} \text{ (due to rest of universe) or } \psi_{\text{Universe}} \text{ always} \propto \sqrt{dk_{\min}} \tag{2.5. 3}$$

As in Figure 2.2. 1 the probability for a small mass m to emit a $k_{\min}$ graviton is $\frac{2}{\pi} m^2 \alpha_G \frac{dk_{\min}}{k_{\min}}$.

The normalized wavefunction $\frac{2k'_{\min}}{4\pi r^2} e^{-2k'_{\min} r} \approx \frac{2k'_{\min}}{4\pi r^2} \approx \frac{2\times 3.556 k_{\min}}{4\pi r^2}$ as $k'_{\min} r \approx 0$ & $k'_{\min} \approx 3.556 k_{\min}$ using Eq. (2.1. 4). Thus we can say the:

$$\begin{gathered}\text{Amplitude } \psi_{Gk\min} \text{ (due to small mass } m) \approx \sqrt{\frac{2}{\pi} m^2 \alpha_G \frac{dk_{\min}}{k_{\min}} \frac{3.556 k_{\min}}{2\pi r^2}} = \frac{2m}{r}\sqrt{\frac{3.556\alpha_G dk_{\min}}{4\pi^2}} \\ \psi_m = \frac{2m}{r}\sqrt{\frac{3.556\alpha_G dk_{\min}}{4\pi^2}} \text{ is allways } \propto \frac{2m}{r}\sqrt{dk_{\min}}\end{gathered} \tag{2.5. 4}$$

The interaction between this small mass and the rest of the universe is

$$\Delta\rho_{Gk\min} \approx \psi_{\text{Universe}}{}^* \psi_m + \psi_m{}^* \psi_{\text{Universe}} \propto \sqrt{dk_{\min}} \times \frac{2m}{r}\sqrt{dk_{\min}} \text{ is allways} \propto \frac{2m}{r} dk_{\min} .$$

We have shown previously that $K_{Gk\min}$ is the proportionality constant. So regardless of peculiar velocities

$$\Delta\rho_{Gk\min} \approx \psi_{\text{Universe}}{}^* \psi_m + \psi_m{}^* \psi_{\text{Universe}} \text{ is allways } \frac{2m}{r} K_{Gk\min} dk_{\min} \tag{2.5. 5}$$

Thus $\Delta\rho_{Gk\min} \approx \psi_{\text{Universe}}{}^* \psi_m + \psi_m{}^* \psi_{\text{Universe}}$ is always proportional to $dk_{\min}$ and at peculiar velocity β_P ; $k'''_{\min} = \gamma_P k_{\min}$ & $dk'''_{\min} = \gamma_P dk_{\min}$. So both $\rho'''_{Gk\min}$ & $\Delta\rho'''_{Gk\min}$ increase as γ_P and their ratio does not change. The logic of our aguments is not affected by peculiar velocities. The same is true for large masses moving at peculiar velocities. In a metric γ_M as in section 2.2.2 (using four blue primes for combined peculiar velocity and metric changes) $k''''_{\min} = \gamma_P \gamma_M k_{\min}$

and $dk''''_{\min} = \gamma_P \gamma_M dk_{\min}$. Both $\Delta\rho''''_{Gk\min}$ & $\rho''''_{Gk\min}$ increase as $\gamma_P \gamma_M$ and again their ratio does not change. All the arguments we used in section 2.2.2 do not change and Equ's. (2.2. 14), (2.2. 15) & (2.2. 16) still apply in non comoving coordinates providing β_M is the velocity reached by a small test mass falling from infinity in the same rest frame as the mass concentration m moving at peculiar velocity β_P. We can think of $K_{Gk\min} \approx 0.262\alpha_G$ as a constant scalar throughout the universe representing the *Probability Density* of finding a minimum wavenumber $k''''_{\min} = \gamma_P \gamma_M k_{\min}$ virtual graviton at all points of spacetime. Near mass concentrations the metric changes; local clock rates change, and so does the measurement of $k_{\min}$, but not the scalar $K_{Gk\min}$. Locally measured infinitesimal volumes increase to accommodate the extra locally emitted maximum wavelength gravitons keeping the scalar of probability density constant. We argue that General Relativity is consistent with this. If we think of the mass in the universe as a dust of density ρ_U essentially at rest in comoving coordinates we can define a tensor $T_{\mu\upsilon}(\text{Background})$. In comoving coordinates $T_{\mu\upsilon}(\text{Background})$ has only one non zero term $T_{00}(\text{Background}) = \rho_U$. In any other coordinates this same $T_{\mu\upsilon}(\text{Background})$ tensor is transformed by the usual tensor transformations that apply in GR. If these coordinates move at peculiar velocity β_P then $T'''_{00}(\text{Background}) = \gamma_P^2 \rho_U$ $= \gamma_P^2 T_{00}(\text{Background})$. This all suggests the infinitesimally modified Einstein field equations

$$G_{\mu\upsilon} \equiv R_{\mu\upsilon} - \frac{1}{2} g_{\mu\upsilon} R = \frac{8\pi G}{c^4}\left[T_{\mu\upsilon} - T_{\mu\upsilon}(\text{Background})\right] \qquad (2.5.\ 6)$$

We argue that Eq. (2.5. 6) is consistent with keeping the scalar $K_{Gk\min} \approx 0.262\alpha_G$ constant throughout all spacetime as in Figure 2.5. 1. This infinitesimal modification is only relevant in the extreme case as $T_{\mu\upsilon}$ approaches $T_{\mu\upsilon}(\text{Background})$. Far from mass concentrations $T_{\mu\upsilon} \le T_{\mu\upsilon}(\text{Background})$. Space curvature, in these remote voids, is in general somewhere between slightly negative and zero; but the causally connected universe is flat on average regardless of the value of Ω..

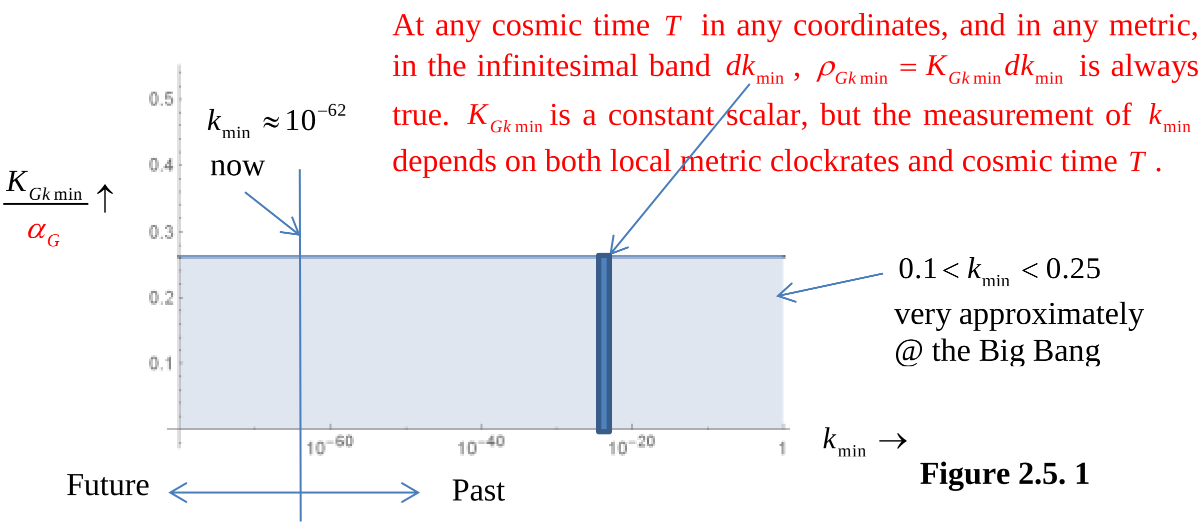


Figure 2.5. 1

If there is no inflation, in comoving coordinates, at the Big Bang or slightly after, $k_{\min}$ starts at just under one and is always close to the inverse of the causally connected horizon radius. It is also close to the inverse of cosmic time T. It is always at its minimum far from mass concentrations, but increases with the slower clock rates in the local metric around mass concentrations as in Figure 2.5. 1

2.5.3 Is inflation in this proposed scenario really necessary?

There are two main reasons, usually given, for why inflation is necessary:
(a) The average flatness of space.
(b) The almost uniform temperature of the cosmic microwave background from regions that were initially out of causal contact.
If we put $T_{\mu\upsilon}(\text{Local}) = T_{\mu\upsilon}(\text{Background})$ in Eq. (2.5. 6), the right hand side is identically zero, and $G_{\mu\upsilon} \equiv R_{\mu\upsilon} - \frac{1}{2} g_{\mu\upsilon} R \equiv 0$ on average throughout all space. The average curvature of all space must be zero and space is compelled to be flat on average.
In section 2.4.4 we found that space naturally expands exponentially as in Eq.(2.4. 18) and plotted in Figure 2.4. 4. The value of the constant b in $V = 3Exp(bt)$ has to fit experimental observations. But if it is some fundamental constant, which does not seem unreasonable, it must be the same for all comoving observers. If this is so the physics is identical for all such observers regardless of whether they are in causal contact. Provided we can assume identical starting points everywhere, of say the Planck temperature at cosmic time $T = 0$, then apart from quantum fluctuations, the average background temperature should be some function of cosmic time T for all comoving observers, or at least up to the time the universe became transparent. The physics controlling this should be identical in each comoving frame. Causal contact should not be essential for this. Inflation only guarantees that the starting temperature is uniform everywhere when it stops at approximately $T = 0$. It also has to assume identical physics everywhere from $T \approx 0$ for about the first 375,000 years, or untill the universe is transparent. This is virtually identical to what we are proposing in our scenario.

2.5.4 Why do we think virtual particle pairs do not matter?

This topic is discussed more fully in the first paper [7] on pages 85 & 86. A shortened summary goes a bit like this: Virtual particle pairs by definition only last briefly. Zero point energies are limited mainly for times similar to the age of the universe. The conservation of energy or in reality 4 momentum says that what we call “real matter or energy” can last for close to the age of the universe. It will have mass and by definition it can be weighed. It can move around, even close to the speed of light, but it is conserved. Gravitons that last this long we have called $k_{\min}$ gravitons and they can only couple to real, or long lasting energy/matter that can be weighed in whatever manner. The rotating dark matter in galaxies we cannot weigh directly, but it contributes to the theoretical weight of a galaxy. We have to allow for this mass when studying galaxy dynamics. The gluons that bind quarks are virtual, and form the bulk of nuclear mass and all normal matter. They are virtual particles, but protons appear to last for at least the age of the universe. They must couple to long lasting $k_{\min}$ gravitons.

We cannot weigh the virtual particle pair background. It may have huge consequences in quantum field theory, and we can measure these effects very accurately, but they are all due to very brief events. We argue however that they do not couple to $k_{\min}$ gravitons. If they somehow did, the total number of $k_{\min}$ gravitons would be so vast it would completely outstrip (by about 10^{120}) the supply of $k_{\min}$ quanta supply from the holographic horizon.

2.6 Messing up what was starting to look promising, or maybe not

2.6.1 The *k*min virtual gravitons emitted by the mass interacting with itself

In section 2 we started out by finding the average $k_{\min}$ graviton probability density in a uniform universe. We then placed a mass concentration in it and calculated the extra probability density of $k_{\min}$ gravitons (before the dilution due to local space expansion) due to the amplitude of this mass by the amplitude of the rest of the mass in the universe. This ended up being proportional to m/r in Planck units.

$$\Delta\rho_{Gk\min} = (\psi_{\text{Universe}} {*}\psi_m) + (\psi_m {*}\psi_{\text{Universe}}) \propto m/r \quad \text{as in Eq.(2.2. 6)}$$

And this is true in weak field metrics, except as we start approaching the Schwarzchild Radius because of the extra $k_{\min}$ gravitons from the mass interacting with itself: $\psi_m {*}\psi_m$.

$$\text{Using Eq. (2.1. 5)}\ \psi_m {*}\psi_m = \alpha_G \frac{m^2}{r^2}\frac{k'e^{-2k'r}}{\pi^2}\frac{dk}{k}$$

$$\text{Also using Eq. (2.1. 4)}\ k' = \sqrt{k^2 + 11.644k_{\min}^2} \approx 3.556k_{\min} \quad \text{when } k = k_{\min}$$

$$\psi_m {*}\psi_m = \alpha_G \frac{m^2}{r^2}\frac{3.556k_{\min}e^{-2(3.556k_{\min}r)}}{\pi^2}\frac{dk_{\min}}{k_{\min}}$$

The exponential term $e^{-2k'r} = e^{-2(3.556k_{\min}r)} = e^{-7.11k_{\min}r}$ and we are only interested in radii r that are small in relation to the observable radius of the Universe $R_{OU} \approx k_{\min}^{-1}$, just as in the assumptions we made in section 2.2.1. Thus $k'r \to 0$ and $e^{-2k'r} \approx 1$ in these regions so we can approximate this equation as

$$\psi_m {*}\psi_m \approx \alpha_G \frac{m^2}{r^2}\frac{3.556}{\pi^2}dk_{\min}$$

$$\Delta\rho_{Gk\min} \text{ due to self emission } \psi_m{}^*\psi_m \approx \alpha_G \frac{m^2}{r^2} 0.36 dk_{\min}$$

$$\approx 1.375 \frac{m^2}{r^2} 0.262 \alpha_G dk_{\min}$$

$$\approx 1.375 \frac{m^2}{r^2} K_{Gk\min} dk_{\min} \text{ using Eq.(2.2. } \mathbf{11}\text{)}$$

If the local clock rate is $\sqrt{g'_{00}} = \frac{1}{\gamma_M}$ as in Eq.(2.2. 13) but with a slightly modified g_{00} (as we will see below), before dilution due to the local space expansion we can measure:

$$\text{Before dilution } \Delta\rho_{Gk\min} \text{ due to } \psi_m{}^*\psi_m \approx 1.375 \frac{m^2}{r^2} \gamma_M^2 K_{Gk\min} dk_{\min} \tag{2.6. 1}$$

2.6.2 What does this extra term mean for non rotating black holes?

When deriving Eq.(2.2. 14) we found (about two equations previous) that due to interactions with the rest of the Universe $\Delta\rho_{Gk\min} \approx \gamma_M^2 \frac{2m}{r} 0.262 \alpha_G dk_{\min} \approx 2\frac{m}{r}\gamma_M^2 K_{Gk\min} dk_{\min}$

$$\text{Thus } \Delta\rho_{Gk\min} \text{ total} \approx \left[2\frac{m}{r} + 1.375 \frac{m^2}{r^2} \right] \gamma_M^2 K_{Gk\min} dk_{\min} \text{ in Planck units.} \tag{2.6. 2}$$

Staying on our current path appears to contradict General Relativity, but temporarily ignoring this, let us repeat section 2.2.2 which modifies a non rotating black hole metric to

$$g'_{00} = -\frac{1}{g'_{rr}} = 1 - \frac{2m}{r} - 1.375\frac{m^2}{r^2}$$
$$\beta_M^2 = \frac{2m}{r} + 1.375\frac{m^2}{r^2} \tag{2.6. 3}$$
$$\gamma_M^2 = \frac{1}{1 - 2m/r - 1.375m^2/r^2}$$

Where β_M is the velocity reached by a small test mass falling in from infinity in the same rest frame. Applying the same proceedures as in section 2.2.2 we can use Equ's. (2.6. 3) to show that $\rho_{Gk\min} = K_{Gk\min} dk_{\min}$ in this new metric, and we will discuss possible tensions with General Relativity in section 2.6.5. The modified non rotating horizon radius occurs when $r^2 - 2mr - 1.375m^2 = 0$ or the:

$$\text{Modified non rotating horizon radius } r \approx 2.54m \tag{2.6. 4}$$

This is approximately 27% larger than the Schwarzchild value.

2.6.3 What does it mean for rotating black holes?

In section 2.3 when we looked at the Kerr Metric we used a dimensionless form of the metric in Equ's.(2.3. 2). We also used a dimensionless parameter A where we initially put $A = 2m/r$. We also showed that we could change A without changing $g'_{tt} = \Delta / g_{\varphi\varphi}$ the time component in the corotating frame, provided there is a modified $\Delta = 1 + \frac{\alpha^2}{r^2} - A$. So again temporarily ignoring potential conflicts with General Relativity let us change $A = \frac{2m}{r}$ to $A = \frac{2m}{r} + 1.375\frac{m^2}{r^2}$ and look at the consequences. Firstly from Equ's. (2.6. 3) we can see that $A = \beta_M^2$ where β_M is the radial inward velocity, in a corotating rest frame, of a small test mass falling from infinity (in the rest frame of the rotating black hole centre). The inner event horizon is the radius where $g_{rr} \to \infty$ so using Equ's.(2.3. 2) $-g_{rr} = \frac{\rho^2}{\Delta} \to \infty$ or

$$\Delta = 1 + \frac{\alpha^2}{r^2} - A = 0$$

$$= 1 + \frac{\alpha^2}{r^2} - \frac{2m}{r} - 1.375\frac{m^2}{r^2} = 0$$

$$\text{or } \; r^2 + \alpha^2 - 2mr - 1.375m^2 = 0$$

$$r = \frac{2m \pm \sqrt{4m^2 + 5.5m^2 - 4\alpha^2}}{2}$$

Event Horizon radius $$r = \frac{2m \pm \sqrt{9.5m^2 - 4\alpha^2}}{2} \qquad (2.6.\ 5)$$

When $\alpha = 0$ $\quad r = \frac{2m \pm \sqrt{9.5m^2}}{2} \approx \frac{2m + 3.082m}{2} \approx 2.54m$ as in the non rotating case.

Maximum spin is when $\quad 4\alpha^2 = 9.5m^2$ or $\alpha_{\max} \approx 1.54m$

At this maximum spin $\quad r = m$ as in the usual Kerr Metric.

The outer horizon occurs when $+g_{tt} = 1 - \frac{A}{\rho^2} = 0$ or $\rho^2 - A = 0$ and using Equ's.(2.3. 2)

$$1 + \frac{\alpha^2}{r^2}\cos^2\theta - A = 1 + \frac{\alpha^2}{r^2}\cos^2\theta - \frac{2m}{r} - 1.375\frac{m^2}{r^2} = 0$$

$$r^2 - 2mr - 1.375m^2 + \alpha^2\cos^2\theta = 0$$

$$r = \frac{2m + \sqrt{4m^2 + 5.5m^2 - 4\alpha^2\cos^2\theta}}{2}$$

$$r = \frac{2m + \sqrt{9.5m^2 - 4\alpha^2\cos^2\theta}}{2}$$

$$\text{Ergosphere radius } r = \frac{2m + \sqrt{9.5m^2 - 4\alpha^2}}{2} \quad @\, \theta = 0 \,\&\, \pi$$
$$= \frac{2m + \sqrt{9.5m^2}}{2} \approx 2.54m \quad @\, \theta = \frac{\pi}{2} \qquad (2.6.\ 6)$$

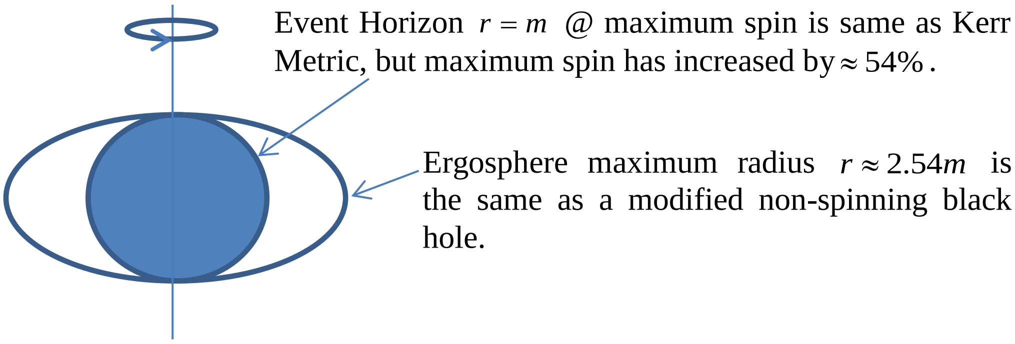


Figure 2.6.1 Modified Kerr Metric with the dimensionless parameter A changed from $A = \frac{2m}{r} \to A = \frac{2m}{r} + 1.375\frac{m^2}{r^2}$. (This conflicts with General Relativity near the horizon.)

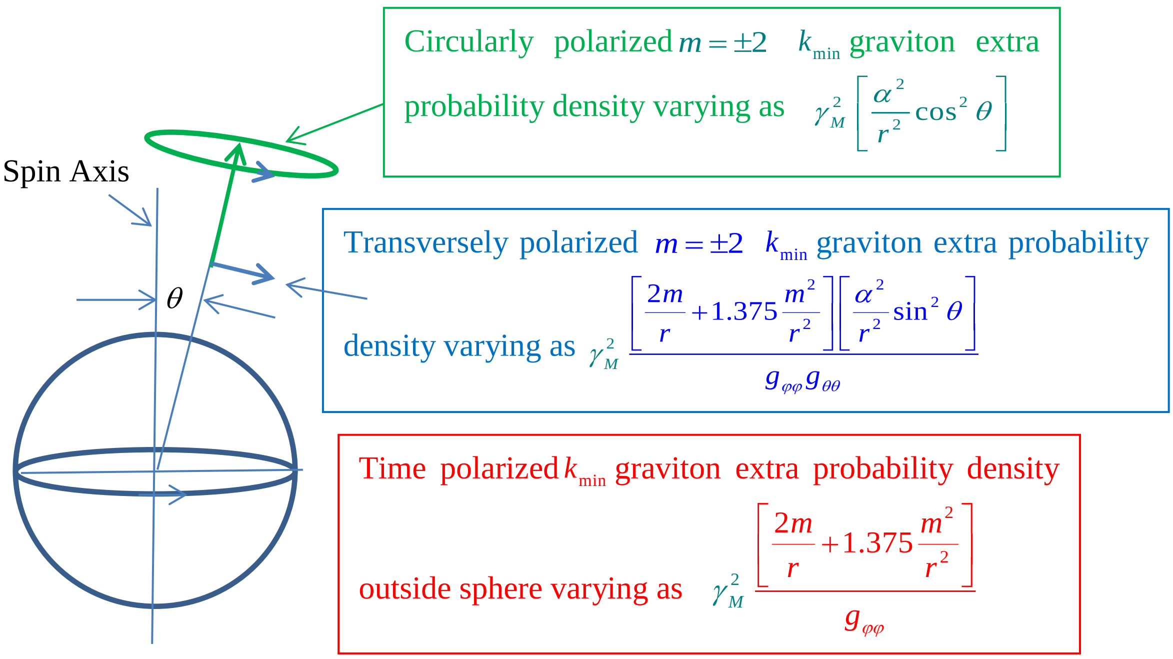


Figure 2.6. 2 Spinning black hole mass m with angular momentum length parameter α, but with the dimensionless parameter A changed from $A = \frac{2m}{r} \to A = \frac{2m}{r} + 1.375\frac{m^2}{r^2}$. The determinant of the metric is independent of A. The denominator terms $g_{\theta\theta}$ & $g_{\phi\phi}$, in dimensionless form as in Equ's. (2.3. 2), rapidly tend to one, as does γ_M^2 for radii $r >> r_{Sw}$, and can be ignored.

Figure 2.6.1 illustrates these changes from the Kerr Metric. The main effect from changing A is to allow an increase in maximum spin from $\alpha = m$ to $\alpha \approx 1.54m$, and an $\approx 27\%$ increase in the maximum ergosphere radius from $r = 2m$ to 2.54m. It may appear to contradict General Relativity, but provided the extra densities of time, $m = \pm 2$ circular and transverse polarized $k_{\min}$ gravitons are as in Eq.(2.3. 7) with $A = \dfrac{2m}{r} + 1.375\dfrac{m^2}{r^2}$ then $\rho_{Gk\min} = K_{Gk\min} dk_{\min}$ is still true in the rotating space outside the black hole.

Figure 2.6. 2 shows the probability densities of time polarized, circular and transverse polarized $m = \pm 2$ $k_{\min}$ gravitons as in Eq.(2.3. 7) in this modified metric before the expansion of space, which dilutes the probabilies so as to keep the $k_{\min}$ graviton constant $K_{Gk\min}$ invariant outside the black hole.

2.6.4 The determinant of the metric and the $k_{\min}$ graviton constant $K_{Gk\min}$

In a corotating rest frame the metric can be written in diagonal form, as in this frame $\dfrac{d\phi}{dt} = 0$.

Working in dimensionless form as in Equ's.(2.3. 2) and using Eq. (2.3. 3) $g'_{tt} = \dfrac{\Delta}{-g_{\phi\phi}}$ but ignoring signs we have $g_{rr} \cdot g'_{tt} \cdot g_{\theta\theta} \cdot g_{\phi\phi} = \dfrac{\rho^2}{\Delta} \cdot \dfrac{\Delta}{g_{\phi\phi}} \cdot \rho^2 \cdot g_{\phi\phi} = \rho^4 = (1 + \dfrac{\alpha^2}{r^2}\cos^2\theta)^2$

$$\text{In dimensionless form the Determinant of } \left| g_{\mu\nu} \right| = \rho^4 = (1 + \frac{\alpha^2}{r^2}\cos^2\theta)^2 \tag{2.6. 7}$$

It is independent of the dimensionless parameter *A*.

Despite possible conflicts with General Relavity, if the determinant of the metric in a corotating frame is as in Eq. (2.6. 7) or always ρ^4 then the $k_{\min}$ graviton probability density is $\rho_{Gk\min} = K_{Gk\min} dk_{\min}$ at all points outside the rotating black hole, and this is also true if there is no rotation.

2.6.5 General Relativity is based on mass not mass squared

It would appear that including the self interaction term $\psi_m * \psi_m$, with its introduction of an m^2 / r^2 term in the metric, does not naturally relate with General Relativity where the Stress Tensor has T_{00} based on mass/energy densities, with no mass squared terms. But if our hypothesis that $\rho_{Gk\min} = K_{Gk\min} dk_{\min}$ is to be always true, and we include the $\psi_m * \psi_m$ term then we are forced to accept an m^2 / r^2 term in the metric. The match between an invariant $k_{\min}$ graviton constant $K_{Gk\min}$, and an infinitesimally modified General Relativity as in Eq.(2.5. 6) $R_{\mu\upsilon} - \dfrac{1}{2} g_{\mu\upsilon} R = \dfrac{8\pi G}{c^4}\left[T_{\mu\upsilon} - T_{\mu\upsilon}(\text{Background}) \right]$ is remarkably accurate from close to black holes to near the cosmic horizon. But not very close to black holes if we include $\psi_m * \psi_m$.

Einstein based his remarkable equation on the Equivalence principle (the same physics in all free falling frames as in empty space) and the covariant derivative behaving correctly in all coordinates and throughout all spacetime. His thinking went along similar lines to Gauss's $\nabla^2\varphi = \rho$, but in curved spacetime. This naturally leads to inverse square force laws with inverse potentials, but the inclusion of an m^2/r^2 potential term in the metric due to $\psi_m{}^*\psi_m$ seems to mess all this up. But does it really? Or alternatively, could it be trying to tell us something that we did not want to know, but need to know?

Quantum mechanics in the form of QED tells us that close to fundamental electric charges Gauss's inverse square force law breaks down and QED takes over with almost unbelievable accuracy. The inverse square electric force law had ruled with remarkable accuracy for over a century before QED arrived on the scene. In fact it was the announcement of the Lamb Shift at the Long Island conference in 1947 that started the big breakthroughs in QED. World War II developments in radar had enabled these remarkably accurate experiments. Is it possible that similar developments today will allow improvements in Gravitational Wave observation accuracy? Developments that may see effects in gravity close to black hole horizons with some parallels to those of QED close to electric charges?

2.6.6 Frame Dragging has to occur in this proposed scenario

Lense and Thirring [25] were the first to show that General Relativity predicted this about two years after Schwarzchild's solution to Einstein's field equations. And of course the Kerr metric exact solution for rotating black holes also confirms it. In section 2.2.2 we showed that the Schwarzchild metric near large non-rotating masses is consistent with the $k_{\min}$ graviton constant $K_{Gk\min}$ as in Eq. (2.2. **11**) remaining constant. This metric tells us that, *as seen from a large distance*, time at the horizon of a black hole stops, and the velocity of light drops to zero. Photons and gravitons are frozen in place. We have argued that the extra $k_{\min}$ gravitons near the horizon, due to this mass, cause this warping of spacetime that freezes time on the horizon. This effectively locks spacetime to mass on that horizon. The extra $k_{\min}$ gravitons just above the horizon can be thought of as due to the adjacent mass immediately below them, and in section 2.6.1 we addressed the affect of this $\psi_m{}^*\psi_m$ self emission. So if space time just above the horizon is locked to non-rotating black hole mass, it must also be locked to the moving mass of a rotating black hole. We are of course assuming here that, as pointed out in the first paper, infinite superpositions cannot exist inside the horizon. This suggests the horizon might be a spacetime boundary consisting of a few Planck thicknesses of exponentially decreasing Planck density mass. This also implies that the Equivalence Principle could possibly breakdown near the horizon if these arguments involving infinite superpositions are true. In normal General Relativity this breakdown in the laws of physics is seen to occur at the central singularity. The breakdown has to happen somewhere in this region, either at the centre or, as we suggest, it has to be the horizon [19] [20] [21] [22] [23].

2.7 Revisiting some aspects of the first paper that we have now modified

2.7.1 Infinitesimal rest masses

This was covered in the first paper but there are some small corrections as we had used the expectation value of the superposition number $\langle n \rangle$ when we should have used $\sqrt{\langle n^2 \rangle}$. Also small corrections we have made in the expansion of the universe have changed the value of $\Upsilon = k_{\min} R_{OH}$ in Eq. (2.2. 10) from $\Upsilon \approx 0.51$ to $\Upsilon \approx 0.63$. From Table 4.3.1 page 61 in the first paper we find that for spin 1 $\sqrt{\langle n^2 \rangle} \approx 4.095$ and for spin 2 $\sqrt{\langle n^2 \rangle} \approx 3.41$. Using these new values and $\Upsilon \approx 0.63$ we can redo Table 6.2.1 on page 84 of the first paper [7]. (These changes increase infinitesimal rest masses approximately 20% compared with the first paper.)

Spin	$\sqrt{\langle n^2 \rangle}$	Compton Wavelength λ_c	Infinitesimal Rest Mass
1	4.095	$\approx 0.58 R_{OH}$	$\approx 7.8 \times 10^{-34} eV.$
2	3.41	$\approx 0.49 R_{OH}$	$\approx 9.3 \times 10^{-34} eV.$

Table 2.7. 1 Infinitesimal rest masses of $N = 2$ photons, gluons and gravitons.

2.7.2 Redshifted zero point energy from the horizon behaves differently to local

Local zero point energies are Lorentz invariant. At high frequencies there is no shortage locally to build the high frequency components of superpositions. If a massive $N = 1$ virtual pair emerges from the vacuum its life is short and it places little demand on long range quanta. If there were no redshifted supply from the horizon there would be only a few modes of the local supply of $k_{\min} \approx 1/R_{OU}$ quanta inside the horizon. Because preons are born with zero momentum and infinite wavelength they can however absorb a different supply of redshifted $k_{\min} \approx 1/R_{OU}$ quanta from the receding horizon as we have discussed. This $k_{\min}$ quanta redshifted supply behaves differently to normal Lorentz invariant zero point local fields. It behaves as $K_{Qk\min} = 1.745\alpha_G$ "The Quanta required @ $k_{\min}$ Constant" of Eq. (2.4. 12) Where $K_{Qk\min} \approx 6.66 \times K_{Gk\min}$ "The $k_{\min}$ Graviton Constant" of Eq. (2.2. 11).This redshifted supply is only available to preons that are born with zero momentum, or infinite wavelength, in the rest frame in which infinite superpositions are built.

2.7.3 Revisiting the building of infinite superpositions

In section 2 of the first paper we developed equations to determine the probability of each mode of a superposition using local zero point fields and in section 2 when we found the cosmic wavelength supply inadequate we switched to a different redshifted supply for long range quanta. So how do we justify our use of the local zero point fields to determine mode probabilities and behaviours? There is simply a plentifull supply of high frequency local zero point fields. This local supply is adequate for high densities of superpositions for all modes from the Planck energy $k = 1$ high energy mode cutoffs to somewhere around $k \approx 10^{-20}$ or near nuclear wavelengths. Thus until we reach somewhere hear nuclear densities there is a sufficient supply of local high frequency zero point fields to build infinite superpositions. The coupling to local zero point fields in this high frequency region determines the behaviour of all the standard model particles. There is however a gradual transition to absorbing quanta from the redshifted horizon supply as the wavelength increases. Because the redshifted supply of $k_{\min}$ quanta behaves as the invariants $K_{Qk\min}$ or $K_{Gk\min}$ above and entirely differently to Lorentz invariant local zero point fields, spacetime has to warp around mass concentrations and the universe has to expand.

2.8 Gravitational Waves

Our hypothesis has been throughout, that the warping of spacetime is directly related to maintaining the maximum wavelength, or $k_{\min}$ graviton density $\rho_{Gk\min} = G_{Gk\min} dk_{\min}$ invariant throughout all spacetime. Around non-rotating (spherically symmetric) mass concentrations this warping decreases inversely with radius (at least well away from black holes) but always in a spherically symmetric manner as the extra $k_{\min}$ gravitons due to this mass are distributed in the same spherical way. Likewise we get cylindrical symmetry for rotating mass concentrations. Both these types of symmetries are the lowest energy stable state of the metric. Disturbances to this stable state will travel as waves at the speed of light.

2.8.1 Constant transverse areas in low energy waves

If these mass concentrations accelerate, then just like accelerating electric charges they will radiate gravitational energy in the form of real transversely polarized $m = \pm 2, k_{\min}$ gravitons. This energy is a disturbance or oscillation in this lowest energy state $k_{\min}$ graviton background, but $\rho_{Gk\min} = G_{Gk\min} dk_{\min}$ cannot change during these disturbances, so what is going on? Let us imagine a region of spacetime far from mass concentrations where the metric $g_{\mu\nu} = \eta_{\mu\nu}$ and using t, x, y, z coordinates let $g_{00} = 1, g_{xx} = -1, g_{yy} = -1, g_{zz} = -1.$ Ignoring signs the determinant of the metric $\left|g_{\mu\nu}\right| = 1$. Let a gravitational wave pass through in the z direction with a tranverse wave in the x, y plane. We know that a circular transverse ring of particles will oscillate into and out of ellipses perpendicular to each other, in such a manner that the enclosed area does not change, or that $g_{xx} \cdot g_{yy} = 1$ during this oscillation. Thus the measured volume of space does not change as the wave passes through and $\rho_{Gk\min} = G_{Gk\min} dk_{\min}$ does not change. The determinant of the metric $\left|g_{\mu\nu}\right| = 1$ also does not change. This is only approximately true as there are extra real transversely polarized

$m = \pm 2, k_{\min}$ gravitons passing through due to the energy in the wave, but the error is second order unless the amplitude of the wave is quite large.

2.8.2 What happens in high energy waves?

We can imagine the extra gravitons around a mass concentration and the background gravitons as in section 2.2 (if they are undergoing an acceleration as in binary pairs) generating real transversely polarized $m = \pm 2$ gravitons of the same wavenumbers. (This has some parallels to what we found in the Kerr metric, but now with real gravitons.) The intensity, or probability density, of these real gravitons will drop as the inverse radius squared. We can also show from Equ's.(2.1. **9**) &(2.2. **5**) that most of these gravitons are close to $k_{\min}$ wavenumber. About 66% between $k_{\min}$ & $2k_{\min}$ and about 96% between $k_{\min}$ & $5k_{\min}$. Thus most of this radiated energy is near $k_{\min}$. Just as measured volumes around mass concentrations had to increase to accommodate extra $k_{\min}$ gravitons, the transverse area of the wave has to increase very slightly in relation to the oscillating constant area. Ignoring signs again $g_{xx} \cdot g_{yy} \approx 1 + \varepsilon$ so $g_{00} \approx 1 - \varepsilon$ to keep the metric determinant $\left| g_{\mu\nu} \right| = 1$. The small energy density in the wave increases infinitesimally the local measurement of $k_{\min}$, thus allowing $\rho_{Gk\min} = G_{Gk\min} dk_{\min}$ to remain invariant as required. Close to orbiting binary black holes or neutron stars this radiated energy intensity is huge and the changes in $g_{xx} \cdot g_{yy}$ & g_{00} become large in relation to the oscillating changes. Transverse areas and hence measured volumes change significantly. This is in complete contrast to what happens at large distances, such as when we observe gravitational waves here on Earth, where the transverse areas are virtually constant during these oscillations.

2.8.3 No connection between wave frequency and radiated quanta energy

The frequency of the radiated wave is twice the orbital frequency of the binary pair source. As most of the energy in the wave is in quanta near $k_{\min}$ there is no connection with the frequency of the radiated wave as in spin 1 photons in electromagnetism. In the recently observed gravitational waves the wave frequency was ≈ 250 cycles per second just before merger with wavelengths ≈ 1200 kilometres or approximately 10^{41} Planck lengths, whereas the wavelength of $k_{\min}$ gravitons is $1/k_{\min} \approx R_{OU} \approx 10^{62}$ Planck lengths. The ratio between them is $\approx 10^{21}$. This ratio is inverse to the binary pair orbital frequency. It could only approach one if the orbital period is approximately twice the age of the universe.

3 Conclusions

If the fundamental particles can be formed from infinite superpositions as outlined in the first paper our hypothesis is that the warping of spacetime is directly related to maintaining the maximum wavelength, or $k_{\min}$ graviton density $\rho_{Gk\min} = G_{Gk\min} dk_{\min}$ invariant throughout all spacetime. Thinking in a simple way and using the proportionality symbol $\propto$ as follows:
In a universe with no mass concentrations $\rho_{Gk\min} \propto (\psi_{\text{Universe}} * \psi_{\text{Universe}})$. With a concentration of mass m, $\rho'_{Gk\min} \propto (\psi_{\text{Universe}} * \psi_{\text{Universe}}) + (\psi_{\text{Universe}} * \psi_m + \psi_m * \psi_{\text{Universe}}) + (\psi_m * \psi_m)$ but space expands locally to restore $\rho'_{Gk\min}$ back to $\rho_{Gk\min} = G_{Gk\min} dk_{\min}$. The green term $(\psi_{\text{Universe}} * \psi_m + \psi_m * \psi_{\text{Universe}})$ requires $2m/r$ in the metric, and blends well with an infinitesimally modified General Relativity. This modification changes the T_{00} component from $T_{00} = \rho$, where ρ is the local mass density, to $T_{00} = \rho - \rho_U$, where ρ_U is the average density of the Universe (only a few hyprogen atoms per cubic metre). It matches the Schwarzchild metric, and can fit the Kerr metric. In the first paper we focused only on this term to illustrate a possible connection with quantum mechanics, provided the fundamental particles can be made from infinite superpositions borrowing energy from zero point fields. This second paper messes up that nice connection by introducing the troublesome blue term $(\psi_m * \psi_m)$ with its associated m^2/r^2 in the metric. This does not seem to relate with mass densities in Einstein's stress energy tensor. It may not however alter the event horizon radius of a maximum spin black hole, but does seem to allow about 54% more spin. These values as with other findings are only approximate however, as for simplicity we assumed a square cutoff at $k_{\min}$. An exponential cutoff is most likely and will no doubt change these values, especially the coefficient of the m^2/r^2 term in the metric due to $(\psi_m * \psi_m)$. But if our conjecture is true this term will not go away. So regardless of these approximations, as most black hole mergers are between high spin black holes, this extra term may change the fine details of the last few cycles. Testing this has to await future accuracy improvements in gravitational wave detectors. It may show up in the fine details of spinning neuton star collapse. It may also raise the possibility that there could be a parallel with the breakdown of the inverse square law for fundamental charges near the Compton wavelength. Does General Relativity hold all the way through the horizon as is normally thought? Most physicists believe that it breaks down at the central singularity and an infalling observer sees no change as they pass the horizon. However this clashes with both the Firewall paradox and the Information paradox [19] [20] [21] [22] [23]. This paper suggests that there may well be other reasons to question the current orthodoxy of the central singularity breakdown?

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