Charge Parity Symmetry and the Matter Antimatter Imbalance

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Abstract

This paper builds on proposals in earlier papers that build the SM fundamental particles from infinite superpositions. The most important prediction of these earlier papers is that all fundamental particles, including bosons, have an infinitesimal mass that at all times is inversely proportional to the horizon radius times the Hubble flow velocity. Photons interacting between electrically charged particles only travel at approximately light velocity when interacting energies are well above inverse horizon radius values. High energy scattering experiments performed in this current era are unlikely to include interacting photon energies approaching the inverse horizon radius, and will thus show mirror symmetry as their interacting bosons travel at virtually light velocity. However, when matter and antimatter were forming, the inverse horizon radius was very small with larger energy interacting photons, and more likely to have included energies inversely proportional to the horizon radius. These photons travel at well below light velocities and will not show mirror symmetry, which Sakharov argued in 1967 could explain the matter antimatter imbalance.

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Contents

1 Introduction

The current formulation of the Standard Model (SM) of particle physics was finalised in the mid-1970s. However, although extremely successful in providing testable experimental predictions and currently the best description we have of the subatomic world, the theory still leaves a significant number of phenomena unexplained. In the last forty years or so there have been a number of theories seeking to move physics beyond the SM, including supersymmetry and string theory. However, none of the particles predicted by supersymmetry have yet been found, despite a decade of work at CERN's Large Hadron Collider (LHC), and string theory, widely considered the most likely path for including gravity in the SM, is not yet supported by any direct empirical evidence. Further, dark matter has yet to be directly detected, and dark energy remains elusive. In contrast to these disappointments however, the ATLAS and CMS experiments at CERN's LHC announced in 2012 that they had each observed a new particle in the mass region around 126 GeV; a particle consistent with the Higgs boson predicted by the SM.

String theory has been strongly criticised over its inability to make testable predictions [1-6]. However, along with the multiverse theory, it has generated intense and important debate over the scientific standing of non-testable theories in physics. In 2009 Dawid, a theoretical physicist turned philosopher, noted substantial conflict between supporters and critics of string theory in assessing its status and success [7]. Dawid argued that this disagreement could best be understood in terms of a paradigmatic rift between the two sides over their understandings of theory assessment. Critics on the one hand believed that "it is a core principle that scientific theories must face continuous *empirical testing* [emphasis added] to avoid going astray" (p988). In contrast, supporters of string theory placed importance on *theoretical criteria* for theory assessment. In an interview several years later Dawid [8] suggested this emergence of non-empirical theory assessment, or post-empirical science, represented a Kuhnian paradigm shift in physics and that it would become increasingly important due to the difficulties associated with experimentally testing new theories. In *Nature*, Ellis and Silk in 2014 [9] made an appeal to "Defend the integrity of physics." They expressed concern that when faced with the difficulties of applying fundamental theories to the observed universe, some researchers had begun explicitly advocating a change to how theories should be assessed, viz., if deemed sufficiently elegant and explanatory, experimental testing was unnecessary. Ellis and Silk disagreed, insisting that empirical testability is a necessary condition for a theory to be considered scientific, and concurred with Hossenfelder [10] that the concept of post-empirical science was an oxymoron.

Another important issue relating to the testability of theories in physics has been highlighted recently by the astrophysicist David Merritt [11]. In regard to the lambda cold dark matter model (ΛCDM), which contains Einstein's theory of gravity, Merritt notes that dark matter, dark energy and inflation were all added to the theory in response to observations that would falsify it, i.e. they are ad hoc, or auxiliary hypotheses. Further, he argues that they are conventionalist hypotheses in that they add no empirical content and hence are unfalsifiable in the sense defined by the philosopher Karl Popper. Popper had set specific criteria for preserving falsifiability (or testability) when such “conventionalist stratagems” are employed, i.e., the modified theory had to make some new, testable predictions, and at least some of the new predictions should be verified. Further, Popper’s student Imre Lakatos, tested and refined these criteria to distinguish between “progressive” and “degenerating” research programs. A progressive research program is one in which “its theoretical growth anticipates its empirical growth, that is, as long as it keeps predicting novel facts with some success.” The ΛCDM, according to Merritt, fails to meet such requirements as the auxiliary hypotheses (dark matter, dark energy and inflation) have yet to be confirmed, and the ΛCDM is notably lacking in successful predictions. Steinhardt [12] one of the founders of inflationary cosmology, now also views that theory untestable and has become one of its sharpest critics. The failure to progress significantly beyond the SM during the past four decades, the increasing prominence of highly theoretical, mathematically elegant but difficult to test or untestable theories, and threats to undermine testability as a sine qua non for a theory to be considered scientific, all appear responsible for a succession of popular books expressing concern at the current state of physics [1-5]. In her recently published *Lost in Math: How Beauty Leads Physics Astray*, Hossenfelder [3] contends that the search for beauty has led physicists astray, giving wonderful mathematics but bad science; belief that the best theories are beautiful, natural and elegant has resulted in theories that are untestable. Lamenting the lack of a major breakthrough in the foundations of physics during the last forty years, she advocates physicists need to rethink their methods. In reviewing her book Wilczec [13] contends that Hossenfelder presents an overly pessimistic view, but concedes that “the malaise expressed...is not baseless and is widely shared among physicists” (p57).

In view of these concerns over the current state of physics we offer an alternative approach, but one which still uses very simple basic principles of quantum mechanics (QM) and special relativity (SR). Apart from infinitesimal differences it is (almost) consistent with the SM. It suggests the possibility of massive spin 2 gravitons emitted by baryons, with galactic radii Compton wavelength spherically symmetric wavefunctions, causing similar effects in the metric as dark matter. It proposes that the acompanying massive gravitons control both the scale factor and cosmic acceleration.

We contend our theory is both simple and capable of making testable predictions; at the cosmological level, if not the quantum level. It is, however, radical in its proposals and implications. Consequently, it will require a significant shift in thinking, not only in regard to the fundamental particles, but also the evolution of the cosmos. Such a shift, however, may facilitate progress beyond the SM and/or the ΛCDM.

Because these proposed ideas are so radical, we start with some preliminary explanatory notes. The forming of fundamental particles from infinite superpositions follows in section 2 with their properties in section 3. Section 4 looks at the effect of the infinitesimal mass on Charge-Parity Symmetry and the Matter-antimatter Imbalance Anomaly which has been a puzzle that the SM does not explain.

1.1 List of Some Abbreviations, Acronyms and Symbols Used in the Text

ΛCDM The Lambda Cold Dark Matter Model of Cosmology.
CMB Cosmic Microwave Background.
EM Electromagnetic.
FLRW Friedmann-Lemaitre-Robertson-Walker metrics.
GR General Relativity.
ICM Intracluster Medium.
MOND Modified Newtonian Dynamics.
SM Standard Model.
SR Special Relativity.
QCD Quantum Chromodynamics
QED Quantum Electrodynamics
QM Quantum Mechanics.

N, n & s. Integers $n = 3,4,5,6$ & 7 are used in $\psi_{nk} = C_{nk} r^3 \exp(-n^2 k^2 r^2 / 18) Y(\theta, \varphi)$ virtual primary $(l = 3)$ wavefunctions at wavenumber k. Their probability is $\left[\frac{sN \cdot dk}{k}\right]$, where s is spin, and $N = 1$ for all massive $s = 1/2$ fermions, as well as $s = 1$ and $s = 2$ massive bosons.

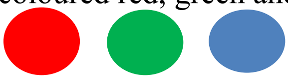
$N = 2$ for all spin 1 and spin 2 infinitesimal mass bosons.

χ_C is the primary to secondary coupling ratio $= \alpha_3^{-1}$ at the Planck energy superposition cutoff.
$k_{\min}$ is the wavenumber of the maximum cosmic wavelength but cuts off exponentially.
R_{OH} is the observable horizon radius.
$\Upsilon = k_{\min} R_{OH}$ radians.
$\rho_{Gk\min}$ is the normal three dimensional density of $k_{\min}$ gravitons
$K_{Gk\min}$ is the $k_{\min}$ graviton invariant as in $\rho_{Gk\min} = K_{Gk\min} dk_{\min}$ where $K_{Gk\min} \approx 0.12\alpha_G$.
$\lambda_{k\min}$ The maximum or $k_{\min}$ wavelength.
α with no subscript is the usual electromagnetic coupling constant.
ρ_U is the average density of both baryonic and massive graviton mass/energy in the universe.
$T'_{\mu\upsilon}$ is the infinitesimally modified Einstein tensor where $T'_{\mu\upsilon} = T_{\mu\upsilon}(\text{Local}) - T_{\mu\upsilon}(\text{Average})$.
$T_{\mu\upsilon}(\text{Average})$ is the Einstein tensor averaged over the observable cosmos..
$\Omega = 1$ in the ΛCDM at critical density for flatness.

1.2 Preliminary Explanatory Notes

1.2.1 Summary flow chart

This paper starts with the assumption that all "fundamental particles" are built from combinations of "virtual preons". There are three preons, coloured red, green and blue, and their antiparticles. All preons are *spin zero* and electrically charged.



Different groups of 8 preons (with no weak charge) couple to the electromagnetic and 8 colour ground state fields, forming $l = 3$ spatially dependant wave functions. Infinite superpositions of these wave functions form all the spin ½ & spin 1 standard model particles, as well as spin 2 gravitons. The frequencies of these wavefunctions start at $k_{\min} \approx (\text{Horizon radius})^{-1}$ → up to Planck scale maximum.

Cosmic wavelength zero point densities are very limited. Because spin zero preons are born with zero momentum and infinite wavelength they can couple to modes anywhere inside the extra space generated by the expanding Hubble flow horizon.

High frequency coupling is to local ground state fields where the available densities are plentiful.

Low frequency coupling controls the average universe density $\rho_U \propto \dfrac{\text{Total mass/Baryonic mass}}{R_{OH}^2 V'}$ in Planck units, where R_{OH} is the observable horizon radius, V' is the Hubble flow velocity.

When mass is distributed evenly as a dust there is a uniform density of $k_{\min}$ gravitons throughout a horizon radius sphere, space and spacetime is flat everywhere. If any of this mass is moved to a central location it increases the spatial density of $k_{\min}$ gravitons surrounding it, distorting spacetime locally, and restoring density in agreement with Einstein's equations, but with infinitesimal differences effective at cosmic radii: $G_{\mu\upsilon} = R_{\mu\upsilon} - \frac{1}{2} g_{\mu\upsilon} R = \frac{8\pi G}{c^4}\left[T_{\mu\upsilon}(\text{Local}) - T_{\mu\upsilon}(\text{Average})\right] = \frac{8\pi G}{c^4} T'_{\mu\upsilon}$. Inside the observable hnorizon the average values of $T'_{\mu\upsilon} \equiv 0 \equiv G_{\mu\upsilon}$. Space is flat and the Freidman equation components average zero. QM controls the expansion of space regardless of Ω. with or without inflation. Intergalactic voids have $T_{\mu\upsilon}(\text{Local}) < T_{\mu\upsilon}(\text{Average})$ with negative $G_{\mu\nu}$ and $R_{\mu\nu}$.

1.2.2 General relativity as an initial guide

GR informs us that all forms of mass, energy and pressure are sources of the gravitational field. Thus to create gravitational fields, all spin ½ leptons & quarks, spin 1 gluons, photons, $W^{\pm}$ & Z^{0} particles etc. emit virtual gravitons, except possibly gravitons themselves (section 6.2.6 in **[24])**as gravitational energy is not part of the Einstein tensor.

The starting point of this paper assumes there is a common thread uniting these fundamental particles making this possible. Equations are developed that unite the amplitudes of the colour and electromagnetic coupling constants with that of gravity. The precision required by quantum mechanics for half integral and integral angular momentum allows gravity to be included, despite the vast disparity in magnitude between gravity and the other two. This combination of colour, electromagnetic and gravitational amplitudes in the same equation is possible because of a radically different approach taken in this paper: an approach using infinite superpositions of positive and negative integral $\hbar$ angular momentum virtual wavefunctions for spin ½, spin 1 and spin 2 particles. The result is almost identical to the SM, with infinitesimal but important differences. The total angular momentum can be summed over all wavenumbers k; from $k=0$ to some cutoff value k_{cutoff}. We will assume (as with many unification theories) that the cutoff for these infinite superpositions is somewhere near Planck scale. Firstly, imagine a universe where the gravitational constant $G \to 0$. As $G \to 0$, the Planck length $L_P \to 0$, the Planck energy $E_P \to \infty$ and $k_{cutoff} \to \infty$ also. If we sum the angular momentum of these infinite superpositions when $G \to 0$ (i.e. from $k=0$ to $k_{cutoff} \to \infty$) we get precisely half integral or integral $\hbar$ for the fundamental spin ½, spin 1 & spin 2 particles in appropriate m states. If we now put $G > 0$ the infinitesimal effect of including gravity can be balanced by an equal but opposite effect due to the non-infinite cutoff value in k. A near Planck scale superposition cutoff requires gravity to be included to get precisely half integral or integral $\hbar$. (Section4.2 in **[24])**

These infinite superpositions have another very relevant property relating to the fact that all experiments indicate that fundamental particles such as electrons can behave as point particles. Each wavefunction with wavenumber k, which we label as ψ_k, has a maximum radial probability at $r \approx 1/k$ and they all look the same (Figure 1.1.1). Every wavefunction ψ_k of these infinite superpositions, interacts only with virtual photons (for example) of the same k; if superpositions representing say an electron are probed with such photons (that interact only with wavefunction ψ_k) the resolution possible is of the same order as the dimensions of ψ_k, both have $r \approx 1/k$. The higher the energy of the probing particle the smaller the ψ_k it interacts with; the resolution of an observing photon can never be fine enough to see any ψ_k dimensions. Even if this energy approaches the Planck value, with a matching ψ_k radius near the Planck length it is still not possible to resolve it. This behaviour is consistent with the quantum mechanical properties of point particles.

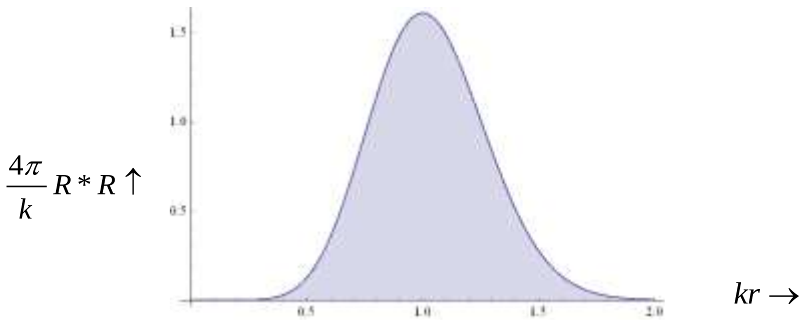


Figure 1.1.1 Radial probability of the dominant $n = 6$ mode of a spin ½ wavefunction ψ_{6k}.

1.2.3 **Primary and secondary interactions**

Supposing that superpositions can in fact build the fundamental spin ½, spin 1, and spin 2 particles, then what builds the superpositions? Answering that question requires dividing all interactions into two categories: primary and secondary.

Secondary interactions are those we are familiar with, and are covered by the SM; but with the addition of gravity, which is not included in the SM. They take place between the fundamental spin ½, spin 1 and spin 2 particles formed from infinite superpositions. They are the quantum electrodynamics/quantum chromodynamics (QED)/(QCD) etc, interactions of all real world experiments.

Primary interactions we conjecture on the other hand, are those that build virtual infinite superpositions. The base states of virtual infinite superpositions only last for time $\Delta T \leq \hbar / 2\Delta E,$ and the primary interactions that build them are completely hidden to the real world of experiments. Infinite superpositions cannot be decomposed into their base states, in the same way as base states of fundamental particles can be observed. The quantum world is always hidden until observation, even if we know base state probabilities. But virtual infinite superpositions are always hidden, and only fundamental particles can be observed.

Primary interactions are extremely simple. They are only one way; zero-point fields act on the particle, but the particle cannot act on, or influence, zero point fields. (Its invariance is guaranteed by Heisenberg's uncertainty principle.) In contrast, secondary interactions involve all the excited modes above the ground state and are two way. These excited field modes both act on the particle which in turn acts back on the field. Quantum field theory (QFT) is all about these complicated two way interactions. Lagrangians are ideal for these two way interactions, predicting symmetries and conservations. However, Lagrangians are less relevant in primary interactions: the natural invariance of the ground state carries through into symmetries and conservation laws. In view of this, our proposals depart from the current practice of basing new theories on Lagrangians. In this regard, while acknowledging their enormous predictive power, Penrose **[6]** expresses unease with this modern trend, arguing against relying too strongly on Lagrangians in searches for improved fundamental theories (p 491). History tells us progress can be inhibited by assuming that what has worked so well up to now must always be so. Newton reigned supreme for almost two centuries until superseded by Einstein.

The first half of this paper is about these primary interactions, and the superpositions they build representing the fundamental spin ½, spin 1 and spin 2 particles. 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 [14-17]. In contrast with the virtual particles in this paper, some of these earlier models used real spin ½ building blocks. However, real substructure has difficulties with large masses if compressed into the small volumes required to approach point particle behaviour. It was probably because of this high mass/small volume problem that these earlier preon proposals fell out of favour. On the other hand our proposed virtual substructure borrows energy from zero point fields where the mass contribution at high k values can be cancelled (section 3.2.1). As in earlier models this paper also calls the common building blocks preons, but here the preons are both virtual and spin zero. They also now build all spin ½ leptons and quarks, spin 1 gluons, photons, W & Z particles, plus spin 2 gravitons, in contrast to only the leptons and quarks in the earlier models. (SeeTable 2.2.1) As these preons have zero spin they possess no weak charge. Primary interactions (section 2.2.1) can take place only with the zero point colour, electromagnetic and gravitational fields. The three primary coupling constants for each of these three zero-point fields are different from, but related to, secondary coupling constants.

The behaviour of primary coupling is also entirely different from secondary coupling. Secondary coupling strengths vary (or run) with wavenumber k (the electromagnetic increasing with k and colour decreasing with k). In contrast, we conjecture primary coupling strengths (or constants) do not run. In this paper virtual preons are continually born with mass out of a Higgs type scalar field, existing only for time $\Delta t \leq \hbar / 2E$. At their birth, they interact while still bare with zero point vector fields; at this instant of birth $t = 0$. The primary coupling constants consequently are fixed for all k; there is no time for charge cancelling or reinforcing, which in secondary interactions forms around the bare charge progressively after its birth. The equations work only if this is true, and they also work only if the primary colour coupling constant is one. (Sections 2.2.2). The ratio between the primary and secondary colour coupling constants labelled χ_C is thus (if primary colour coupling is one) the inverse of the secondary (or usual α_3^{-1} of QCD) colour coupling constant at the superposition cutoff at Planck Energy. (Sections 3.3&4.2.2 in [24]) To enable the primary coupling to colour, electromagnetic and gravitational zero point fields, preons need colour, electric charge and mass. There are three preons, red, green & blue with positive electric charge, and their three anticounterparts. Their mass borrowed from some type of scalar Higg's field, or the time component of zero-point fields must always be non-zero. This is discussed further in section 1.2.4. As there are eight gluon fields, superpositions are built with eight virtual preons for each virtual wavefunction ψ_k. The nett sum of these eight electric charges is $0, \pm 2, \pm 4, \pm 6$, and never $> \pm 6$. This leads to the usual $0, \pm 1/3, \pm 2/3, \pm 1$ electric charge seen in the real world. Various combinations of these eight preons in appropriate superpositions can build leptons and quarks, colour changing and neutral gluons, neutral photons, neutral massive Z^0 photons and the charged massive $W^{\pm}$ photons**.** (Table 2.2.1)

1.2.4 **Photons, gluons and gravitons with infinitesimal mass ($\approx 10^{-34} eV$).**

Einstein taught us that regardless of how fast a particle with mass moves, a ray of light always passes it at the same velocity *c*. The SM builds on this principle with one group of particles travelling at less than *c*, and another group at *c*: massive and massless, with a clear division between them. In the SM the neutrino family was included in the massless group.

However, towards the end of last century evidence slowly emerged that this was not true, and the family of three neutrinos must have masses somewhere in the electron volt range. There is no explanation for this in the SM.

Due to their very low mass, and normal emitted energies, neutrinos invariably travel at virtually the velocity of light c. Photons also have always been included in the massless group traveling precisely at velocity c, except in the case of the massive $W^{\pm} \& Z^{0}$. Massless virtual photons have an infinite range, which has always been seen as an absolute requirement of the electromagnetic field. On the other hand, this paper requires some rest frame (even if this frame can move at virtually c) in which to build all the fundamental particles. Table 6.2.2 in**[24]** suggests photons, gluons and gravitons have $\approx 10^{-34} eV$ mass with a range of approximately the inverse of the causally connected horizon radius, and velocities sufficiently close to that of light their helicity remains essentially fixed. This allows some form of Higgs mechanism to increase this infinitesimal mass to the various values in the massive set. (These infinitesimal masses are also in line with some recent proposals [18,19] where gravitons have a mass of $< 10^{-33} eV$ to explain accelerating expansion.)

The virtual wavefunction we use is $\psi_{nk} = C_{nk} r^3 \exp(-n^2 k^2 r^2 / 18) Y(\theta, \varphi)$, an $l = 3$ wavefunction. This virtual $l = 3$ property is normally hidden. In the same way as scattering experiments on spin 0 pions show spin 0 properties, and not the properties of the two cancelling spin ½ component particles, this $l = 3$ property of the virtual components of superpositions is not visible in the real world. Scattering experiments can exhibit only the spin properties of the resulting particle. The individual angular momentum vectors $|\mathbf{L}| = 2\sqrt{3}\hbar$ of the infinite superposition all sum to a resulting: $|\mathbf{L}_{Total}| = (\sqrt{3}/2)\hbar$, $\sqrt{2}\hbar$ or $\sqrt{6}\hbar$ for spin ½ , spin 1 or spin 2 respectively, in a similar way to two spin ½ particles forming spin 0 or spin 1 states. We also use the fact that the angle $(\pi/6)$ to the z axis of the angular momentum vector for $s = 1/2, m = \pm 1/2$ is identical to $l = 3, m = \pm 2$.

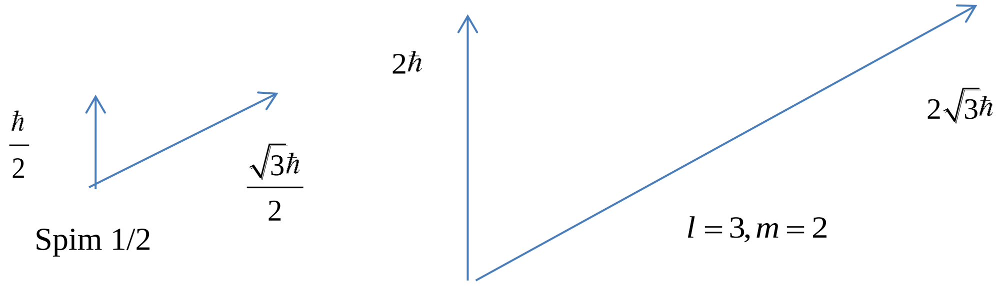


Figure 1.1.2 Spatially dependant $l = 3, m = \pm 2$ wave functions have the same angle $(\pi/6)$ to the z axis as $s = 1/2, m = \pm 1/2$. It is proposed that all fundamental particles are built from infinite superpositions of $l = 3$ spatially dependant wavefunctions in appropriate $\pm m$ states.

The wavefunction $\psi_{nk} = C_{nk} r^3 \exp(-n^2 k^2 r^2 / 18) Y(\theta, \varphi)$ has eigenvalues $\mathbf{P}_{nk}{}^2 = n^2 \hbar^2 k^2$ with $|\mathbf{P}_{nk}| = n\hbar k$, suggesting it borrows n parallel $|\hbar \mathbf{k}|$ quanta from zero point vector fields provided n is integral. We can see this by letting $k \to \infty$ allowing energy $E \to n\hbar\omega$ by absorbing n quanta $\hbar\omega$ from the zero point vector fields (section 2.3.2). As spin 3 needs at least three spin 1 particles to create it, the lowest integral number n can be is 3. The virtual $l = 3$ property can however be used to derive the magnetic moment of a charged spin ½, $m = \pm 1/2$ state as a function of n. Section 3.5 in **[24]** shows $g = 2$ Dirac electrons need an average (over integral n states) of $\bar{n} \approx 6.0135$. Three member superpositions $\psi_k = \sum_n c_n \psi_{nk}$ with $n = 5, 6, \& 7$ achieve this, creating Dirac spin ½ states. We also find that $n = 6$ is the dominant member and each superposition ψ_k needs at least three members to make all the equations consistent for Dirac particles. Secondary interactions at any wavenumber k can occur with ψ_k if integers n change by ± 1, thus changing the eigenvalues $|\mathbf{P}| = n\hbar k$ by $\pm \hbar k$ where this can be only a temporary rearrangement of the triplets of values of n. This is true, whether the interaction is with leptons, quarks, photons, gluons, W & Z particles, or gravitons. (Section 3.3)

1.2.5 Superposition wavefunctions require only squared vector potentials

The wavefunction $\psi_{nk} = C_{nk} r^3 \exp(-n^2 k^2 r^2 / 18) Y(\theta, \varphi)$ requires an invariant in all coordinates spherically symmetric squared vector potential to create it: $Q^2 A^2 = n^4 \hbar^2 k^4 r^2 / 81$. There are no linear potential terms in contrast with secondary interactions. The primary interaction operator is $\hat{P}^2 = -\hbar^2 \nabla^2 + Q^2 A^2$, with no linear potential terms included and Q simply represents a collective symbol for all the effective charges concerned. As an example, the dominant $n = 6$ wavefunction of a spin ½ Dirac ψ_k requires a squared vector potential of $Q^2 A^2 = n^4 \hbar^2 k^4 r^2 / 81 = 16 \hbar^2 k^4 r^2$ (section 2.3.1). Primary coupling between the eight virtual preons and the colour, electromagnetic and gravitational zero-point fields produces a vector potential squared value for all infinite superpositions which can be expressed as:

$$Q^2 A^2 = \frac{\left[8 + 8\sqrt{\alpha_{EMP}} + i m_0 \sqrt{G_p / (2 s \hbar c)}\right]^2 (\hbar^2 k^4 r^2)}{3\pi (sN)(1+\varepsilon)} \left[\frac{(sN)(1+\varepsilon) dk}{k}\right]$$

(Where the length of the complex vector is simply squared here.) The significance of the cancelling top and bottom factors (sN) is explained in section 2.1.2. Also the cancelling $(1+\varepsilon)$ factors are due to gravity and explained in section 4.2 in **[24].** The primary_colour coupling amplitude is conjectured to be 1 to each of the eight preons, and $\sqrt{\alpha_{EMP}}$ the primary electromagnetic coupling. This equation applies regardless of the individual preon colour or electric charge signs, whether positive or negative (section 2.2.3). The primary gravitational coupling is to the particle mass m_0. The primary gravitational constant is G_P divided by $\hbar c$ to put it in the same form as the other two coupling constants. The magnitude of the total angular momentum vector of the infinite superposition is $|\mathbf{L}_{Total}| = \sqrt{s(s+1)}$. This $Q^2 A^2$ without the gravity term generates superpositions with probability $(N \cdot s) dk / k$, where s is the superposition spin, $N=1$ for massive spin ½ fermion & massive boson superpositions, but $N=2$ for infinitesimal mass boson superpositions (Table 4.3.1 and its subsections cover this more fully plus section 4.2 in **[24]** includes gravity raising the superposition probability to $(1+\varepsilon)(N\cdot s)dk/k$ where the infinitesimal ε (not to be confused with infinitesimal mass) is $\varepsilon\approx 2m_0^2/Spin\ \approx 7\times 10^{-45}$ for electrons, and $\varepsilon\approx 10^{-34}$ for a Z^0 in Planck units $\hbar=c=G=1$. The ψ_k superpositions require at least three integral n members. The following three member superpositions fit the SM best (see Table 4.3.1 again.

Spin ½ massive $N=1$ fermion superpositions $\qquad \psi_k=\sum_{n=5,6,7} c_n\psi_{nk}$.

Spin 1 massive $N=1$ boson superpositions $\qquad \psi_k=\sum_{n=4,5,6} c_n\psi_{nk}$.

Spins 1 & 2 infinitesimal mass $N=2$ boson superpositions $\qquad \psi_k=\sum_{n=3,4,5} c_n\psi_{nk}$.

Below are infinite superpositions $\left|\psi_{\infty,s,m}\right\rangle$ for only spins ½ & 1. The symbol ∞ refers to the infinite sum, s the spin of the resulting real particle, m its angular momentum state, and ss a spherically symmetric state. Section 3.1.3 explains this format. Also, square cutoffs in wavenumber k are used here for simplicity. Infinitesimal mass superpositions are introduced in section 6.2 in [24]. (Complex number factors are not included here for clarity.)

$$\text{Massive} \qquad N=1 \text{ Spin } \tfrac{1}{2}, \left|\psi_{\infty,1/2,m}\right\rangle=\sum_{n=5,6,7} c_n \int_0^{k(cutoff)} \left[\frac{\left|\psi_{nk,ss}\right\rangle}{\gamma_{nk}}+\beta_{nk}\left|\psi_{nk,4m}\right\rangle)\right]\sqrt{\frac{1+\varepsilon}{2k}}dk \qquad (1.1.\ 1)$$

$$\text{Infinitesimal mass } N=2 \text{ Spin } 1, \left|\psi_{\infty,1,m}\right\rangle=\sum_{n=3,4,5} c_n \int_0^{k(cutoff)} \left[\frac{\left|\psi_{nk,ss}\right\rangle}{\gamma_{nk}}+\beta_{nk}\left|\psi_{nk,2m}\right\rangle\right]\sqrt{\frac{2(1+\varepsilon)}{k}}dk$$

In these infinite superpositions the probability that the wavefunction is spherically symmetric is always $\gamma_{nk}^{-2}=1-\beta_{nk}^2$ and the probability that it is an m state is β_{nk}^2, where β_{nk} is the magnitude of the velocity of the centre of momentum frame (see Figure 3.1.1), which is where the primary interactions that generate each ψ_{nk} take place. This is similar to the superposition of time and spatially polarized virtual photons in QED. For example, spin ½ has probabilities of $\gamma_{nk}^{-2}=1-\beta_{nk}^2$ spherically symmetric ψ_{nk} wavefunctions, and $\beta_{nk}^2\ \times(\psi_{nk},m=\pm 2)$ wavefunctions. Each ψ_k is normalized to one but the infinite superpositions $\psi_{\infty,s,m}$ are not normalized, diverging logarithmically with k; the same logarithmic divergence that applies to virtual photon emission. (Real wavefunctions must be normalized to one as they refer to finding a real particle somewhere, but this need not apply here.) Section 3.1 finds that $m=+2$ virtual wavefunctions have β_{nk}^2 probability of leaving an $m=-2$ debt. Integrating over all k produces a total angular momentum for a spin ½ state of $\hbar/2$. (The procedures for spin 1 & spin 2 particles are covered in section 3.2.2.)

This paper is about the primary interactions between spin zero preons and spin one quanta that build the fundamental particles. The SM is about the secondary interactions between them. (The weak force is only between spin ½ particles and thus a secondary interaction. It cannot be involved in primary interactions.) Apart from infinitesimal effects, such as infinitesimal masses, the properties of fundamental particles covered in this paper should be consistent with their SM counterparts. All $N=1$ & $N=2$ superpositions as in Table 4.3.1 in **[24]** are conjectured to cutoff at Planck energy E_P. If this is so, both colour and electromagnetic interaction energies must cutoff at $E_P / \langle n \rangle \approx 2.03\times 10^{18} GeV.$, or $\approx 1/6$ of the Planck energy. (The expectation value $\langle n \rangle$ is ≈ 6.0135 for spin ½ leptons and quarks Eq. (3.5.16) in**[24]**). The electromagnetic and colour coupling constants at this cutoff are consistent with SM predictions assuming three families of fermions and one Higgs field. (See Figueww 4.1.1 and 4.1.2 in **[24].**

Whereas the SM assumes massless and massive particles, infinite superpositions have an infinitesimal mass that, at all cosmic time, is approximately the inverse horizon radius. It proposes massive spin 2 gravitons that, with inverse radius squared radial probability wavefunctions, give galaxies MOND-like properties and could behave as dark matter.

This paper finishes by looking at the relationship between the infinitesimal masses of the interacting photons and charge-parity symmetry, leading to a possible connection with the matter- antimatter anomaly.

Fundamental Particles as Infinite Superpositions

2 Building Infinite Virtual Superpositions

2.1 The Possibility of Infinite Superpositions

2.1.1 Early ideas

After World War II there was still much confusion about QED. In 1947 at the Long Island Conference the results of the Lamb shift experiment were announced **[21].** This conference was perhaps the starting point for the development of modern QED: perhaps the pinnacle of accurate theory supported by experiment. QED is also about what we have called secondary interactions. (See 1.2.3.) Part 1 of this paper is about the much simpler primary interactions and we start it with an oversimplified semi-classical way of explaining the Lamb shift. We are going to imagine that the Lamb shift involves primary interactions when, in fact, it doesn't. It is a real world secondary interaction experiment, and therefore our illustration is not the correct QED way of handling this phenomenon. Picturing it as a primary interaction however, with zero point fields, may help illustrate the possibility of connections between fundamental particles and infinite virtual superpositions. Hopefully this is in a similar manner to the way Bohr's original simple semi-classical explanation of quantized atomic energy levels played such a large part in the eventual development of full three dimensional wavefunction solutions of atoms, and quantum mechanics.

The density of transverse modes of waves at frequency ω is $\omega^2 d\omega / \pi^2 c^3$ and the zero point energy for each of these modes is $\hbar\omega / 2$. The electrostatic and magnetic energy densities in electromagnetic waves are equal, thus for electromagnetic zero point fields:

The total average field energy $\dfrac{\varepsilon_0 E^2}{2} + \dfrac{\varepsilon_0 c^2 B^2}{2} = \dfrac{\hbar\omega}{2}\left[\dfrac{\omega^2 d\omega}{\pi^2 c^3}\right]$ or $\overline{\varepsilon_0 E^2} = \overline{\varepsilon_0 c^2 B^2} = \dfrac{\hbar\omega^4}{2\pi^2 c^3}\dfrac{d\omega}{\omega}$.

For a fundamental charge e using $\alpha = e^2 / 4\pi\varepsilon_0 \hbar c$, and provided $\beta << 1$, this gives an

$$\text{average force squared of} \quad \overline{F^2} = \overline{e^2 E^2} = \frac{2\alpha}{\pi}\frac{\hbar^2\omega^4}{c^2}\frac{d\omega}{\omega} \tag{2.1.1}$$

Thinking semi-classically, for an electron of rest mass m this can generate simple harmonic motion of amplitude r, where $F^2 = m^2\omega^4 r^2$ (if $\beta << 1$). Solving for r^2 (where r^2 is superimposed on the normal quantum mechanical electron orbit, $\lambda\!\!\!^{-}_C = \hbar / mc$ is the Compton wavelength, and $k = \omega / c$):

$$r^2 = \frac{\hbar^2}{m^2 c^2}\frac{2\alpha}{\pi}\frac{d\omega}{\omega} = \left[\lambda\!\!\!^{-2}_C\right].\left[\frac{2\alpha}{\pi}\frac{dk}{k}\right]$$

Integrating r^2 (as directions are random): $r^2_{Total} = \lambda\!\!\!^{-2}_C \dfrac{2\alpha}{\pi}\displaystyle\int_{k\min}^{k\max}\dfrac{dk}{k} = \lambda\!\!\!^{-2}_C \dfrac{2\alpha}{\pi}\log(k_{\max} / k_{\min})$.

The minimum and maximum values for k can be chosen to fit atomic orbits, and a root mean square value for r can be found. Combining this with the small probability that the electron will be found in the nucleus, this small root mean square deviation shifts the average potential by approximately the Lamb shift. This can also be thought of as simple harmonic motion of amplitude $\approx \bar{\lambda}_C$, occurring with probability $(2\alpha/\pi)dk/k$. It can also be interpreted as the electron recoiling by $\approx \bar{\lambda}_C$, (provided $\beta_{\text{Recoil}} << 1$) in random directions due to virtual photon emission with a probability of $(2\alpha/\pi)dk/k$.

2.1.2 Dividing probabilities into the product of two component parts

This probability $(2\alpha/\pi)dk/k$ can be thought of as the product of two terms $A \& B$, where A includes the electromagnetic coupling constant α, B includes dk/k, and $AB = (2\alpha/\pi)dk/k.$ This suggests that this same behaviour is possible if we have an appropriate superposition of virtual wavefunctions occurring with probability B, which emits virtual photons with probability A (by changing eigenvalues $|\mathbf{p}_{nk}| = n\hbar k$ by $n = \pm 1$). For example, if a virtual superposition occurs with probability $B = (N \cdot s)dk/k$, and has a virtual photon emission probability for each member of these superpositions of $A = (N \cdot s)^{-1}(2\alpha/\pi)$, then the overall virtual photon emission probability remains as above at $AB = (2\alpha/\pi)dk/k$. This applies equally whether it is virtual gluon/photon/W&Z/graviton etc. emission. Provided A includes the appropriate coupling constant this same logic applies regardless of the type of boson emitted. As is usual to get integral or half integral total angular momentum $2s$ has to be integral and section 6.2**[24]** argues rhat N must also be integral. (This paragraph is simplified to illustrate the principle and will later be modified in section 3.3.)

In section 1.2.5 we said that these wavefunctions are built with squared vector potentials. If superpositions of them are to represent real particles they must be able to exist anywhere. This is possible only if they are generated by invariant fields. The only fields uniform in space-time are the zero point fields and looking at the electromagnetic field first we can use section 2.1.1 above. Consider a vector $\mathbf{r}$ from some central origin O and a magnetic field vector $\mathbf{B}$ through origin O, then the vector potential at point $\mathbf{r}$ is $\mathbf{A} = (\mathbf{B} \times \mathbf{r})/2$ and the vector potential squared is $A^2 = (B^2 r^2 \sin^2\theta)/4$ where the angle between vectors $\mathbf{B} \& \mathbf{r}$ is θ.

As $\sin^2\theta$ averages 2/3 over a sphere: $\overline{A^2} = B^2 r^2/6$ (2.1.2)

This requires the source of these fields to be spherically symmetric, where B^2 here is the magnetic field squared at any point due to the invariant cubic intensity of zero point electromagnetic fields, also as in section 2.1.1. This is only true at higher frequencies, and we will find later that at cosmic wavelengths we need a similarly invariant spherically symmetric source redshifted from the receding spherical horizon. Putting Eqs. (2.1.1) and (2.1.2) together the vector potential squared is

$$\overline{e^2A^2} = \frac{e^2B^2r^2}{6} = \frac{\alpha}{3\pi}\frac{\hbar^2\omega^4r^2}{c^4}\frac{d\omega}{\omega} = \frac{\alpha}{3\pi}\hbar^2k^4r^2\frac{dk}{k} \qquad (2.1.3)$$

As in section 2.1.2 we can divide this into two parts, noting the inclusion of spin s and integer N *in* the numerator and denominator:

$$\overline{e^2A^2} = \left[\frac{\alpha}{3\pi sN}\hbar^2k^4r^2\right].\left[\frac{sN \cdot dk}{k}\right] \qquad (2.1.4)$$

But here a vector potential squared term $\left[\dfrac{\alpha}{3\pi sN}\hbar^2 k^4 r^2\right]$ occurs with probability $\left[\dfrac{sN \cdot dk}{k}\right]$.
Another way of looking at this is that a wavefunction ψ_k that is generated by a vector potential squared term $\left[\dfrac{\alpha}{3\pi sN}\hbar^2 k^4 r^2\right]$ can occur with $\left[\dfrac{sN \cdot dk}{k}\right]$probability.
This is similar reasoning to that used in the semi-classical Lamb shift explanation of section 2.1.1. In the first bracketed term of Eq. (2.1.4), α is the electromagnetic coupling constant, but the same logic applies for the eight gluon and gravitational zero point vector fields where we will sum appropriate amplitudes of these and square this total as our effective coupling constant in Eq. (2.1.4). But first we need to look at groups of spin zero preons that could build these wavefunctions. What mixtures of colours and electrical charges end up with the appropriate final colour and electrical charge for each of the fundamental particles or at least the ones we know of?

2.2 Spin Zero Virtual Preons from a Higgs Type Scalar Field

2.2.1 **Groups of eight preons that form superpositions**

In this paper preons have zero spin and can have no weak charge. The only fields they can interact with (via *primary interactions* that build superpositions as in section 1.2.3) are colour, electromagnetic and gravity. In the simplest world there would be just one type of preon that comes in three colours, always positively charged say, with their three anti colours all negatively charged. We will indeed find that this seems to work. Looking at Table **2.2.1** we see that a minimum of 6 preons is required to get the correct charge ratios of 3:2:1 between electrons, and up and down quarks. To get vector potential squared values that make all our equations work however, we need to couple to all eight gluon fields requiring a total of eight preons. Table **2.2.1** has all the basic properties required to build infinite superpositions for the fundamental particles. We need to remember when looking at this table that from section 1.2.3 the effective secondary charge is much less than the primary charge and we have no idea yet of the effective value of the primary preon electric charge. Particles only are addressed in the groups of preons in Table 2.2.1. The first point to notice, however, is that both the electron and the W^- are predominantly antipreons, yet they are both defined as particles. Have we got something wrong? When we look at relativistic masses in section 3.2.1 we get the usual plus and minus solutions and Feynman showed us how to interpret the negative solutions as antiparticles.

Table 2.2.1 Groups of eight virtual preons forming the fundamental particles. The electric charges we measure in the real world are one sixth of the group electric charges in this table. The Higgs boson is discussed in section 8.2.4 in **[24].**

Fundamental Particles	Preon colour	Preon electric charge	Group colour	Group electric charge
Spin ½ Neutrino family Spin 1 photons, Z_0 Neutral gluons Spins 1 & 2 gravitons Possibly Higgs boson	Any colour + its Anticolour Red Antired Green Antigreen Blue Antiblue	1 -1 1 -1 1 -1 1 -1	Colourless	0
Spin ½ Electron family Spin 1 W^-	Any colour + its Anticolour Antired Antired Antigreen Antigreen Antiblue Antiblue	1 -1 -1 -1 -1 -1 -1 -1	Colourless	-6
Spin ½ Blue up quark Family	Red Antired Green Antigreen Green Blue Blue Red	1 -1 1 -1 1 1 1 1	Blue	+4
Spin ½ Red down Quark family	Green Antigreen Red Antired Green Antigreen Antiblue Antigreen	1 -1 1 -1 1 -1 -1 -1	Red	-2
Spin 1 Red to Green Gluons	Red Antigreen Red Antired Green Antigreen Blue Antiblue	1 -1 1 -1 1 -1 1 -1	Red plus Antigreen	0

If this also applies in anti preons then because they are zero spin, and the weak force discriminates between particles and antiparticles by their helicity, this discrimination can apply only in secondary interactions. The preon antipreon content of the groups in Table 2.2.1 does not necessarily tell us whether they produce particles or antiparticles. We will discuss this further in section 3.2.1; also, as of now, there is still no good understanding of the predominance of matter over antimatter in our universe. In Table 2.2.1 only one example of colour is given for quarks and gluons. Different colours can be obtained by simply changing appropriate preon colours. Various combinations of eight preons in this table are borrowed from a scalar field for time $\Delta T \leq \hbar / 2\Delta E$, this process continually repeating in time. Conservation of charge normally allows only opposite sign pairs of electric charges to appear out of the vacuum. Let us imagine that these virtual preons are building an electron, for example, whose electric charge exists continually unless it meets a positron and is annihilated. This charged electron is thus due to a continuous appearance out of and back into the vacuum of virtual charged preons in a steady state process existing for the life of the superposition, and not conflicting with conservation of charge. If the electron itself does not conflict, then neither do the borrowed preons that build it.

2.2.2 **Primary coupling constants behave differently and are constant**

QED informs us that the bare (electric) charge of an electron, for example, increases logarithmically inversely with radius from its centre. Polarizations of the vacuum (of virtual charged pairs) progressively shield the bare charge from a radius of approximately one Compton radius $\bar{\lambda}_C$ inwards towards the centre. When an electron (for example) is created in some interaction the full bare charge is exposed for an infinitesimal time.

Instantaneously after its creation, shielding due to polarization of the vacuum builds progressively outward from the centre of its creation at the velocity of light. For radii $\geq \bar{\lambda}_C$ we measure the usual fundamental charge e. There are similar but more complicated processes that occur to the colour charge. Camouflage is the dominant one where the colour charge grows with radius as the emitted gluons themselves have colour charge. At the instant of their birth the preons are bare and at this time, $t = 0$ say, all the zero point vector fields can act on these bare colour and electric charges as there is simply no time for shielding and other effects to build. The primary coupling constants that we use must consequently be the same for all values of k, in complete contrast to those for secondary interactions. We don't know what this primary electromagnetic coupling constant is, so we will just call it α_{EMP}. Also, we will find that to get any sense out of our equations the primary colour coupling has to be very close to 1. A coupling of one is a natural number and simply reflects certainty of coupling. Provided the secondary colour coupling can be in line with the SM, and there does not seem to be any other good reason to pick a number less than 1, we will make the (apparently arbitrary) assumption that the bare primary colour coupling is exactly 1. In section 4.1.1 **[24]** we will find that this seesms to be consistent with the SM.

2.2.3 **Primary interactions also behave differently**

Let us define a frame in which the central origin of the wavefunctions ψ_k of our infinite superposition is at rest. The laboratory or rest frame we will refer to as the LF. The preons that build each ψ_k are born from a Higg's type scalar field with zero momentum in this frame. This has very relevant consequences as their wavelength is infinite in this rest frame at time $t = 0$, and after they become wavefunction ψ_k their wavelength is of the order $1/k$ for times $0 < t < \hbar / 2E$. This implies that there could possibly be significant differences in the way amplitudes are handled between primary and secondary interactions.

Let us consider secondary interactions first with an electron and positron, for example, located approximately distance r apart. For photon wavelengths $<< r$ both the electron and the positron each emit virtual photons with probabilities proportional to α, but for wavelengths $>> r$ their amplitudes cancel. Returning to primary interactions, zero momentum preons must always have an infinite wavelength which is greater than the wavelengths (or $1/k$ values) of the zero point quanta they interact with, for all $k \neq 0$. This implies that we cannot simply add or subtract amplitudes algebraically as the charged preons can be always further apart than the wavelength of the interacting quanta (except when $k = 0$, but we will see there is always a minimum k value, i.e. $k_{\min} > 0$ in sections 5&6 **[24]).**In fact, if algebraic addition of amplitudes did apply in primary interactions, infinite superpositions for colourless and electrically neutral neutrinos would be impossible. So how can infinitely far apart preons of differing charge generate wavefunctions of all dimensions down to Planck scale? This can happen only if the amplitudes of all eight preons are somehow linked over infinite space, all at the same time $t = 0$ contributing to generating the wavefunction ψ_k. This non-local behaviour is not new. All experiments confirm that what Einstein struggled to come to terms with is, in fact, true; he called it "spooky action at a distance". While these experiments are currently limited in the distance over which they demonstrate entanglement, there is now wide acceptance that it can reach across the universe. In the same manner wavefunctions covering all space can instantly collapse. We want to suggest that this same non-locality applies in primary interactions; our eight virtual preons all unite instantaneously at time $t = 0$ across infinite space in generating each ψ_k. Also, the vector potential squared equations that they generate must always be the same for all the preon combinations in Table **2.2.1**. This can happen only if the amplitudes of all eight are added, regardless of charge sign for primary interactions. This applies to both colour and electric charge.

The opposite is true for the secondary interactions. At time $t = 0$ all eight preons instantaneously collapse into some sort of virtual composite particle that for times $0 < t < \hbar / 2E$ obeys wavefunction ψ_k. The dimensions of ψ_k are of the same order as the wavelength of the interacting quanta, and the usual algebraic total electric charge and nett colour charge must now apply as in the group charges in Table **2.2.1**. All of this may seem contrary to current thinking which has gradually been built up over several centuries of secondary interaction experiments; however, it may not be so out of place when viewed in the context of the counter intuitive results of entanglement experiments. The key point to bear in mind is that the predictions of this paper must agree or at least be able to fit the SM, or secondary interaction experiments; as we may never be able to look into virtual primary interactions, but only observe their effects.

Amplitudes to interact are complex numbers which we can draw as a vector. This applies to both colour and electric coupling, where these two vectors can be at the same complex angle or at different angles. The simplest case is if they are in line and we will assume this is true for both colour and electromagnetic primary interactions which are both spin 1. This seems to work and when we later include gravity, a spin 2 interaction, we find that the spin 2 vector only works if it is at right angles to the two in line spin 1 vectors. Let us start in a zero gravity world by simply adding the eight preon colour vectors of amplitude one and the eight primary electromagnetic vectors of amplitude $\sqrt{\alpha_{EMP}}$ together, as all this only works if they are all in line.

The total colour plus electromagnetic primary amplitude is $8+8\sqrt{\alpha_{EMP}}$ (2.2.1)

This equation is always true regardless of signs as in section 2.2.3

The colour plus electromagnetic primary coupling constant is $\left(8+8\sqrt{\alpha_{EMP}}\right)^2$ (2.2.2)

Inserting this into Eq. (2.1.4) we get

$$Q^2A^2 = \left[\frac{\left[8+8\sqrt{\alpha_{EMP}}\right]^2}{3\pi sN}\hbar^2k^4r^2\right]\cdot\left[\frac{sN\cdot dk}{k}\right] \qquad (2.2.3)$$

Again we interpret this just as we did in section 2.1.2 and Eq. (2.1.4) as a vector potential squared term

$$Q^2A^2 = \frac{\left[8+8\sqrt{\alpha_{EMP}}\right]^2}{3\pi sN}\hbar^2k^4r^2 \text{ occurring with probability } = \frac{sN\cdot dk}{k} \qquad (2.2.4)$$

Where Q is a symbol representing the entire eight colour and eight electric amplitudes combined, with s the spin and $N=1$ for massive superpositions, but $N=2$ for infinitesimal mass superpositions. Table 4.3.1 and section 6 **in [24]** and its subsections cover this more fully.)

2.3 Virtual Wavefunctions that form Infinite Superpositions

2.3.1 Infinite families of similar virtual wavefunctions

Consider the family of wave functions where ignoring time:

$$\psi_{nk} = U(nrk)Y(\theta\varphi)$$
$$U(nrk) = C_{nk} r^{l} \exp(-n^2k^2r^2/18) \tag{2.3.1}$$

$U(nrk)$ is the radial part of ψ_{nk}, $Y(\theta\phi)$ the angular part, C_{nk} a normalizing constant, and we will find that l is the usual angular momentum quantum number. There is an infinite family of ψ_{nk}, one for each value k where $0 < k < \infty$ in a zero gravity world.

Now put $R(nrk) = rU(nrk) = C_{nk} r^{l+1} \exp(-n^2k^2r^2/18)$ (2.3.2)

As we are dealing with zero spin preons we use Klein-Gordon equations **[22].** The Klein-Gordon equation is based on the relativistic equation $\mathbf{p}^2 = E^2/c^2 - m_0^2c^2$ and in a spherically symmetric squared vector potential the time independent Klein Gordon Equation is

$$\hat{P}^2\psi = -\hbar^2\nabla^2\psi + Q^2A^2\psi = \left[\frac{E^2}{c^2} - m_0^2c^2\right]\psi \tag{2.3.3}$$

Using $\dfrac{\nabla^2\psi}{\psi} = \dfrac{1}{R}\dfrac{\partial^2 R}{\partial r^2} - \dfrac{l(l+1)}{r^2}$ we get the time independent radial Klein Gordon equation

$$\frac{\hbar^2}{R}\frac{\partial^2 R}{\partial r^2} = \frac{l(l+1)\hbar^2}{r^2} + Q^2A^2 - \left[\frac{E^2}{c^2} - m_0^2c^2\right] \tag{2.3.4}$$

For each ψ_{nk} the energy is E_{nk} a function of $n \,\&\, k$, and we will label the rest mass as m_{0snk} a function of spin $s, n \,\&\, k$, but also a function of the particle rest mass m_0. Using different colours to more clearly compare the next two equations this becomes

$$\frac{\hbar^2}{R}\frac{\partial^2 R}{\partial r^2} = \frac{l(l+1)\hbar^2}{r^2} + Q^2A^2 - \left[\frac{E_{nk}^2}{c^2} - m_{0snk}^2 c^4\right] \tag{2.3.5}$$

Differentiating $R(nrk) = rU(nrk) = C_{nk} r^{l+1} \exp(\dfrac{-n^2k^2r^2}{18})$ twice with respect to r, multiplying by $\hbar^2$ and dividing by R

$$\frac{\hbar^2}{R}\frac{\partial^2 R}{\partial r^2} = \frac{l(l+1)\hbar^2}{r^2} + \frac{n^4\hbar^2k^4r^2}{81} - \frac{(2l+3)n^2\hbar^2k^2}{9} \tag{2.3.6}$$

Comparing Eqs. (2.3.5) & (2.3.6) we see that l is the usual angular momentum quantum number and the vector potential squared required to generate these wavefunctions is

$$Q^2A^2 = \frac{n^4\hbar^2k^4r^2}{81} = \left[\frac{n}{3}\right]^4 \hbar^2k^4r^2 \qquad (2.3.7)$$

The momentum squared is $\mathbf{p}_{nk}^2 = \frac{E_{nk}^2}{c^2} - m_{0snk}^2c^2 = \frac{(2l+3)n^2\hbar^2k^2}{9}$ (2.3.8)

For $l = 3$ wavefunctions this becomes $\mathbf{p}_{nk}^2 = n^2\hbar^2k^2$ & $|\mathbf{p}_{nk}| = n\hbar k$ (2.3.9)

2.3.2 Eigenvalues of these virtual wavefunctions and parallel momentum vectors

From Eqs. (2.3.8) & (2.3.9) as $k \to \infty$, the energy squared $E_{nk}^2 \to \mathbf{p}_{nk}^2c^2 = n^2\hbar^2\omega^2$ and thus if $l = 3$ when $k \to \infty$ energy $E_{nk} \to n\hbar\omega$ (considering only the positive solution). (2.3.10)

This suggests that *n* must be integral. If it is integral when $k \to \infty$, we will conjecture that it must be integral for all values of *k*. This is a virtual or "off shell" process, where energy can depart from $E^2 = m_0^2c^4 + \mathbf{p}^2c^2$ for time $\Delta T \approx \hbar / 2\Delta E$ .We can also perhaps think of Eq. (2.3.9) as integral n parallel momentum vector $|\mathbf{p}| = \hbar k$ quanta, transferring total momentum $|\mathbf{p}_{nk}| = n\hbar k$ and energy $E \le n\hbar\omega$ from the zero point fields to generate the virtual wavefunction ψ_{nk}. Using different colours for both operator and wavefunction, we can say that provided $Q^2A^2 = (n/3)^4\hbar^2k^4r^2$ as in Eq. (2.3.7) the operator $\hat{P}^2 = (-\hbar^2\nabla^2 + Q^2A^2)$ applied to the virtual wavefunction $\psi_{nk} = C_{nk}r^3\exp(-n^2k^2r^2/18)Y(\theta\varphi)$ produces $\hat{P}^2|\psi_{nk}\rangle = (-\hbar^2\nabla^2 + Q^2A^2)|\psi_{nk}\rangle = n^2\hbar^2k^2|\psi_{nk}\rangle$, where *n* is integral, but *k* is continuous as for free particles. Thus, we conjecture that:

$\psi_{nk} = C_{nk}r^3\exp(-n^2k^2r^2/18)Y(\theta\varphi)$ are eigenfunctions with eigenvalues $\mathbf{p}_{nk}^2 = n^2\hbar^2k^2$ with continuous k but integral n . (2.3.11)

Also, there are no scalar potentials involved, only squared vector potentials, so this is a magnetic or vector type interaction. Particles in classical magnetic fields have a constant magnitude of linear momentum which is consistent with the squared momentum eigenvalues of Eq. (2.3.11). This also implies that each ψ_{nk} is formed from quanta of wave number k only and that secondary interactions with ψ_{nk} emit or absorb $|\hbar k|$ virtual quanta if n changes by ±1. The wavefunction ψ_{nk} is virtual and in this sense both the energy E_{nk} and rest mass m_{0snk} in Eq. (2.3.8) are also virtual quantities borrowed from zero point vector fields and its time component or a scalar Higgs type field. We use these virtual quantities to calculate the amplitude that the wavefunction ψ_{nk} is in an m state of angular momentum in section 3.1, and in section 3.2 to calculate the total angular momentum and rest mass. As in section 2.3.2 above, we can think of $|\mathbf{p}_{nk}| = n\hbar k$ as n parallel momentum vectors $|\mathbf{p}| = \hbar k$. As spin 3 (or $l = 3$) needs at least three spin 1 quanta to build it, n must be at least 3. When $n = 3$ we can think of this as three of the eight preons each absorbing quanta $|\hbar k|$ at time $t = 0$. We will find that a spin ½ state has a dominant $n = 6$ eigenfunction where six of the eight preons each absorb quanta $|\hbar k|$. It needs at least two smaller side eigenfunctions $n=5$ & $n=7$ with either five or seven respectively, of the eight preons each absorbing quanta $|\hbar k|$ respectively at $t=0$. (Figure 3.1.4 illustrates the three n modes of a positron superposition.)

From Eq. (2.3.7) $Q^2A^2 = \left[\frac{n}{3}\right]^4 \hbar^2 k^4 r^2 = 16\hbar^2 k^4 r^2$ for this dominant $n=6$ mode.

Thus using Eq. (2.2.4) $Q^2A^2 = \frac{\left[8+8\sqrt{\alpha_{EMP}}\right]^2}{3\pi sN}\hbar^2 k^4 r^2 = 16\hbar^2 k^4 r^2$ for an $n=6$ mode.

Now $s=1/2$ & $N=1$ for spin ½ fermions and $\frac{2\left[8+8\sqrt{\alpha_{EMP}}\right]^2}{3\pi} = 16$ if we have only an $n=6$ mode. Thus $8+8\sqrt{\alpha_{EMP}} = \sqrt{24\pi}$ and $\alpha_{EMP}^{-1} \approx 137.1$, but this is true for an $n=6$ eigenfunction only, and we have a superposition where the amplitudes of the smaller side eigenfunctions $n=5$ & $n=7$ determine the ratio between the primary to secondary (colour and electromagnetic) coupling amplitudes or the value of $\alpha_3^{-1} @ k_{cutoff}$ (Section 3.3). The Q^2A^2 required to produce this superposition with amplitudes c_n is, using Eq. (2.3.7)

$$Q^2A^2 = \sum_{n=5,6,7} c_n * c_n \frac{n^4\hbar^2k^4r^2}{81} \tag{2.3.12}$$

Repeating the same procedure as above for three member superpositions using Eq. (2.3.12) we find the strength of α_{EMP} required increases considerably (see section 4.1 & Table 4.1.1 in **[24]** As the secondary electromagnetic coupling $\alpha_{EMS}^{-1} @ k_{cutoff}$ must be constant for all spin ½ leptons and quarks, the amplitudes of the smaller side eigenfunctions $n=5$ & $n=7$ that determine this must also be constant for all the fermions, implying that Eq. (2.3.12) must be the same for all fermions. The same arguments apply to the other groups of fundamental particles but we return to this in sections 3.3 where we see that the same also applies with graviton emission.

3 Properties of Infinite Superpositions

3.1 The Amplitude that Wavefunction ψ_{nk} is Spherically Symmetric

3.1.1 Four vector transformations

The rules of quantum mechanics tell us that if we carry out any measurement on a real spherically symmetric $l=3$ wavefunction it will immediately fall into one of the seven possible states $l=3, m=0,\pm1,\pm2,\pm3$ **[23].** But ψ_{nk} is a virtual $l=3$ wave function so we cannot measure its angular momentum. During its brief existence it must always remain in some virtual superposition of the above seven possible states and we can describe only the amplitudes of these. So, is there any way to calculate these amplitudes, as they must relate to the amplitudes of the angular momentum states of the spin 1 quanta it absorbs from the zero point vector fields?

First consider the 4 vector wavefunction of a spin 1 particle and start with a time polarized state which has equal probability of polarization directions. It is thus spherically symmetric, which we will label as ss. Using 4 vector (t, *x*, *y*, *z*) notation

In frame A, a time polarized or ss spin 1 state is (1,0,0,0).
Let frame B move along the z axis at velocity $\beta = v/c$ in the z direction.
In frame B the polarization state transforms to $(\gamma, 0, 0, \gamma\beta)$.
But this is γ^2 time polarized $|ss\rangle$ states minus $\gamma^2\beta^2 \times z$ polarized or $|m=0\rangle$ states
In frame B the probabilities are $\gamma^2\,|ss\rangle\; -\gamma^2\beta^2\,|m=0\rangle$ states.

Now $\gamma^2 - \gamma^2\beta^2 = \gamma^2(1-\beta^2) = 1$ is an invariant probability in all frames and in removing $\gamma^2\beta^2$ $\times\, m=0$ states from $\gamma^2 \times ss$ states, the new ratio of spherical symmetry is $(\gamma^2 - \gamma^2\beta^2)/\gamma^2 = 1-\beta^2$. Thus, a spherically symmetric state is transformed from probability 1 in frame A, to $1-\beta^2$ in frame B. Also removing $m=0$ states from spherically symmetric states leaves a surplus of $m=\pm 1$ states, as spherically symmetric states are equal superpositions of $|m=-1\rangle$, $|m=0\rangle$, & $|m=+1\rangle$ states.

Thus in Frame B the probabilities are $(1-\beta^2)|ss\rangle + \beta^2|m=\pm 1\rangle$ states. (3.1.1)

We can describe this as a virtual superposition of $\frac{1}{\gamma}|ss\rangle + \beta|m=\pm 1\rangle$ states. (3.1.2)

As $\beta^2 \to 1$ we have transverse polarized states, the same as real photons. Now transverse polarized spin 1 states can be either left $(m=-1)$, or right $(m=+1)$ circular polarization, or equal superpositions of $(1/\sqrt{2})|L\rangle + (1/\sqrt{2})|R\rangle$ as in $x\,\&\,y$ polarization. If we think of individual spin zero preons absorbing these spin 1 quanta at $t=0$ they must also have this same β^2 probability of transversely polarized spin 1 states. If they then merge into some composite $l=3$ particle (as in Figure 3.1.4) for time $0<t<\hbar/2E$, the probability of it being in some particular state $(l=3, m=0)$, $(l=3, m=\pm 1)$, $(l=3, m=\pm 2)$ or $(l=3, m=\pm 3)$, must be the same β^2. We initially write the amplitudes in these three equations in terms of β_{nk} & γ_{nk} as this is the most convenient way to express them. Velocity operators are momentum operators over relativistic masses. Our eigenvalues are $\mathbf{p}_{nk}^2 = n^2\hbar^2k^2$ for each $n\,\&\,k$, and this allows the velocity operators to give constant β_{nk}^2. Later in Eqs. (3.1.11) and (3.1.12) we write β_{nk} & γ_{nk} in momentum terms. Even though the mass in these operators is virtual, we can still use it to calculate $|\beta_{nk}|$. For each k and integral n there will be a constant $|\beta_{nk}|$ and $\gamma_{nk} = (1-\beta_{nk}^2)^{-1/2}$. As we will see, β_{nk} can be thought of as the magnitude of the velocity of an imaginary centre of momentum frame in which these interactions take place. We will also draw our Feynman diagrams of these interactions in terms of β_{nk} & γ_{nk} for convenience, even though this is unconventional. To proceed from here we define two frames as follows:

1) The Laboratory Frame (LF) or Fixed Frame as in section 2.2.3

The infinite superposition has rest mass m_0 and zero nett momentum in this frame. Each ψ_{nk} is centred here with magnitude of momentum $|\mathbf{p}_{nk}| = n\hbar k$. Even though we have no idea of the direction of this momentum vector we will define it as the z direction. The eight preons are born in this frame with zero momentum and can thus be considered here as being at rest or with zero velocity and infinite wavelength at their birth. The Feynman diagram of the interaction in this frame that builds ψ_{nk} is illustrated in Figure 3.1.3.

2) The Centre of Momentum Frame (CMF)

This (imaginary) frame is the centre of momentum of the interaction that builds ψ_{nk}. The CMF moves at velocity β_{nk} relative to the laboratory frame in the z direction or parallel to the unknown momentum vector direction $\mathbf{p}_{nk}$. In this CMF the momenta and velocities of the preons at birth and after the interaction are equal and opposite. This is illustrated in Figure 3.1.2 again in terms of $m_0, \beta_{nk}, \& \gamma_{nk}$. In the LF the velocity of the preons at birth is zero, in the CMF this is $-\beta_{nk}$ and after the interaction $+\beta_{nk}$, where both $-\beta_{nk}$ and $+\beta_{nk}$ are in the unknown z direction. In the LF the particle velocity $\beta_{nk}(\text{particle}) = \beta_{nkp}$ is the simple relativistic addition of the two equal velocities β_{nk} as in Figure 3.1.1.

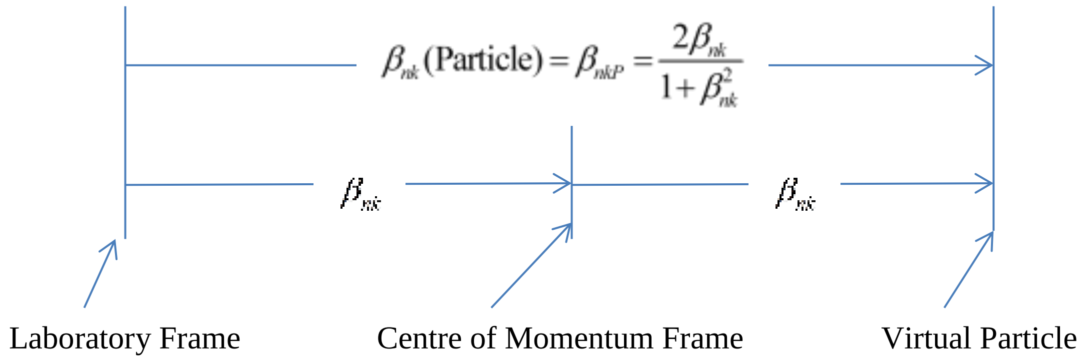


Figure 3.1.1 Velocities in unknown but the same directions in different frames.

3.1.2 **Feynman diagrams of primary interactions**

Let us start with

$$\beta_{nk}(\text{Particle}) = \beta_{nkP} = \frac{2\beta_{nk}}{1+\beta_{nk}^2} \text{ and } \gamma_{nkP} = (1-\beta_{nkp}^2)^{-1/2} = \gamma_{nk}^2(1+\beta_{nk}^2) \tag{3.1.3}$$

If the particle rest mass is m_0 let each preon have a virtual rest mass $m_0 / (8\gamma_{nk}\sqrt{2s})$.

The eight preons are effectively a virtual particle of rest mass $m_{0snk} = \dfrac{m_0}{\gamma_{nk}\sqrt{2s}}$ (3.1.4)

The particle momentum in the LF is zero at birth. After the interaction using these equations

$$\left|\mathbf{p}_{nk}\right| = n\hbar k \;= m_{0snk}\beta_{nkP}\gamma_{nkP}c = \left[\frac{m_0}{\gamma_{nk}\sqrt{2s}}\right]\left[\frac{2\beta_{nk}}{1+\beta_{nk}^2}\right]\left[\gamma_{nk}^2(1+\beta_{nk}^2)\right]c$$

The particle momentum after the interaction in the LF $\left|\mathbf{p}_{nk}\right| = n\hbar k = \dfrac{2m_0\beta_{nk}\gamma_{nk}c}{\sqrt{2s}}$ (3.1.5)

Using Eq. (3.1.4), in the LF the particle energy at birth is

$$m_{0snk}c^2 = \frac{m_0c^2}{\gamma_{nk}\sqrt{2s}} \tag{3.1.6}$$

In the LF the particle energy after the interaction is by using Eq. (3.1.3)

$$m_{0snk}\gamma_{pnk}c^2 = \frac{m_0}{\gamma_{nk}\sqrt{2s}}\gamma_{nk}^2(1+\beta_{nk}^2)c^2 = \frac{m_0\gamma_{nk}}{\sqrt{2s}}(1+\beta_{nk}^2)c^2 \qquad (3.1.\ 7)$$

In the CMF the momentum at birth is using Eq. (3.1.4)

$$-m_{0snk}\gamma_{nk}\beta_{nk} = \frac{-m_0\beta_{nk}}{\sqrt{2s}} \tag{3.1.8}$$

In the CMF the momentum after the interaction is equal but in the opposite direction

$$= \frac{+m_0\beta_{nk}}{\sqrt{2s}} \tag{3.1.9}$$

In the CMF the energy at birth, and after the interaction is

$$m_{0snk}\gamma_{nk}c^2 = \frac{m_0c^2}{\sqrt{2s}} \tag{3.1.10}$$

These values are all summarized in Figure 3.1.2 and Figure 3.1.3 but with $c=1$.

From Eq. (3.1.5) $\left|\mathbf{p}_{nk}\right| = n\hbar k = \dfrac{2m_0\beta_{nk}\gamma_{nk}c}{\sqrt{2s}}$ and $\beta_{nk}\gamma_{nk} = \dfrac{n\hbar k\sqrt{2s}}{2m_0c} = \dfrac{\lambdabar_C nk\sqrt{2s}}{2}$

(where $\lambdabar_C = \dfrac{\hbar}{m_0c}$ is the Compton wavelength). We can now express β_{nk} & γ_{nk} in momentum terms:

$$\text{Let } K_{nk} = \beta_{nk}\gamma_{nk} = \frac{n\hbar k\sqrt{2s}}{2m_0c} = \frac{\lambdabar_C nk\sqrt{2s}}{2} \tag{3.1.11}$$

$$\text{In terms of } K_{nk}\text{:} \quad \beta_{nk}^2 = \frac{K_{nk}^2}{1+K_{nk}^2} \quad \text{and} \quad \gamma_{nk}^2 = 1+K_{nk}^2 \tag{3.1.12}$$

Each infinite superposition has fixed $\lambdabar_C$. Each wavefunction ψ_{nk} of this infinite superposition has fixed $n\,\&\,s$, thus $K_{nk} \propto k$.

$$\text{For example, we can put} \quad \frac{dK_{nk}}{K_{nk}} = \frac{dk}{k} \tag{3.1.13}$$

These simple expressions and what follows are not possible if $m_{0snk} \neq m_0 / \gamma_{nk}\sqrt{2s}$, and when we include gravity we find $m_{0snk} = m_0 / (\gamma_{nk}\sqrt{2s})$ is essential (section 4.2 in [24].

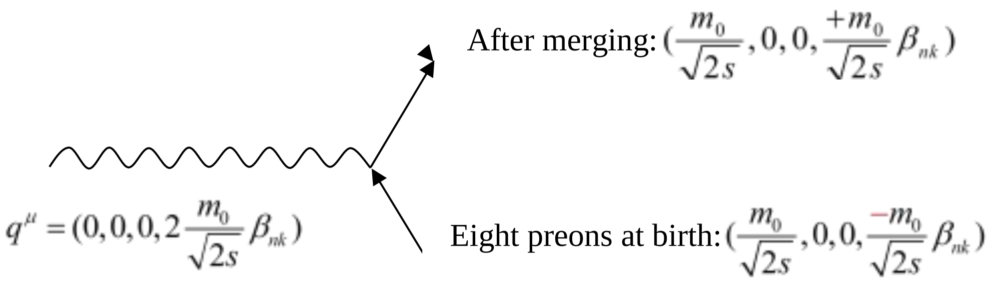


Figure 3.1.2 Feynman diagram in an imaginary centre of momentum frame.

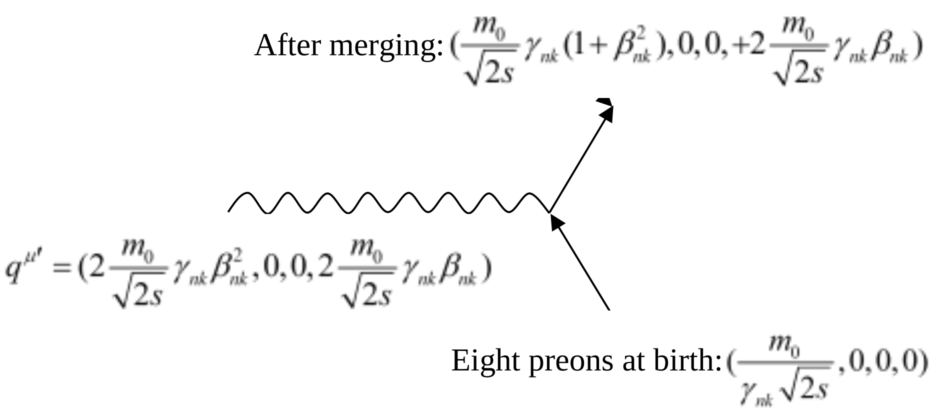


Figure 3.1.3 Feynman diagram in the laboratory frame.

The interaction in the Feynman diagrams above is with spin 1 quanta. The Feynman transition amplitude of this interaction shows that the polarization states of these exchanged quanta is determined by the sum of the components of the initial, plus final 4 momentum $(p_i + p_f)^{\mu}$. Ignoring all other common factors this says that the space polarized component is the sum of the momentum terms $(\mathbf{p}_i + \mathbf{p}_f)$ and the time polarized component is the sum of the energy terms $(p_i + p_f)^0$. We have defined our momentum as in an unknown z direction:

The ratio of z polarization to time polarization amplitudes is $\frac{(p_i + p_f)^z}{(p_i + p_f)^0}$ (3.1.14)

In the CMF $(p_i + p_f)^z = 0$, thus an interaction in the CMF exchanges only time polarized, or spherically symmetric $l = 1$ states. In the LF the ratio of z (or $m = 0$) polarization, to time polarization in the LF is β_{nk}^2,

$$\text{where} \quad \frac{(p_i + p_f)^z}{(p_i + p_f)^0} = \frac{2m_0\gamma_{nk}\beta_{nk}}{2m_0\gamma_{nk}} = \beta_{nk} \tag{3.1.15}$$

From section 3.1.1 these are probabilities of $\gamma_{nk}^2 \left|ss\right\rangle - \gamma_{nk}^2\beta_{nk}^2 \left|m=0\right\rangle$ states, or as $l=1$ here $(1-\beta_{nk}^2)\left|ss\right\rangle + \beta_{nk}^2 \left|m=\pm 1\right\rangle$ states.

In the LF this is a virtual superposition of $(\frac{1}{\gamma_{nk}}\left|ss\right\rangle + \beta_{nk}\left|m=\pm 1\right\rangle)$ states. (3.1.16)

From section 3.1.1 as these quanta from the scalar and vector zero point fields build each ψ_{nk} this implies that:

In the LF ψ_{nk} has virtual superposition amplitudes $\frac{1}{\gamma_{nk}}\left|ss\right\rangle + \beta_{nk}\left|m\right\rangle$ states. (3.1.17)

From section 3.1.1 appropriate $l=1, m=\pm 1$ superpositions can build any $l=3,\ m$ state. Figure 3.1.4 is an example of such a ψ_{nk} for $n=5,6,\&7\ \left|l=3, m=+2\right\rangle$ states.

3.1.3 **Different ways to express superpositions**

We have expressed all superpositions here in terms of spherically symmetric and m states for convenience and simplicity. We could have expressed them in the form:

$$\frac{1}{\gamma_{nk}\sqrt{7}}\left[\left|m=-3\right\rangle + \left|m=-2\right\rangle + \left|m=-1\right\rangle + \left|m=0\right\rangle + \left|m=+1\right\rangle + \left|m=+2\right\rangle + \left|m=+3\right\rangle\right] + \beta_{nk}\left|m=+2\right\rangle$$

This is equivalent to (as above we ignore complex number amplitude factors for clarity)

$\psi_{nk} = \frac{1}{\gamma_{nk}}\left|ss\right\rangle + \beta_{nk}\left|m=+2\right\rangle$ where we have put m = +2 in this example.

Because all these wavefunctions are virtual they cannot be measured in the normal way that collapses them into any of these eigenstates, it is more convenient to use the method adopted here which is similar to QED virtual photon superpositions.

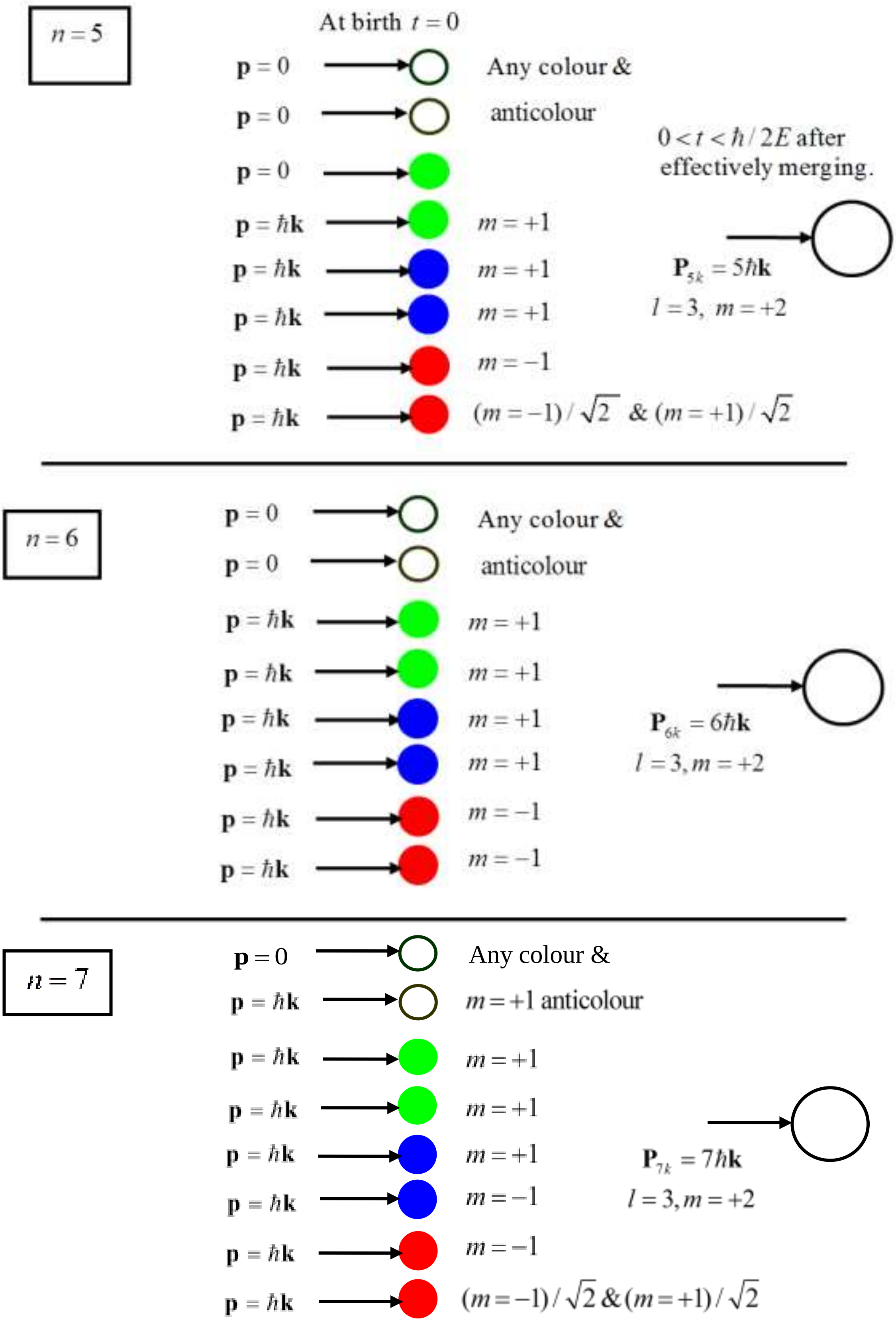


Figure 3.1.4 Eight preons forming $m = +2$ states as part of a positron superposition. If a zero spin and zero momentum preon absorbs a quantum its momentum becomes $\mathbf{p} = \hbar\mathbf{k}$ and its angular momentum becomes either $m = \pm 1$, or an $m = 0$ equal superposition of $m = \pm 1$, states. When it does not absorb a quantum it remains at both spin zero and momentum $\mathbf{p} = 0$. There is no significance in which preons have absorbed quanta.

3.2 Mass and Total Angular Momentum of Infinite Superpositions

3.2.1 Total mass of massive infinite superpositions

We will consider first the total mass of an infinite superposition, and to help illustrate, consider only one integral n eigenfunction ψ_{nk} at a time; temporarily assuming that the amplitude c_n of each ψ_{nk} has magnitude $|c_n| = 1$. Each time ψ_{nk} is born it borrows mass from a scalar Higgs field (or a zero point field time component) and momentum from a zero point field spatial component. The mass that it borrows is exactly cancelled by an equal debt in the Higgs scalar field (or the zero point field time component) so this sums to zero for all *k*. (This is a different way of looking at what generates mass; however, the end result is identical.) But what about the momenta borrowed from the spatial component of zero point fields, do these momenta also leave momentum debts in the vacuum? At any fixed value of *k* the momentum is a constant of the motion in a squared vector potential A^2. We can think of this as in any particular direction there is some probability of momentum $\mathbf{p}_{nk} = n\hbar\mathbf{k}$ due to this A^2 field. When interacting with the magnetic or the spatial component of any electromagnetic field the velocity squared factor β_{nk}^2 determines the rate of quanta absorbed.

Our wavefunctions ψ_{nk} are generated from a vector potential squared term A^2 derived in section 2.1.2 which in turn came from a B^2 type term as in section 2.1.1. As discussed in section 2.3.2 the eigenvalues $\mathbf{p}_{nk}^2 = n^2\hbar^2 k^2$ confirm the constant momentum squared feature of magnetic, or space mode interactions. Also in section 2.1.1 the scalar virtual photon emission probability is directly related to the force squared term $F^2 = \varepsilon^2 E^2$. Magnetic type coupling probabilities are related to a magnetic type force squared term $F^2 = \beta^2\varepsilon^2 B^2 / c^2 = \beta^2\varepsilon^2 E^2$, where from section 3.1.2 and Eqs. (3.1.14) & (3.1.15) the ratio of this scalar to magnetic coupling is β_{nk}^2. Thus when $k < \infty$ and the exchanged energy $E_X \neq \hbar\omega$, $\beta_{nk}^2 n$ quanta $|\hbar k|$ are absorbed from the vacuum and

we can expect a momentum debt of $\mathbf{p}_{nk}(debt) = -\beta_{nk}^2 n\hbar\mathbf{k}$ (3.2.1)

We could sum $\sum \mathbf{p}_{nk}^2$ & $\sum \mathbf{p}_{nk}^2(debt)$ but both vectors $\mathbf{p}_{nk}$ and $\mathbf{p}_{nk}(debt)$ are antiparallel in the same unknown direction. We can pair them together giving a nett momentum per pair of:

$$\mathbf{p}_{nk}(nett) = \mathbf{p}_{nk} + \mathbf{p}_{nk}(debt) = (1-\beta_{nk}^2)n\hbar\mathbf{k} = \frac{n\hbar\mathbf{k}}{\gamma_{nk}^2} = \frac{\mathbf{p}_{nk}}{\gamma_{nk}^2} \text{ at wavenumber } k. \quad (3.2.2)$$

We have said above that the mass of each virtual particle is cancelled by an equal and opposite debt in the Higgs scalar field so we can now use the relativistic energy expression

$E_n^2 = \sum_{k=0}^{k=\infty} \mathbf{p}_{nk}(nett)^2 c^2$ times the probability of each pair at each wavenumber *k*.

We will initially look at only $N = 1$ massive infinite superpositions in Eq. (2.2.4).
Thus, using probability $sN \cdot dk / k = s \cdot dk / k$, also Eqs. (3.1.11), (3.1.12), (3.1.13),& (3.2.2)

$$E_n^2 = c^2 \int_{k=0}^{k=\infty} \mathbf{p}_{nk}(nett)^2 \frac{s\cdot dk}{k} = c^2 \int_0^{\infty} \frac{n^2\hbar^2 k^2}{\gamma_{nk}^4} \frac{s\cdot dk}{k} = 4m_0^2c^4 \int_0^{\infty} \frac{K_{nk}^2}{(1+K_{nk}^2)^2} \frac{dK_{nk}}{2K_{nk}}$$

$$E_n^2 = m_0^2 c^4 \left[\frac{-1}{1+K_{nk}^2} \right]_0^{\infty} = m_0^2 c^4 \text{ or } E_n = \pm m_0 c^2 \tag{3.2.3}$$

This energy is due to summing momenta squared and it must be real, with a mass $\pm m_0$ for infinite superpositions of Eigenfunctions ψ_{nk}. These superpositions can form all the non-infinitesimal mass fundamental particles. The equations do not work if the mass m_0 is zero. (We will look at infinitesimal masses in section 6.2 **[24])** Negative mass solutions in Eq. (3.2.3) must be handled in the usual Feynman manner, and treated as antiparticles with positive energy going backwards in time. If they are spin ½ this also determines how they interact with the weak force.

3.2.2 **Angular momentum of massive infinite superpositions**

We will use the same procedure for the total angular momentum of $N=1$ type infinite superpositions with non-infinitesimal mass in Eq. (2.2.4).

Wavefunctions $\psi_{nk} = C_{nk} r^3 \exp(-n^2k^2r^2/18) Y(\theta,\varphi)$ have angular momentum squared eigenvalues $\mathbf{L}^2 = 12\hbar^2$ and the various m states have angular momentum eigenvalues $\mathbf{L}_z = m\hbar$. We will treat both angular momentum and angular momentum debts as real just as we did for linear momentum. Even though m state wavefunctions are part of superpositions they still have probabilities, just as the linear momenta squared above, and it seemed to work. Using exactly the same arguments as in section 3.2.1, if ψ_{nk} is in a state of angular momentum $\mathbf{L}_{zk} = m\hbar$, then it must leave an angular momentum debt in the vacuum of $\mathbf{L}_{zk}(debt) = -\beta_{nk}^2 m\hbar$ (or as in section 3.2.1) $\mathbf{L}_{zk}(nett) = \mathbf{L}_{zk} - \mathbf{L}_{zk}(debt)$.

$$\mathbf{L}_{zk}(nett) = (1-\beta_{nk}^2)m\hbar = (1-\beta_{nk}^2)\mathbf{L}_{zk} = \frac{\mathbf{L}_{zk}}{\gamma_{nk}^2} \quad (\text{if } \mathbf{L}_{zk} \text{ is in state } m\hbar) \tag{3.2.4}$$

But from Eq. (3.1.17) the probability that $\mathbf{L}_{zk}$ is in an m state is also β_{nk}^2 so that

including this extra β_{nk}^2 probability term: $\mathbf{L}_{zk}(nett) = m\hbar \dfrac{\beta_{nk}^2}{\gamma_{nk}^2}$ at wavenumber k. (3.2.5)

For an $N=1$ type infinite superposition $\mathbf{L}_z(Total) = \displaystyle\int_{k=0}^{k=\infty} \mathbf{L}_{zk}(nett) \frac{s\cdot dk}{k}$. $= sm\hbar \displaystyle\int_0^{\infty} \frac{\beta_{nk}^2}{\gamma_{nk}^2} \frac{dk}{2k}$

Using Eqs. (3.1.11) to (3.1.13) $\mathbf{L}_z(Total) = sm\hbar \displaystyle\int_0^{\infty} \frac{K_{nk}^2}{(1+K_{nk}^2)^2} \frac{dK_{nk}}{K_{nk}} = \frac{sm\hbar}{2} \left[\frac{-1}{1+K_{nk}^2} \right]_0^{\infty}$

$$\mathbf{L}_z(Total) = m'\hbar = \frac{sm\hbar}{2} \qquad \text{or} \qquad m' = \frac{s}{2}m \tag{3.2.6}$$

Where m' is the angular momentum state of the infinite superposition and m the state of ψ_{nk}. Thus for spin ½ particles with $s=$ ½ in Eq. (3.2.6) $m'=m/4$ but m' can be only ± ½, implying the m state of ψ_{nk} that generates spin ½ must be $m=\pm 2$. An $N=1$ massive spin 1 particle has $s=1$ with $m'=m/2$. ($N=2$ is covered in section 6.2 in [24]**)** This is summarized in the following three member infinite superpositions ignoring complex number factors.

$$\text{Massive } (N=1) \text{ Spin } \tfrac{1}{2},\ \left|\psi_{\infty,1/2,\pm 1/2}\right\rangle = \sum_{n=5,6,7} c_n \int_{k=0}^{k=\infty} \left[\frac{\left|\psi_{nk,ss}\right\rangle}{\gamma_{nk}} + \beta_{nk}\left|\psi_{nk,\pm 2}\right\rangle\right]\sqrt{\frac{1}{2k}}dk \tag{3.2.7}$$

$$\text{Massive } (N=1) \text{ Spin } 1,\ \left|\psi_{\infty,1,m}\right\rangle = \sum_{n=4,5,6} c_n \int_{k=0}^{k=\infty} \left[\frac{\left|\psi_{nk,ss}\right\rangle}{\gamma_{nk}} + \beta_{nk}\left|\psi_{nk,2m}\right\rangle\right]\sqrt{\frac{1}{k}}dk \tag{3.2.8}$$

The spin vectors of each ψ_{nk} with $|\mathbf{L}|=2\sqrt{3}\hbar$, and their spin vector debts in the zero point vector fields, have to be aligned such that the sum in each case is the correct value: $|\mathbf{L}|=\sqrt{3}\hbar/2$,$|\mathbf{L}|=\sqrt{2}\hbar$ or $|\mathbf{L}|=\sqrt{6}\hbar$ for spins ½ , 1 & 2 respectively.

Spherically symmetric massive $N=1$ spin 1 states are a superposition of three states $\frac{1}{\sqrt{3}}\left[\left|m'=-1\right\rangle+\left|m'=0\right\rangle+\left|m'=+1\right\rangle\right]$, and using Eq. (3.2.8) can be formed as follows

$$\text{Massive spin 1} \begin{bmatrix} \frac{1}{\sqrt{3}}\left|\psi_{\infty,1,m'=-1}\right\rangle = \frac{1}{\sqrt{3}}\sum_{n=4,5,6} c_n \int_{k=0}^{k=\infty}\left[\frac{\left|\psi_{nk,ss}\right\rangle}{\gamma_{nk}}+\beta_{nk}\left|\psi_{nk,m=-2}\right\rangle\right]\sqrt{\frac{1}{k}}dk \\ +\frac{1}{\sqrt{3}}\left|\psi_{\infty,1,m'=0}\right\rangle = \frac{1}{\sqrt{3}}\sum_{n=4,5,6} c_n \int_{k=0}^{k=\infty}\left[\frac{\left|\psi_{nk,ss}\right\rangle}{\gamma_{nk}}+\beta_{nk}\left|\psi_{nk,m=0}\right\rangle\right]\sqrt{\frac{1}{k}}dk \\ +\frac{1}{\sqrt{3}}\left|\psi_{\infty,1,m'=+1}\right\rangle = \frac{1}{\sqrt{3}}\sum_{n=4,5,6} c_n \int_{k=0}^{k=\infty}\left[\frac{\left|\psi_{nk,ss}\right\rangle}{\gamma_{nk}}+\beta_{nk}\left|\psi_{nk,m=+2}\right\rangle\right]\sqrt{\frac{1}{k}}dk \end{bmatrix} \tag{3.2.9}$$

3.2.3 Mass and angular momentum of multiple integer *n* superpositions

In sections 3.2.1 & 3.2.2 for simplicity we looked at single integer *n* superpositions ψ_{nk}. For superpositions $\psi_k=\sum_n c_n\psi_{nk}$, we replace K_{nk}^2 with $\langle K_k\rangle^2$. Equation (2.3.9) appears to suggest $|\mathbf{p}_k|^2=\sum_n c_n{}^*c_n n^2\hbar^2k^2=\langle n^2\rangle\hbar^2k^2$ and $\langle|\mathbf{p}_k|\rangle=\hbar k\sqrt{\langle n^2\rangle}$. In section3.5.3 in [24] we discuss why $\langle|\mathbf{p}_k|\rangle\neq\hbar k\sqrt{\langle n^2\rangle}$ but $\langle|\mathbf{p}_k|\rangle=\hbar k\sum_n c_n{}^*c_n\cdot n=\hbar k\langle n\rangle$. Thus using Eq. (3.1.11)

$$\langle K_k\rangle=\frac{\lambdabar_C k\sqrt{2s}}{2}\langle n\rangle \ \ \& \ \ \langle K_k\rangle^2=\frac{\lambdabar_C^2k^2s}{2}\langle n\rangle^2 \ \text{ but } \ \langle K_k\rangle^2\neq\frac{\lambdabar_C^2k^2s}{2}\langle n^2\rangle \tag{3.2.10}$$

Replacing K_{nk}^2 with $\langle K_k \rangle^2 = \lambda_C^2 k^2 s \langle n \rangle^2 / 2$ in the key equations (3.2.3) & (3.2.6) does not change the final results. The laws of quantum mechanics tell us the total angular momentum is precisely integral $\hbar$ or half integral $\hbar / 2$. Looking at the above integrals used to derive total angular momentum we see that *N* must be 1 (we discuss *N*=2 in section 6.2) and s must be exactly ½ or one for spin ½ & spin 1 massive particles respectively in our probability formula Eq. (2.2.4). Also, these integrals are infinite sums of positive and negative integral $\hbar$ that are virtual and cannot be observed. If an infinite superposition for an electron is in a spin up state and flips to spin down in a magnetic field, a real $m = \pm 1$ photon is emitted carrying away the change in angular momentum. This is the only real effect observed from this infinity of $(l = 3, m = +2)$ virtual wavefunctions all flipping to $(l = 3, m = -2)$ states, plus an infinite flipping of the virtual zero point vector debts. Also, Eqs. (3.2.3) and (3.2.6) are true only if our high energy cutoff is at infinity and the low frequency cutoff is at zero. We look at high energy Planck scale cutoffs in section 4.2 and in section 6 low energy cutoffs **[24]** near the radius of the causally connected horizon.

3.3 Ratios between Primary and Secondary Coupling

3.3.1 **Initial simplifying assumptions**

This section is based on a special case thought experiment that tries to illustrate, hopefully in a simple way, how superpositions interact with one another; in the same way as virtual photons, for example, interact with electrons. It is unfortunately long and not very rigorous, but it illustrates how, in all interactions between fundamental particles represented as infinite superpositions, the actual interaction is between only the same k single wavenumber superpositions of each particle. We will later conjecture that an interacting virtual particle is a single wavenumber k superposition only, and not a full infinite superposition. Only real particles whose properties we can measure are full infinite superpositions. The full properties do not exist until measurement, just as in so many other examples in quantum mechanics. This will be clearer as we proceed. It is also important to remember here, that because primary coupling constants are to bare charges (section 2.2.2), and thus fixed for all *k*, while secondary coupling constants run with *k*, the coupling ratios can be defined only at the cutoff value of *k* applying to the bare charge (sections 4.1.1 &4.2.2 in **[24]**). From Table **2.2.1** there are six fundamental primary charges for electrons and positrons. But electrons and positrons are defined as fundamental charges. In other words, what we define as a fundamental electric charge is in reality six primary charges. Of course, we can never in reality measure six as their effect is reduced by the ratio between primary and secondary coupling. Because electromagnetic and colour coupling are both via spin one bosons their coupling ratios are fundamentally the same, but because of the above they are related as $6^2 = 36:1$.

$$\frac{1}{\chi_{Colour}} = \frac{36}{\chi_{EM}} \tag{3.3.1}$$

We define the colour and electromagnetic ratios as follows (leaving gravity till section 6.2.6 in **[24])**

$$\frac{1}{\chi_{Colour}}=\frac{\alpha_{Colour\,(\text{Secondary})}}{\alpha_{Colour\,(\text{Primary})}}=\frac{\alpha_{3S}}{\alpha_{3P}} \qquad \text{and} \qquad \frac{1}{\chi_{EM}}=\frac{\alpha_{EM\,(\text{Secondary})}}{\alpha_{EM\,(\text{Primary})}}=\frac{\alpha_{EMS}}{\alpha_{EMP}} \tag{3.3.2}$$

The secondary coupling constants α_{EMS} & α_{3S} are the bare charge values, both at the fermion interaction cutoff near the Planck length Eq.4.2.10 in **[24]).** Also we assumed in section 2.2.2 that $\alpha_{3P}=1;$ thus from Eq. (3.3.2)

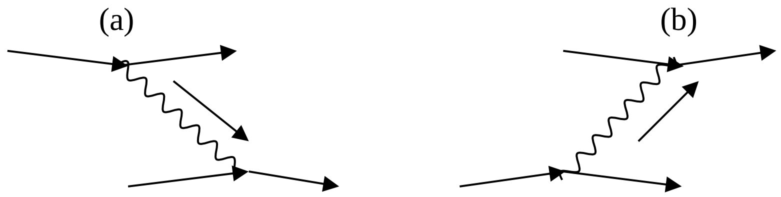
$$\chi_C=\alpha_{3S}^{-1}=\alpha_3^{-1}\,@\,k_{cutoff}\approx 2.029\times 10^{18}GeV \tag{3.3.3}$$

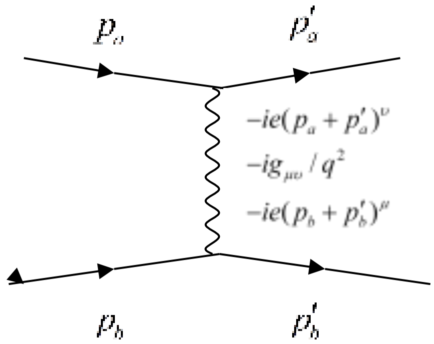
In other words, provided $\alpha_{3P}=1,$ the ratio χ_C (or χ_{Colour}) is also the inverse of the colour coupling constant α_3 at the high energy interaction cutoff near the Planck length. In this respect χ_C or χ_{Colour} is the fundamental ratio we will use mainly from here on. From the above paragraphs, to find the coupling ratios we need secondary interactions that are between bare charges. But this implies extremely close spacing where the effects of spin dominate. If the spacing is sufficiently large the effects of spin can be ignored but then we are not looking at bare charges. However, we can ignore the effects of shielding due to virtual charged pairs by imagining, as a simple thought experiment, an interaction between bare charges even at such large spacing. We can also simplify things further by considering only scalar or coulomb type elastic interactions at this large spacing. We are also going to temporarily ignore Eq. (3.3.2) and imagine that we have only one primary electric and or one colour charge. Consider two superpositions and (due to the above simplifying assumptions) imagine them as spin zero charges. QED considers the interaction between them as a single covariant combination of two separate and opposite direction non-covariant interactions (a) plus (b) as in the Feynman diagram of Figure 3.3.1 below. The Feynman transition amplitude is invariant in all frames [22], so let us consider a special simple case in a CM frame where we have identical particles on a head-on (elastic) collision path with spatial momenta:

$$\mathbf{p}_a=-\mathbf{p}'_a=-\mathbf{p}_b=+\mathbf{p}'_b \tag{3.3.4}$$

From Eq. (3.3.4) the initial and final spatial momenta are reversed with mirror images of each other at each vertex. Of course, when we know momenta accurately we have no idea where the particles are when this takes place, so in reality there is no head-on collision. We are also going to assume in what follows that the vertices of this interaction are on opposite sides of the interacting boson superposition. While we have no idea where this boson superposition is centred, what we do know in this simple special scalar case is that the transferred four momentum squared is simply the transferred three momentum squared, and ignoring the minus sign for q^2 (due to i^2) in what we are doing here for simplicity we can say :

$$q^2 = (p_a - p_a{}')^2 = (p_b - p_b{}')^2 = 4\mathbf{p}_a^2 = 4\mathbf{p}_b^2. \qquad (3.3.5)$$





The Feynman diagram is drawn with a vertical photon line representing the superposition of two opposite direction and non-covariant processes (a) plus (b).
The exchanged 4 momentum is:

$$q = p_a - p'_a = p'_b - p_b.$$

Figure 3.3.1 Feynman diagram of virtual photon exchange between two spin zero particles of charge e.

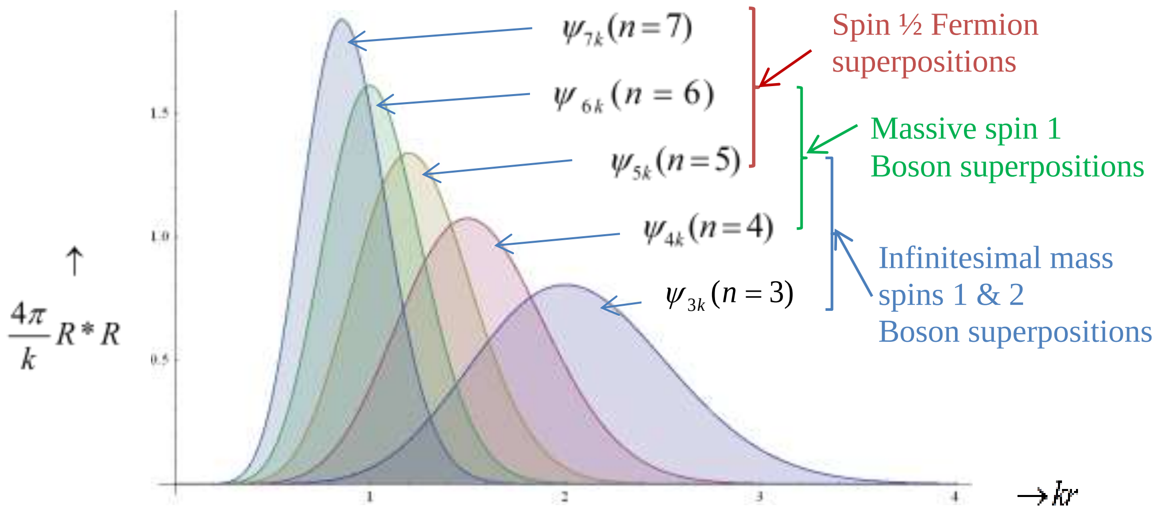


Figure 3.3.2 All eigenfunctions ψ_{nk} in the groups of three overlap at a fixed wavenumber *k*.

If we look at Figure 3.3.2 we see that at any fixed value of k, all modes ψ_{nk} in the groups of three overlapping superpositions for the various spins ½, 1 & 2 occupy similar sized regions of space. The directions of their linear momenta are unknown but let us imagine some particular vector $\hbar\mathbf{k}$ that is parallel to the above vectors $\mathbf{p}_a = \mathbf{p}_b$. As we are considering only scalar interactions, all these modes must be spherically symmetric or time polarized. Equation (3.1.16) says spherical symmetry is $\propto 1/\gamma_{nk}$ and Eqs. (3.1.11) and (3.1.12) tell us $\gamma_{nk} \rightarrow 1$ as $\beta_{nk} \rightarrow 0$. But we are considering bare charges at large spacings where the exchanged virtual photons have small momenta and are time polarized as in Eq. (3.1.15). At a fixed value of k

they thus have momenta $\pm n\hbar\mathbf{k}$. Also, as they overlap each other, we can imagine units of $\pm\hbar\mathbf{k}$ quanta somehow transferring between these superpositions so that the values of n in each mode can change temporarily by ± 1 for times $\Delta T \approx \hbar / \Delta E$. The directions of these momentum transfers causing either repulsion or attraction depending on the charge signs of the superpositions at each vertex, whether the same or opposite.

3.3.2 **Restrictions on possible eigenvalue changes**

Before we look at changing these eigenvalues by $n = \pm 1$ we need to consider what restrictions there are on these changes.

From Eq. (2.3.12) superposition ψ_k requires $Q^2 A^2 = \sum_n c_n * c_n \dfrac{n^4 \hbar^2 k^4 r^2}{81}$ and Eq. (2.2.4) informs us the available $Q^2 A^2 = \dfrac{\left[8 + 8\sqrt{\alpha_{EMP}}\right]^2}{3\pi sN} \hbar^2 k^4 r^2$ occurs with probability $= \dfrac{sN \cdot dk}{k}$.

For very brief periods the required value of $Q^2 A^2$ can fluctuate, such as during these changes of momentum, but if its average value changes over the entire process then Eq. (2.2.4) says that the probability $sN \cdot dk / k$ changes also, and we have shown in section 3.2.1 that this is disallowed. For example, in a spin ½ superposition $\psi_{5k}, \psi_{6k}, \psi_{7k}$, (see Table 4.3.1 in [24]) the average values of $|c_5|, |c_6| \& |c_7|$ must each remain constant. This can only happen if n remains within its pre-existing boundaries of $(5 \le n \le 7)$. For example, if ψ_7 adds $+\hbar\mathbf{k}$ (we will ignore the subscript k in ψ_{nk} from here assuming that it will be understood) it can create ψ_8, but $|c_8|$ must average zero, which it can do only if it fluctuates either side of zero, and $|c_n|$ cannot be negative. Similarly $|c_4|$ must average zero, thus ψ_4 & ψ_8 are forbidden fermion superposition states. Keeping the average values of $|c_n|$ constant is also equivalent to a constant internal average particle energy (we have shown in section 3.2.1 that rest mass is a function of $\sum c_n * c_n . \mathbf{p}_{nk}^2$). By changing these eigenvalues by $n = \pm 1$ there are only four possibilities: $\psi_6 \& \psi_7$ can both reduce by $-\hbar\mathbf{k}$ quanta; $\psi_6 \& \psi_5$ can both increase by $+\hbar\mathbf{k}$ quanta. If ψ_6 becomes ψ_7, $|c_7|$ also increases and $|c_6|$ decreases, but then ψ_7 has to drop back becoming ψ_6, with $|c_7|$ decreasing back down and $|c_6|$ increasing back up in exact balance. If we view this as one overall process the average values of both $|c_6|$ and $|c_7|$ remain constant but fluctuate continuously. We can use exactly the same argument if ψ_5 increases which has to be followed by ψ_6 dropping, where if we view this as one process again, the average values of both $|c_5|$ and $|c_6|$ remain constant. This is similar to a particle not being able to absorb a photon in a covariant manner, it has to re-emit within time $\Delta T \approx \hbar / E$. Just as transversely polarized photons are the equal left and right superposition of circular polarizations $|L\rangle / \sqrt{2} + |R\rangle / \sqrt{2}$, we can perhaps express Eq. (2.3.**9**) $\mathbf{p}_{nk}^2 = n^2 \hbar^2 k^2$ as equivalent to:

$$\mathbf{p} = \pm n\hbar\mathbf{k} \text{ is the equal superposition } \mathbf{p} = |+n\hbar\mathbf{k}\rangle / \sqrt{2} + |-n\hbar\mathbf{k}\rangle / \sqrt{2}. \tag{3.3.6}$$

This superposition is in opposite directions of the vector $\mathbf{k}$, implying equal 50% probabilities of momentum vectors for any pair of opposite directions. (It is a virtual superposition so neither of these two components can be observed.) Thus if n changes by $+1$ say, there are equal 50% probabilities of the momentum transfers $\mathbf{p} = +\hbar\mathbf{k}$ and $\mathbf{p} = -\hbar\mathbf{k}$. And the same is true if n changes by -1. Spin 1 bosons transfer momentum $\Delta\mathbf{p} = \pm\hbar\mathbf{k}$, which means that two 50% probability transfers are required, such as $\psi_{5k} \to \psi_{6k}$ combined with a $\psi_{6k} \to \psi_{5k}$ provided the momentum directions add appropriately as in the Figure 3.3.3 top diagram But if $\psi_{5k} \to \psi_{6k}$ and $\psi_{6k} \to \psi_{5k}$, with $\mathbf{p} = \pm n\hbar\mathbf{k}$ keeping the same sign during this process, there is no nett 3 momentum transfer as in the lower half of Figure 3.3.3. The probability of these two processes is identical, and we will use this same probability for spin 2 graviton probability densities when looking at gravity which Einstein showed is not a force, as particles simply follow geodesics in the warped spacetime surrounding any mass. For all the two way transitions at both vertices, similar to those discussed above, the following is true:

Probability of all transitions similar to $\psi_5 \rightleftarrows \psi_6$ is equal in either direction. (3.3.7)

As we are looking at virtual interactions between fermions and bosons we will use subscripts *a* for spin ½ and *b* for spins 1 and 2 superpositions in what follows.

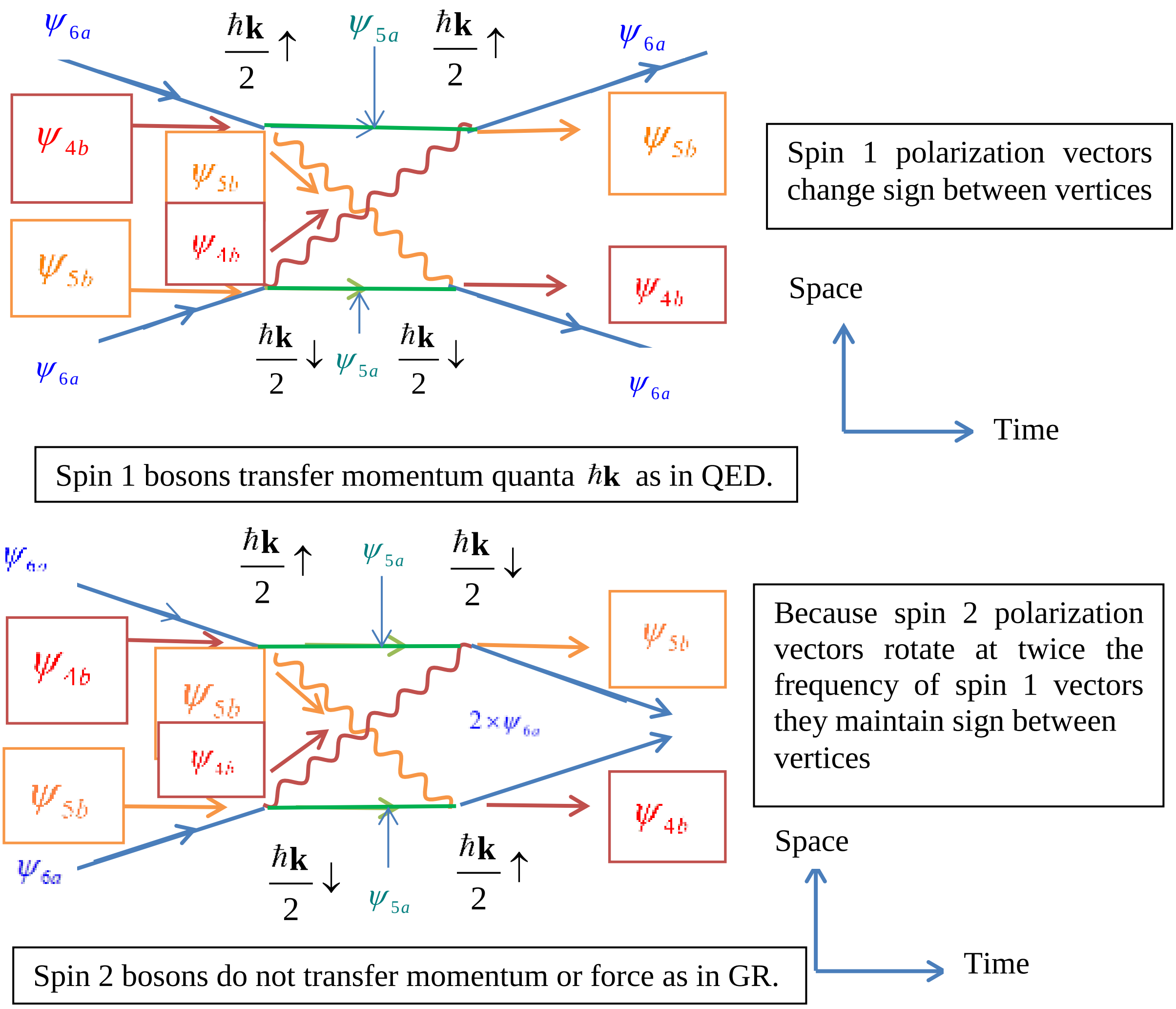


Figure 3.3.3 Covariant interaction (as in Eq. (3.3.4) and Figure 3.3.1) between fermion (subscript a) and boson (subscript *b* and in boxes) eigenfunctions, with spin 1 photons in the top diagram, and spin 2 gravitons in the bottom diagram. Orange and magenta are used for bosons, blue and green for spin 1/2 to help identify the transitions at each of the four

spacetime corners. This is one process, but a superposition of two diagonal components splitting the 3 momentum $\hbar\mathbf{k}$ equally. Momentum is transferred in the spin 1 case only, but real spin 2 gravitons however, as in gravitational waves from rotating binary pairs for example, do carry energy and momentum,

We can think of the interactions in both the top and bottom of Figure 3.3.3 as a spacetime rectangle. Starting with the top left corner, the key factors are the superposition component/member amplitudes $c_{6a}\,\&\,c_{4b}$, then proceeding clockwise (the order is irrelevant) $c_{5a}\,\&\,c_{4b}$, $c_{5a}\,\&\,c_{5b}$, and finally $c_{6a}\,\&\,c_{5b}$. As this is part of one process, we can rearrange all terms and multiply them to get $(c_{4b}*c_{4b})(c_{5b}*c_{5b})(c_{6a}*c_{6a})(c_{5a}*c_{5a})$.
Putting $P_{4b}=c_{4b}*c_{4b}, P_{5a}=c_{5a}*c_{5a}$etc.

$$(c_{4b}*c_{4b})(c_{5b}*c_{5b})(c_{6a}*c_{6a})(c_{5a}*c_{5a})\equiv P_{4b}P_{5b}P_{6a}P_{5a} \tag{3.3.8}$$

However, our superposition members (ψ_{nk} shortened to ψ_n) are all Eigenfunctions with Eigenvalues $\mathbf{p}_{nk}^2=n^2\hbar^2k^2$ having equal probabilities of momentum vectors $\mathbf{k}$ pointing in opposite directions, as in Eq.(3.3.**7**) and the following paragraph. Thus, we can interchange the red and orange boson $\psi_{4b}\,\&\,\psi_{5b}$ and also the blue and green fermion $\psi_{5a}\,\&\,\psi_{6a}$ in Figure 3.3.3 with no change in exchanged momentum. These four possibilities increase the amplitude factor for this group by four, so that (if all other factors are one) Eq. (3.3.**8**) becomes:

$$2^2(c_{4b}*c_{4b})(c_{5b}*c_{5b})(c_{6a}*c_{6a})(c_{5a}*c_{5a})\equiv 4P_{4b}P_{5b}P_{6a}P_{5a} \tag{3.3.9}$$

But there are four different groups of four Eigenfunctions **A, B, C & D** as in Figure 3.3.4 below, and we have only been considering group **C** above.

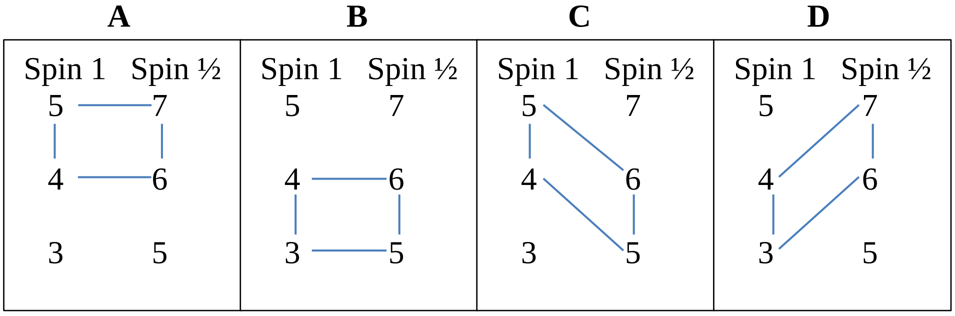


Figure 3.3.4 Interaction between the four Eigenfunction groups A, B, C and D

Using Eq. (3.3.**9**), if all other factors are one the amplitudes for the groups in Figure 3.3.4 are:

$$\begin{aligned}
A &= 4(c_{4b}*c_{4b})(c_{5b}*c_{5b})(c_{6a}*c_{6a})(c_{7a}*c_{7a}) = 4P_{4b}P_{5b}P_{6a}P_{7a} \\
B &= 4(c_{3b}*c_{3b})(c_{4b}*c_{4b})(c_{6a}*c_{6a})(c_{5a}*c_{5a}) = 4P_{3b}P_{4b}P_{6a}P_{5a} \\
C &= 4(c_{4b}*c_{4b})(c_{5b}*c_{5b})(c_{6a}*c_{6a})(c_{5a}*c_{5a}) = 4P_{4b}P_{5b}P_{6a}P_{5a} \\
D &= 4(c_{3b}*c_{3b})(c_{4b}*c_{4b})(c_{6a}*c_{6a})(c_{7a}*c_{7a}) = 4P_{4b}P_{5b}P_{6a}P_{7a}
\end{aligned} \tag{3.3.10}$$

These amplitudes are all numbers as $P_{4b}=c_{4b}*c_{4b}, P_{5a}=c_{5a}*c_{5a}$etc. are just probabilities. But we can perhaps imagine these numbers as in the complex plane. From section 2.2.2 and

Figure 3.1.4, however, the three eigenfunctions forming each of the interacting particles are born simultaneously. It would thus seem reasonable to assume that the amplitudes of each group of three eigenfunctions have the same complex phase angle. So whether they are in the complex plane or not, provided they are all at the same angle we can get the overall probability of this virtual exchange by simply adding the four amplitudes *A,B,C&D* from Eq. (3.3.**10**) and squaring the total to get:

$$\begin{aligned}
&\text{Overall interaction probability if all other factors are one } =(A+B+C+D)^2 \\
&\qquad =16\left[P_{4b}P_{5b}P_{6a}P_{7a}+P_{3b}P_{4b}P_{6a}P_{5a}+P_{4b}P_{5b}P_{6a}P_{5a}+P_{3b}P_{4b}P_{6a}P_{7a}\right]^2 \\
&\qquad =16\left[P_{4b}(P_{3b}+P_{5b})\right]^2\left[P_{6a}(P_{5a}+P_{7a})\right]^2
\end{aligned} \tag{3.3.11}$$

Using different colours again for common terms in each of the equations following and then using $c_{3b}{*}c_{3b}+c_{4b}{*}c_{4b}+c_{5b}{*}c_{5b}=c_{5a}{*}c_{5a}+c_{6a}{*}c_{6a}+c_{6a}{*}c_{6a}=1$ the interaction probability is

$$(A+B+C+D)^2=2^4\left[c_{4b}{*}c_{4b}(1-c_{4b}{*}c_{4b})\right]^2\left[c_{6a}{*}c_{6a}(1-c_{6a}{*}c_{6a})\right]^2 \tag{3.3.12}$$

We have assumed to here that all other amplitude factors are one. However at each vertex there are both fermion and boson superposition probabilities from Eq. (2.2.4). *Writing the superposition probability at each vertex* $sN\cdot dk/k$ *as* $s_{1/2}N_1dk/k,\ s_1N_2dk/k$ for clarity where spin $1=s_1$, $N=1$ is N_1 etc. Including these factors (if all other factors are one) in Eq. (3.3.12) our overall probability at wavenumber k is

$$\left[\frac{2s_{1/2}N_1c_{6a}{*}c_{6a}(1-c_{6a}{*}c_{6a})}{k}\right]^2\left[\frac{2s_1N_2c_{4b}{*}c_{4b}(1-c_{4b}{*}c_{4b})}{k}\right]^2$$

$$=\frac{\left[2s_{1/2}N_1c_{6a}{*}c_{6a}(1-c_{6a}{*}c_{6a})\right]^2\left[2s_1N_2c_{4b}{*}c_{4b}(1-c_{4b}{*}c_{4b})\right]^2}{(k)^4}.$$

The momentum per transfer is a total of $\pm\hbar\mathbf{k}$ and using Eqs. (3.3.5), (3.3.6) &

$(\pm\hbar\mathbf{k})^4=q^4$ then putting $\hbar=1$ the interaction probability is

$$\frac{\left[2s_{1/2}N_1c_{6a}{*}c_{6a}(1-c_{6a}{*}c_{6a})\right]^2\left[2s_1N_2c_{4b}{*}c_{4b}(1-c_{4b}{*}c_{4b})\right]^2}{q^4} \tag{3.3.13}$$

This is the scalar interaction probability between two spin ½ fermions exchanging infinitesimal rest mass spin 1 bosons at very large spacings, where the fermions are effectively spin zero, imagining them as bare charges and all other factors being one. When exchanging spin 2 infinitesimal rest mass time polarized gravitons (as in the bottom half of Figure 3.3.3 with no 3 momentum) we can simply keep using wavenumber k in the denominator for the interaction probability between fermions and gravitons. If all other amplitude factors are one this interaction probability becomes (using subscript c for spin 2 and $N=2=N_2$ for clarity):

$$\frac{\left[2s_{1/2}N_1c_{6a}*c_{6a}(1-c_{6a}*c_{6a})\right]^2\left[2s_2N_2c_{4c}*c_{4c}(1-c_{4c}*c_{4c})\right]^2}{k^4} \text{ gravitons \& fermions.} \quad (3.3.14)$$

And if, for example, two spin 1 photons exchange spin 2 gravitons (all infinitesimal rest mass with $N=2=N_2$) the interaction probability if all other amplitude factors are one becomes

$$\frac{\left[2s_1N_2c_{4b}*c_{4b}(1-c_{4b}*c_{4b})\right]^2\left[2s_2N_2c_{4c}*c_{4c}(1-c_{4c}*c_{4c})\right]^2}{k^4} \text{ for } N=2 \text{ photons.} \quad (3.3.15)$$

If two massive $N=1$ photons (as in Figure 3.3.2) exchange spin 2 gravitons the interaction probability if all other factors are one becomes

$$\frac{\left[2s_1N_1c_{5b}*c_{5b}(1-c_{5b}*c_{5b})\right]^2\left[2s_2N_2c_{4c}*c_{4c}(1-c_{4c}*c_{4c})\right]^2}{k^4} \text{ for } N=1 \text{ photons.} \quad (3.3.16)$$

According to GR (section 1.2.2) the emission of gravitons is identical for both mass and energy. Keeping all other factors (such as mass/energy) in Eqs. (3.3.14), (3.3.15) and (3.3.16) constant, the graviton interaction probabilities must be the same in each. We can thus put them equal to each other and cancel out all the common red terms on the RH sides above:

$$2s_1N_2c_{4b}*c_{4b}(1-c_{4b}*c_{4b})=2s_1N_1c_{5b}*c_{5b}(1-c_{5b}*c_{5b})=2s_{1/2}N_1c_{6a}*c_{6a}(1-c_{6a}*c_{6a})$$

or

$$\underset{N=2 \text{ Spin } 1}{4c_{4b}*c_{4b}(1-c_{4b}*c_{4b})} = \underset{N=1 \text{ Spin } 1}{2c_{5b}*c_{5b}(1-c_{5b}*c_{5b})} = \underset{N=1 \text{ Spin } 1/2}{c_{6a}*c_{6a}(1-c_{6a}*c_{6a})} \quad (3.3.17)$$

In this special case as in Eq. (3.3.**4**) we have shown that the time polarized interaction probabilities are the same whether 3 momentum is exchanged or not, and this equation for the above ratios is identical for both virtual spin 2 graviton and virtual spin 1 photon exchanges. Ignoring complex numbers for simplicity, we can use either 4 momentum q or wavenumber k interchangeably. Now assume that all other factors (other than coupling constants) are one, and remember that we are simplifying with a thought experiment by looking at spin ½ superpositions sufficiently far apart so we can treat them as approximately spherically symmetric or effectively spin zero, even if they are supposed to be bare charges with spin. Under these same scalar exchange conditions QED says that with electrons, for example:

The probability of scalar spin one photon exchange in Eq. (3.3.13) $=\dfrac{4\alpha^2}{q^4}$. (3.3.18)

(This probability is for one momentum k direction only, but the mode density of these is k^2dk/π^2. *We can perhaps think of* $\dfrac{4\alpha^2}{k^4}\cdot\dfrac{k^2dk}{\pi^2}=\left(\dfrac{2\alpha}{\pi k}\right)^2 dk$ *as an imaginary emission probability* $\dfrac{2\alpha}{\pi}\dfrac{dk}{k}$, *multiplied by an imaginary absorption probability* $\dfrac{2\alpha}{\pi}\dfrac{dk}{k}$ *in all possible directions.*

The rest of this paper is mainly about virtual particles which cannot be experimentally detected. However, as we will see, imaginary probability densities can have real world consequences. This is similar to our postulated infinite virtual superpositions being undetectable, but the particles they generate can certainly be experimented on in the real world.

This paper uses these imaginary probabilities throughout, as it allows a very simple approximate way to look at gravity using only very long wavelength time polarized gravitons. We demonstrate how it works in the next section on electromagnetic energy between charges.

Let us now temporarily ignore the fact that gluons have limited range and imagine our thought experiment applying to colour charges exchanging gluons. The α of Eq. (3.3.18) becomes the usual colour coupling α_3. To get the fundamental coupling ratio labelled as $\chi_C = \alpha_3^{-1}$ $@ k_{cutoff}$ we substitute the α of Eq. (3.3.18) with $\alpha = \chi_C^{-1}$ as we assumed $\alpha_3(\text{Primary}) = 1$. Substituting $2s_{1/2} = 1,\ 2s_1 = 2,\ N_1 = 1\ \&\ N_2 = 2$ and equating Eqs. (3.3.13) & (3.3.18)

$$\frac{\left[c_{6a} * c_{6a}(1 - c_{6a} * c_{6a})\right]^2 \left[4c_{4b} * c_{4b}(1 - c_{4b} * c_{4b})\right]^2}{q^4} = \frac{4(\chi_C^{-1})^2}{q^4}$$
$$\left[c_{6a} * c_{6a}(1 - c_{6a} * c_{6a})\right]\left[4c_{4b} * c_{4b}(1 - c_{4b} * c_{4b})\right] = 2\chi_C^{-1} \qquad (3.3.19)$$

But from Eq. (3.3.17) the blue and green terms are equal (also the magenta terms) and we can solve for the fundamental coupling ratio by combining Eqs. (3.3.17) & (3.3.19).

$N = 2$ Spin 1	$N = 1$ Spin 1	$N = 1$ Spin 1/2	(3.3.20)
Photons or Gluons	Massive Photons	Fermions	

$$4c_{4b} * c_{4b}(1 - c_{4b} * c_{4b}) = 2c_{5b} * c_{5b}(1 - c_{5b} * c_{5b}) = c_{6a} * c_{6a}(1 - c_{6a} * c_{6a}) = \sqrt{2/\chi_C}$$

The coupling ratio is fundamentally the same for colour and electromagnetism apart from the six primary electric charges of Eq. (3.3.1) because of the way electric charge is defined. Equations (3.3.17), (3.3.19) & (3.3.20) tell us that for any interactions between two superpositions, the inverse coupling ratio always involves the product of the central superposition member probability by the probability of the other two members combined $\times N \times \text{spin}$ of the first superposition, times the equivalent product for the other superposition. In section 4 in **[24]** we introduce gravity and solve these ratios. Despite all the simplifications and lack of rigour, the above equations are surprisingly consistent with the SM, provided there are only three families of fermions.

4 CP Symmetry and the Matter-antimatter Imbalance

When we drew **Figure 3.3.3** we assumed equal time intervals for the diagonal terms, but this is only approximately true. Using Equ's, (3.1.11)and (3.1.12):

$$K_{nk} = \beta_{nk}\gamma_{nk} = \frac{n\hbar k\sqrt{2s}}{2m_0 c} = \frac{\bar{\lambda}_C nk\sqrt{2s}}{2}$$ and in terms of K_{nk}: $\beta_{nk}^2 = \frac{K_{nk}^2}{1+K_{nk}^2}$ & $\gamma_{nk}^2 = 1+K_{nk}^2$ so that

$\beta_{nk} \approx 1$ when $K_{nk} >>>> 1$. with $\beta_{nk} \approx 1$ for most values of wavenumber k when exchanging photon superpositions in electromagnetic interactions. However when wavenumber $k = k_{\min}$, the expectation value $\langle K_{nk} \rangle = 1$ (see section 6.2 in **[24]**), and the expectation value of spin 1 photons is $\langle n \rangle \approx 3.98$ (Table 4.3.1 in **[24]**), so that the velocity ratio of the diagonal $n = 4$ and $n = 5$ terms is very approximately $\sqrt{\frac{5}{4}}$ using the above equations, with a similar ratio of the elapsed times. As $k_{\min}$ is approximately inverse to the horizon radius ($\approx 10^{61}$ Planck lengths now), any experiments in this current era will almost certainly show mirror symmetry if the time axis is reversed (unless the interacting wavenumbers are close to $\approx 10^{-61} Lp$.) However, when matter and anti-matter were forming, the horizon radius was about $\approx 10^{16}$ times smaller, and $k_{\min} \approx 10^{16}$ times larger. The diagonal terms, and the time elapsed in these very early era photon exchanges between electrically charged particles, may not have shown mirror symmetry, which Sarkarov demonstrated in 1967 is linked with the matter-antimatter imbalance **[25].**

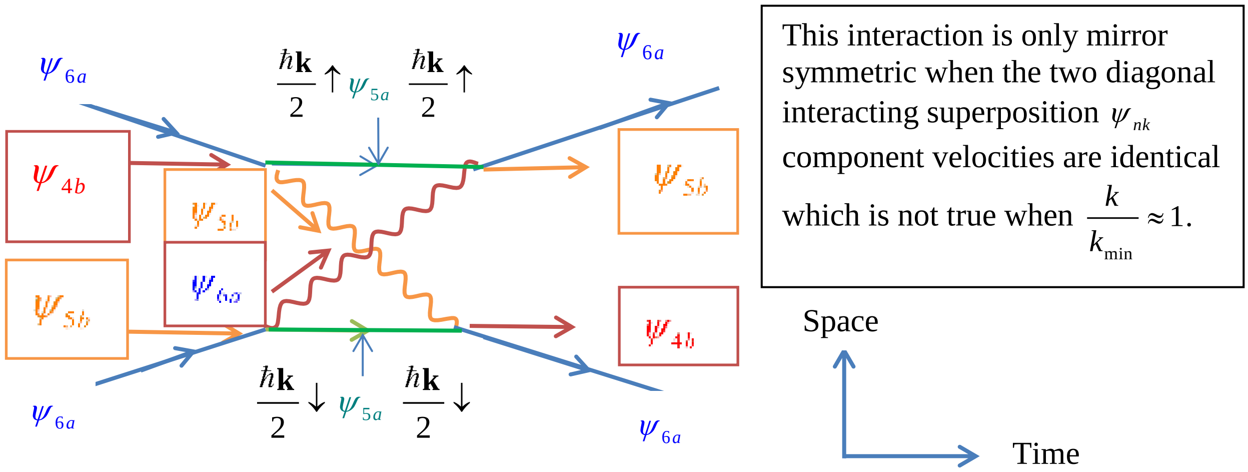


Figure 4.1 Covariant interaction (as in Eq. (3.3.4) and Figure 3.3.3) between fermion (subscript a) and photons (subscript b and in boxes) eigenfunctions. Orange and magenta are used for bosons, blue and green for spin 1/2 to help identify the transitions at each of the four spacetime corners. This is one process, but a superposition of two diagonal components splitting the 3 momentum $\hbar\mathbf{k}$ equally.

5 Conclusions

In the full previous paper building the SM fundamental particles from infinite superpositions [24] we found that they all had to have an infinitesimal mass that was always approximately inverse to the causally connected (or observable) horizon radius R_{OH}.

This infinitesimal mass requires an infinitesimal change to GR:

$$G_{\mu\upsilon} = R_{\mu\upsilon} - \frac{1}{2} g_{\mu\upsilon} R = \frac{8\pi G}{c^4}\left[T_{\mu\upsilon}(\text{Local}) - T_{\mu\upsilon}(\text{Average})\right] = \frac{8\pi G}{c^4} T'_{\mu\upsilon}.$$

In large regions of space the average values of $T'_{\mu\upsilon} \equiv 0 \equiv G_{\mu\upsilon}$. Space is flat and the Freidman equation components average zero. QM controls the expansion of space regardless of Ω. with or without inflation.

Intergalactic voids have $T_{\mu\upsilon}(\text{Local}) < T_{\mu\upsilon}(\text{Average})$ with negative $G_{\mu\nu}$ and $R_{\mu\nu}$.

This paper shows that these infinitesimal masses could well relate with the matter-antimatter anomaly, especially as these inifinitesimal masses were much larger when matter was forming not long after the big bang and the observable radius was still very small.

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