Part II
Chapter 11

$r<r_H$ Application implies Cosmology

9.1 $r<r_H$ Application of Equation 1.9 Using Sections 3.4 and 9.2 Results

Here we multiply section 1.3 chain rule result $p\psi=-i\partial\psi/\partial x$ by ψ^* and integrate over volume to define the expectation value:

$$\int\psi^* p_x\psi dV \equiv \langle p_x\rangle=\langle p,t|p_x|p,t\rangle \text{ of } p_x. \qquad (11.1)$$

In general for any QM operator A we write $\langle A\rangle=\langle a,t|A|a,t\rangle$. Let A be a constant in time (from Merzbacher, pp.597). Taking the time derivative then:

$$i\hbar\frac{d}{dt}<a,t\,|\,A\,|\,a,t>=i\hbar\frac{d}{dt}<\Psi(t),A\Psi(t)>=\left(\Psi(t),Ai\hbar\frac{\partial}{\partial t}\Psi(t)\right)-\left(i\hbar\frac{\partial}{\partial t}\Psi(t),A\Psi(t)\right)$$

$$=\left(\Psi(t),AH\Psi(t)\right)-\left(\Psi(t),HA\Psi(t)\right)=i\hbar\frac{d}{dt}<A>=<AH-HA> \quad \equiv[H,A]$$

In the above equation let $A=\alpha$, from equation 1.9 Dirac equation Hamiltonian H, $[H,\alpha]=i\hbar\, d\alpha/dt$ (Merzbacher, pp.597).

The second and first integral solutions to the Heisenberg equations of motion (i.e., above $[H,\alpha]=i\hbar\, d\alpha/dt$) is: $\mathbf{r}=\mathbf{r}(o)+c^2\mathbf{p}/H+(\hbar c/2iH)[e^{(i2Ht/\hbar)}-1](\alpha(0)-c\mathbf{p}/H)$. (11.2)

$$\mathbf{v}(t)/c=c\mathbf{p}/H+e^{(i2Ht/\hbar)}(\alpha(0)-c\mathbf{p}/H)$$

In the QM operator formulation of R_{ij} the equation 9.2 zitterbewegung oscillation makes GR **un**gauged since the harmonic gauge in $R_{ij}=0$ can be replaced with the zitterbewegung oscillation of equation 9.2 as in section 25.7. Also taking the bilinear operator expectation values of equation 9.2 (and the rest of the $R_{ij}=0$ equations) gives us the Maxwell equations in the weak field approximation (section 25.4) with the excess above coulomb potential giving the lamb shift after energy expectation values are taken for the $\psi_{2,0,0}$ eigenstates. After taking expectation values $\psi^*\psi=e^{-i\omega t}\psi^*(r,\theta,\phi)e^{i\omega t}\psi(r,\theta,\phi)=|\psi(r,\theta,\phi)|^2$ the time dependence of the zitterbewegung goes away, becomes random for the observer, as in the standard QM (but with our Maxwell equations 17.2 and Ungauged GR of section 12.3 still holding). Note also from equations 18.1, 18.2 that:

$$(dt/ds)\sqrt{\kappa_{oo}} = 1/\sqrt{\kappa_{oo}} \qquad (11.3)$$

is where the energy was in the old Dirac equation. Thus $\langle H\rangle=E=1/\sqrt{g_{oo}}$ (with $g_{oo}=1-r_H/r$) the imaginary part of ω *outside* ($r>r_H$) becomes the real part *inside* ($r<r_H$) the horizon since the square root of a negative number (here g_{oo}) is imaginary. Thus $\omega\to i\omega$ and so the above complex conjugation does not occur and so there is "observed" motion (for $r<r_H$) with $e^{\omega t}-1$ below in equation 1.9. Taking $\omega\to i\omega$ and the real part of r in equation 9.2 (setting r(0)=0, p=0) gives us the physics inside:

$$[(r(o)+c^2p/H+(\hbar c/2iH)[e^{(i2Ht/\hbar)}-1](\alpha-cp/H)]=(\hbar c/2iH)[e^{(i2Ht//\hbar)}-1]\alpha$$

Thus with above $\omega\to i\omega$ (in eq.9.2) as we go inside the horizon then this equals

$$= (c/ii2\omega)[e^{(ii2\omega t)}-1]\alpha=[(c/2\omega)[e^{2\omega t}-1]\alpha=r \qquad (11.4)$$

with the e^{kt} dependence of r consistent with equation 1.14.

Chapter 12

12.1 r<r_H $e^{\omega t}$ -1 Coordinate transformation of $Z_{\mu\nu}$: Gravity Derived

In that regard the Heisenberg equations of motion give $e^{i\omega t}$ oscillation (zitterbewegung) both for velocity and position so we use the classical harmonic oscillator probability distribution in a 2D with 1D of radial center of mass of the zitterbewegung cosine oscillation lobe. So the COM (linear) is: x_{cm}= (∑xm)/M = $\int_0^{\pi/2} x\cos x dx/1 = 0.5708$. As a fraction of r_m we have .5708/π/2=.3634=1/2.751 (12.1)
from the r_M=λ_M/2= h/(2m_ec) (i.e.,half Compton λ for radius change) and from equation 11.4. The Hubble time and Hubble constant are not actually measured locally but at around ~30MLY out introducing about a 30/13700 X100=.22% percent error in the local Hubble time. This translates to about a 1.45% error for the T in ω_{M+1} for large value t in the derivative of sinh(ωt(1+.0022)) =ωcoshωt(1+.0022)). Using one plausible value of H_t=**13.8bY** we then find the nonlocal measurement correction to be 13.8X(1+.0145) ≈14X10^9 years. Also from the third term in equation 11.4 the zitterbewegung amplitude:
r_M=λ_M/2= h/(2m_ec)=6.63X10^{-34}/(2X9.11X10^{-31}X3X10^8)=1.213X10^{-12} m. So
r_M/2.751m_ec= 2π 1.93X10^{-13}/(2.751X9.11X10^{-31}X3X10^8)=1.615X10^9.
Using $S_{1/2}$ state of equation 2.6. ε=.06006=m_μ+m_e
e^2/2(1+ε)m_p=9X10^9(1.6X10 $^{-19}$)^2/2(1+ε)1.67X10^{-27} =0.06515
Note from equation 2.6a the 2(1+ε)m_p in the denominator for this S state.

Also cosh(0)=1 (12.2)

To find the physical effects of the equation 11.4 expansion *we must* do a dyadic radial coordinate transformation (equation 11.4) on this single charge horizon (given numerical value of the Hubble constant H in determining its rate) in eq.4.2. In doing the time derivatives we take the ω as a constant in the linear t limit:

$\frac{\partial x^\alpha}{\partial x'^\mu}\frac{\partial x^\beta}{\partial x^{\nu}{}'}Z_{\alpha\beta} = Z'_{\mu\nu}$ with in particular Z_{oo}→Z'_{oo}≡Z_{oo}+z_{oo} (12.3)

After doing this Z'_{oo} calculation the resulting (small) z_{oo} is set equal to the Einstein tensor gravity source ansatz G_{oo}=8πG(2(1+ε)$m_p c^2$/c^4 for this *single* charge source 2(1+ε)$m_p c^2$ (from eq.2.6a) allowing us to solve for the value of the Newtonian gravitational constant G here as well. We have then derived gravity for **all** mass since this single charged m_e electron vacuum source composes all mass on this deepest level as we noted in the section 4.2 discussion of the equivalence principle. Note Lorentz transformation similarities in section 2.3 between r=r_o+Δr and ct=ct_o+cΔt using
$D\sqrt{1-v^2/c^2} \approx D(1-\Delta)$ for v<<c with just a sign difference (in 1-Δ, + for time) between the time interval and displacement D interval transformations. Also the t in equation 10.2 and therefore 12.3 is for a light cone coordinate system (we are traveling near the speed of light relative to t=0 point of origin) so c^2dt^2=dr^2 and so equation 11.4 does double duty as a r=ct time x_o' coordinate. Also note we are trying to find G_{oo} (our ansatz) and we have a large Z_{oo}. Also with Z_{rr}<<Z_{oo} we needn't incorporate Z_{rr}. Note from the derivative of $e^{\omega t}$-1 we have slope=($e^{\omega t}$-1)/H_t=ω$e^{\omega t}$. Also from equation 2.4a we have δ(r)=

$\delta(r_o(e^{\omega t}-1))= (1/(e^{\omega t}-1))\delta(r_o)$. Plugging values of equation 12.1 and 12.2 and the resulting equation 10.2 into equation 12.3 we have in 4.3:

$$\frac{8\pi e^2}{m_p c^2}\delta(0)=Z_{00}=R_{00}-\frac{1}{2}g_{00}R,\ \frac{\partial x^0}{\partial X^\alpha}\frac{\partial x^0}{\partial X^\beta}Z_{\alpha\beta}=Z'_{00}=Z_{00}+z_{00}\approx \qquad (12.4)$$

$$\frac{\partial x^0}{\partial\left[x^0+\frac{r_M}{2.751}[e^{\omega t}-1]\right]}\frac{\partial x^0}{\partial\left[x^0+\frac{r_M}{2.751}[e^{\omega t}-1]\right]}Z_{00}=Z'_{00}=$$

$$\left[\frac{1}{\left[1+\frac{r_M\omega_{M+1}}{2.751c}e^{\omega t}\right]}\right]^2\frac{8\pi e^2}{2(1+\varepsilon)m_p c^2}\delta(r)\equiv\left(\frac{8\pi e^2}{2(1+\varepsilon)m_p c^2}\delta(r)+8\pi G\left(\frac{m_e}{c^2}\right)\delta(r)\right).\text{so}$$

setting the perturbation z_{oo} element equal to the ansatz:

$$2\left(-\frac{e^2}{2(1+\varepsilon)m_p}\right)\left(\frac{r_M}{2.751\,c}\right)\omega e^{\omega t}=\left(2\left(-\frac{e^2}{2(1+\varepsilon)m_p}\right)\left(\frac{r_M}{2.751m_e c}\right)\left([e^{\omega t}-1]/H_t\right)\right)\delta(r)=$$

$$2\left(-\frac{e^2}{2(1+\varepsilon)m_p}\right)\left(\frac{r_M}{cm_e 2.751}\right)\left([e^{\omega t}-1]/H_t\right)\left(\delta(r_0)/[e^{\omega t}-1]\right)\delta(r_o)=G\delta(r_0)$$

.

so $2(0.06515)(2\pi 2.57\text{X}10^8)(1.99\text{X}10^{-18}/2\pi) = 6.67\text{X}10^{-11}\ \text{Nm}^2/\text{kg}^2\equiv G$ (12.5)

from plugging in all the quantities in equation 12.4. This new z_{oo} term is the classical $8\pi G\rho/c^2=G_{oo}$ source for the Einstein's equations and we have then **derived gravity** and incidentally also derived the value of the Newtonian gravitational constant since from our postulate the $2m_p(1+\varepsilon)$ eq. 2.6a mass (our "single" postulated source) is the *only* contribution to the Z_{oo} term. Note Dirac equation implies +E and -E solutions for –e and +e respectively and so in equation 12.5 we have $q_1 X q_2$ and when G is put into the Force law there is an additional $m_1 X m_2$ thus the resultant force is proportional to $q_1 X q_2 X m_1 X m_2$ which is always positive and so the gravitational force is always attractive.

To summarize we have then just done a coordinate transformation to the moving frame to find the contributing fields associated with the moving frame. Analogously one does a coordinate transformation to the charge comoving frame to show that current carrying wires have a magnetic field, also a 'new' force, around them. Also note that in the second derivative of eq.11.1 **$d^2r/dt^2 = r_o\omega^2 e^{\omega t}$= radial acceleration.** Thus in equations 10.2 and 12.5 (originating in section 1.4 and thus in equation 1.2b) **we have a simple account of the cosmological radial acceleration expansion** (discovered recently) **so we don't need any theoretical constructs such as 'dark energy' to account for it.**

If r_o is the radius of the universe then $r_o\omega^2\sinh(\omega t)\approx 10^{-10}\text{m/sec}^2=a_M$ is the acceleration of all objects around us relative to a inertial reference frame and comprises a accelerating

frame of reference. If we make it an inertial frame by adding gravitational perturbation we still have this accelerating expansion and so on. Thus in gravitational perturbations na_M=a where n is an integer.
Note below equation 12.5 above that t=13.8X10^9years and use the standard method to translate this time into a Hubble constant. Thus in the standard method this time translates into light years which are 13.8X10^9/3.26 =4.264X10^9 parsecs= 4.264X10^3 megaparsecs assuming speed c the whole time. So 3X10^5km/sec/4.264X10^3 megaparsecs = 70.3km/sec/megaparsec= Hubble's constant for this theory.

12.2 Cosmological Constant In This Formulation

In equation 4.6 r_H/r term is small for $r>>r_H$ (far away from one of these particles) and so is nearly flat space since ε and Δε are small and nearly constant. Thus equation 4.5 can be redone in the form of a Robertson Walker homogenous and isotropic space time. Given (from Sean Carroll) the approximation of a (homogenous and isotropic) Robertson Walker form of the metric we find that:

$$\frac{a''}{a} = -\frac{4\pi G}{3}(\rho + 3p) + \frac{\Lambda}{3}$$

Λ=cosmological constant, p=pressure, ρ=density, a =1/(1+z) where z is the red shift and 'a' the scale factor. G the Newtonian gravitational constant and a" the second time derivative here using cdt in the derivative numerator. We take pressure=p=0 since there is no thermodynamic pressure on the matter in this model; the matter is commoving with the expanding inertial frame to get the a" contribution. The usual 10 times one proton per meter cubed density contribution for ρ gives it a contribution to the cosmological constant of 4.7X10^{-36}/s^2.
Since from equation 12.1 $a=a_o(e^{\omega t}-1)$ then a" = (ω^2/c^2)sinhωt=a(Λ/3)= (Λ/3)sinhωt and there results:
$\Lambda=3(\omega^2/c^2)$
From section 12.1 above then ω=1.99X10^{-18} with 1 year=3.15576X10^7 seconds, also c=3X10^8 m/s. So:
$\Lambda= 3(\omega^2/c^2)$=1.32X10^{-52} /m^2, which is our calculated value of the cosmological constant. Alternatively we could use 1/s^2 units and so multiply this result by c^2 to obtain: 1.19X10^{-35}/s^2. Add to that the above matter (i.e.,ρ) contributions to get Λ=1.658X10^{-35}/s^2 contribution.

12.3 Ungauged Theory

Solve the Heisenberg equations of motion [H,r]=iħdr/dt using the Hamiltonian H of equation 1.9 and get r=(r(o)+c2p/H+(ħc/2iH)[$e^{(i2Ht/\hbar)}$-1](α-cp/H). (9.2). Recall the detailed calculations in chapter 10 above. In the QM operator formulation of $R_{ij}A_j$|a,t> in section 4.3 the zitterbewegung (harmonic oscillation) coordinate system of equation 1.9 has a $\square^2 g_{ii}$ =0 inside the harmonic (gauge) component (see also section 25.7) of R_{ij}. The phase in each sinusoidal zitterbewegung component is unknown so we sum over all such k components to get the zitterbewegung cloud. Thus $\Sigma_k R_{ij} A_j|\psi>$= $\Sigma_k[R_{ij}$(nonharmonic terms)+$\square^2 g_{ii}]A_j|\psi>$=$\Sigma_k[R_{ij}$(nonharmonic terms)+0]A|ψ>. So <ψ|$\Sigma_k R_{ij}$|A|ψ> = <ψ|$\Sigma_k R_{ij}$(nonharmonic terms) +0]A|ψ> with ungauged GR harmonic term still being zero. After taking probability density expectation values $\psi^*\psi=e^{-i\omega t}\psi^*(r,\theta,\phi)e^{i\omega t}\psi(r,\theta,\phi)=|\psi(r,\theta,\phi)|^2$ the time dependence of the zitterbewegung indeed conjugates out, becomes random for the observer, as in the standard QM but with our Maxwell equations and UNgauged GR remaining.in the geometry component in front of the QM operator A in section 4.3. Alternatively the lack of phase information in the zitterbewegung sine wave coming out of equation 10.1 give this random motion cloud result. However from equation 10.2 we see that for the inside observer $r<r_H$ the $\omega\rightarrow i\omega$ and so the above complex conjugation does not occur and so there is "observed" motion (for $r<r_H$) that does move with 1+sinhωt in equation 10.2. Note that there are then no 'gauges' in this theory in any case.

Note in chapter 1 that equations 1.5 are used in section 16.2 to derive Maxwell equations in 4 vector potential form (A_x,A_y,A_z, V). Thus this is the physics of potentials (A,V) that cannot be added to or subtracted from which is also consistent with this being an UNgauged field theory (can't add stuff to 'A' there either). In any case for the Ahranov-Bohm effect there is a lingering nonzero vector potential 'A' outside the B flux tube causing the neutrons moving in those opposite directions around the flux tube to interfere in an anomalous way on the other side. But in the standard theory it is only B that matters and there is very little or no B field in that region. In fact Ahranov-Bohm's successful minimal interaction idea totally neglects the residual B contribution and just adds a plus or minus KAv to the wave number in the phase thereby giving this neutron interference result. Thus you cannot add nontrivial gauge partial derivatives to the 'A' they chose since the phase difference is set by the numerical value of 'A'. Anyway, in the context of this theory at least, the Ahranov Bohm effect is further evidence of the UNgauged aspect of the physics of this new pde. Note also section 21.3 on the covariant *gaugeless* quantization of the electromagnetic field. See 25.6 and 25.9 for more *un*gauged theoretical physics discussion. In any case we have then shown that gauges are not needed anywhere in theoretical physics.

References

Merzbacher, *Quantum Mechanics,* 2^{nd} Ed, Wiley, pp.597

Chapter 13

r<r_H Application: Rotational Selfsimilarity With pde Spin: CP violation

13.1 Fractal selfsimilar spin

The fractal selfsimilarity with the spin in the (new) Dirac equation 1.9 implies a cosmological ambient metric (Kerr metric) rotation as well as in section 2.1. Thus there will be $2ds_t ds_\phi$ rotation metric cross terms with the dt (without the square) implying time T reversal nonconservation and therefore CP *non*conservation since CPT is always conserved. We thereby derive CP nonconservation from first principles. This adds another matrix element of magnitude ~1/3800 (section 16.3) for Kaon decays thus adding off diagonal elements to the CKM matrix.
Or for Kerr rotator use

$$ds^2 = \rho^2\left(\frac{dr^2}{\Delta} + d\theta^2\right) + \left(r^2 + a^2\right)\sin^2\theta d\phi^2 - c^2dt^2 + \frac{2mr}{\rho^2}\left(a\sin^2\theta d\theta - cdt\right)^2, \tag{13.1}$$

$$\rho^2\left(r,\theta\right) \equiv r^2 + a^2\cos^2\theta; \qquad \Delta\left(r\right) \equiv r^2 - 2mr + a^2$$, or

$$ds^2 = dr^2 + dt^2 + 2dtdr + ..$$

In a polarized state ($\theta = 0^\circ, 180^\circ$) in 25.3, 25.25 the off diagonal elements are proportional to $\phi=(\phi+c)e^{-C}$. Thus if the charge e is conjugated (C, e changes sign), if dr changes sign (P, parity changes sign) and dt is reversed (t reversal) then the ds quantity on the left side of equation 1.3 is invariant. But if dr (P) changes sign by itself, or even e and P together (CP) change sign then ds is not invariant and this explains, in terms of our fractal picture, why CP and P are not conserved generally. P becomes maximally nonconserved in weak decays as we saw in above. The degree to which this nonconservation occurs depends on the "a" (in equation 23.1) transfer <final lal initial> (equation 3.2) which itself depends on the how much momentum and energy is transferred from the S_{M+2} to the S_{M+1} fractal scales as we saw in this section. Recall chapter 5 alternative derivation of that new (dirac) equation pde (eq.1.9) **linearization of the Klein Gordon equation**(c=1, $\hbar$=1, m=1, eq.5.5):

$$\left(-\alpha_1 i\frac{\partial}{\partial x_1} - \alpha_2 i\frac{\partial}{\partial x_2} - \alpha_3 i\frac{\partial}{\partial x_3} + \beta\right)\left(-\alpha_1 i\frac{\partial}{\partial x_1} - \alpha_2 i\frac{\partial}{\partial x_2} - \alpha_3 i\frac{\partial}{\partial x_3} + \beta\right) = \tag{13.2}$$

$$-\alpha_1^2\frac{\partial^2}{\partial x_1^2} - \alpha_2^2\frac{\partial^2}{\partial x_2^2} - \alpha_3^2\frac{\partial^2}{\partial x_3^2} + \beta^2 + 2\sum_{\mu=1}^{3}\sum_{\nu=1}^{3}\alpha_\mu\alpha_\nu\frac{\partial}{\partial x_\mu}\frac{\partial}{\partial x_\nu} + 2\sum_{\mu=1}^{3}\beta i\alpha_\mu = -\frac{\partial^2}{\partial t^2}$$. This equals

$= c^2p_1^2 + c^2p_2^2 + c^2p_3^2 + m^2c^4 = E^2$ if the off diagonal elements zero (with 23.3) which is the condition used in the standard Dirac equation derivation of the α s and β. Note that from appendix A that the off diagonal elements $2\sum_{\mu=1}^{3}\sum_{\nu=1}^{3}\alpha_\mu\alpha_\nu\frac{\partial}{\partial x_\mu}\frac{\partial}{\partial x_\nu} + 2\sum_{\mu=1}^{3}\beta i\alpha_\mu$ are equivalent to the off diagonal elements in equation 5.1 (and are corrections to 5.2 in fact) so *are not* zero for parity and CP NONconservation in this context (in a rotating

universe). So in the context of the Dirac equation the CP violation term $e_s(dr)dt \to (dr/ds)(dt/ds) \to pE\chi$ (after division by ds^2). Thus CP violation goes up as the square (pE) of the energy (so should be larger in bottom factories). The section 13.2 below Cabbibo angle calculation (not rotation related however) is an example of how this method can give the values of the other terms in the CKM matrix. They arise from calculation of <Z> between higher order m harmonics.
This section is important in that we see that CP violation is explainable and calculable in terms of perturbative effects on the ambient metric (and therefore the Dirac equation) of a rotating universe with nearly complete inertial frame dragging (section 22.1 in the E&M form), CP violation doesn't need yet more postulates as is the case with the GSW model. In fact the whole CKM matrix is explainable here as a consequence of this perturbation.

Note the orientation relative to the cosmological spin axis is important in CP violation. Integration of the data over a 3 month time (at time intervals separated by a sidereal day) is going to yield different CP violation parameters than if integration is done over a year.

Chapter 14

14.1 **Potential Energy Formulation in** $E^2=p^2c^2+m_o^2c^4$

(From 104.10, 105.9, Sokolnikov, Tensor Analysis, 2nd Ed. Wiley) we have $dt/ds=1/g_{oo}$. Also from the first term in equation 18.1 we can compare the location of the energy E term in the ordinary Dirac equation with equation 18.1 and find that $E=(dt/ds)\sqrt{g_{oo}}$ $=(1/g_{oo})\sqrt{g_{oo}}=1/\sqrt{g_{oo}}$ with $g_{oo}=1-r_H/r$

From the energy component of polarized representation of equation 18.1, 18.2: and using iterated (as in bosonic) section 19.13 $E^2=p^2c^2+m^2{}_oc^4$ =

$$E^2=\left(\frac{1}{\sqrt{g_{oo}}}\right)^2=\frac{1}{1-\frac{r_H}{r}}=\frac{r}{r-r_H}=\frac{r}{r-r_H}-\frac{r-r_H}{r-r_H}+1=\frac{r_H}{r-r_H}+1=\text{V+k} \qquad (14.1)$$

Note the resemblance of $E^2=p^2c^2+m^2{}_oc^4$ to the Schrodinger equation if the $E^2=k+1/(r-r_H)$ of equation 14.1 is substituted into it. The system can then be treated as nonrelativistic even if the internal electron motion is ultrarelativistic. This is the reason that the Schrodinger equation can be used as the starting point of nuclear shell model calculations. The Proca equation comes out of this formulation for spin 1 field also. We use the equation 14.1 integer spin source and proceed in the usual way of Bjorken and Drell [13] to construct the one vertex S matrix for the triplet state (spin= ½ + ½) Dirac equation but for integer spin sum. The results are those of a radially displaced Schrodinger equation Hydrogen atom. This V is an application to the chapter 6 alternative $\Sigma(1/r)^n$ geometric series expansion method if by mistake a gauge is added.

Also if we iterate equation 1.9 (square it) in the form of the separated 'r' dependence of 18.1 and 18.2 we also get 14.1 nonzero positive integer spin Proca Equation and the chapter 15 and chapter 16 results.

Chapter 15

$r>r_H$ Application: New Potential in New PDE Implies No Running Coupling Constant

15.1 No Need for a Running Coupling Constant

If the Coulomb V= α/r is used for the coupling instead of $\alpha/(k_H-r)$ (Equation 14.1) then we must multiply α in the Coulomb term by a floating constant (K) to make the coulomb V give the correct potential energy. Thus if an isolated electron source is used in Z_{00} we have that $(-K\alpha/r)=\alpha/(k_H-r)$ to define the running coupling constant multiplier "K". The distance k_H corresponds to about $d=10^{-18}m=ke^2/m_\tau c^2$, with an interaction energy of approximately $hc/d=2.48X10^{-8}$joules= 1.55TeV. For 80 GeV, r≈20 (≈1.55Tev/80Gev) times this distance in colliding electron beam experiments, so $(-K\alpha/r)= \alpha/(r_H-r)$ $=\alpha/(r(1/20)-r)$)= $-\alpha/(r(19/20))=(20/19)\alpha/r$ $=1.05\alpha/r$ so K=1.05 which corresponds to a $1/K\alpha\equiv1/\alpha'\approx130$ also found by QED (renormalization group) calculations of (Halzen, Quarks). Therefore we can dispense with the running coupling constants, higher order diagrams, the renormalization group, adding infinities to get finite quantities; all we need is the correct potential of equation 4.1.

Note that the $\alpha'=\alpha/(1-[\alpha/3\pi(\ln\chi)]$ running coupling constant formula (Faddeev, 1981)] doesn't work near the singularity (i.e., $\chi\approx e^{3\pi/\alpha}$) because the constant is assumed small over all scales (therefore there really *is no formula to compare* $\alpha/(r-r_H)$ to over all scales) but this formula works well near $\alpha\sim1/137.036$ which is where we used it just above.

Chapter 16

New Potential And Therefore New S Matrix and ε Expectation Value

16.1 Weak Field Equations

Note in the Heisenberg equations of motion application that the phase in A_μ (required for the quantization, ch.20) goes as phase =kx+ωt. We adopt an ansatz (equation 10.1) $g_{oo}=e^{iAo}$ (or the Fourier series sum). Also recall from equation 1.7 that $g_{oo}g_{rr}$ is a constant. So we can do the equation 1.3 variation with respect to time (and not r) just as in classical Hamiltonian theory. So from equation 3.5 we have $\delta(g_{oo}g_{rr})=0=(\partial(g_{oo}g_{rr})/\partial t)dt=((\partial g_{oo}/\partial t)g_{rr})dt+((\partial g_{rr}/\partial t)g_{oo})dt=((g_{oo}\partial iA_o/\partial t)g_{rr})dt+(g_{rr}\partial iA_r/\partial r)(dr/dt)g_{oo}dt=(g_{oo}(\partial iA_o/\partial t)g_{rr}dt+(g_{rr}(\partial iA_r/\partial r)cg_{oo}dt$. Multiplying both sides by $1/cg_{oo}g_{rr}idt$ gives us:

$$\partial A_o/c\partial t+\partial A_r/\partial r=0 \qquad (16.1)$$

But from the weak field equation 4.11b:

$$A_o\rightarrow A_oe^{i\omega t}\rightarrow A_oe^{i(\omega t\text{-}kr)} \qquad (16.2)$$

for observer motion v (with kr α vt) and so each g_{oo} and g_{rr} obeys a wave equation in t $\partial^2g_{ii}/c^2\partial t^2-\partial^2g_{ii}/\partial r^2=0$. For example in free space: $g_{oo}\partial^2A_o/c^2\partial t^2-g_{oo}\partial^2A_o/\partial r^2=0$ and $g_{rr}\partial^2A_r/c^2\partial t^2-g_{rr}\partial^2A_r/\partial r^2=0$ or

$$\partial^2A_o/c^2\partial t^2-\partial^2A_o/\partial r^2=0 \quad \text{and} \quad \partial^2A_r/c^2\partial t^2-\partial^2A_r/\partial r^2=0 \qquad (16.3)$$

So we have the (Lorentz gauge, Pugh, pp.270) weak field formulation of the free space E&M (spin 1) Maxwell equations in 2D and can generalize to 4D as before. We replace r in equation 16.3 with x, y, z in succession and so get $A_o=A_{ox}$, $A_o=A_{oy}$, $A_o=A_{oz}$ and redefine $A_o\equiv A_{ox}+A_{oy}+A_{oz}$. So add up the resulting equations to obtain:
$\partial(A_{ox}+A_{oy}+A_{oz})/c\partial t+\partial A_x/\partial x+\partial A_y/\partial y+\partial A_z/\partial z=0=\partial A_o/c\partial t+\partial A_x/\partial x+\partial A_y/\partial y+\partial A_z/\partial z$
Apply Heisenberg's equations of motion to x,y,z motion as well and then get the usual Lorentz gauge form of the Maxwell's equations in the usual x,y,z coordinates.
We use the Heisenberg's equations of motion again on the r in 16.5 for the new Hamiltonian generated by the spin 1 momentum p of equation 16.3. Note the ps are proportional to the mass times π, Mπ in eq.16.3. The real part of the phase is then $r\rightarrow r+r_o\cos(KMt)=r+r_o\cos(KMt)=\omega t+kr+r_o(1-(KMt)^2/2)+..$(neglecting the much smaller dt^3 term here) in $\Box^2A_\mu=0$ (eq.16.3). The D'Alembertian second derivative of t^2 with respect to t is a constant so this gives rise to the Proca equation:

$$\Box^2A_\mu+((KM)^2A_\mu \qquad (16.4)$$

=massive spin 1 particle (the W). See also section 25.4. If ϕ=0 in equation 16.4 (so M=0) we are back to the old Maxwell equation 16.4 spin 1 massless field. Thus we have derived both the Proca equation for spin 1 mass M of eq.16.4 and the Maxwell equations for the allowed ϕ=0, M=0 case of 16.3.

16.2 r>r_H Application: New Potential V in New PDE Implies New S Matrix with W and Z as Resonances. Find Expectation Value of ε In W Region

We use the equation 14.1 source and proceed in the usual way of Bjorken and Drell (here $1/r\rightarrow1/(r-k/2)$ to construct the one vertex S matrix for the new Dirac equation 1.9. Recall the ½ came from the square root in equation 14.1. Thus the k in the integrand denominator is found from the result of our $V=-1/(r-r_H/2)$ potential in equation 14.1 instead of the usual Coulomb potential 1/r in the large r limit.

$$S_{if} \equiv iZ\frac{1}{V}\sqrt{\frac{m^2}{E_f E_i}}\bar{u}(p_f,s_f)\gamma^o u(p_i,s_i)\int_0^\infty \frac{e^{i(p_f-p_i)x}}{\sqrt{1-r_H/r}}dx^4 \equiv if(u)\int_o^\infty \frac{\sqrt{r}e^{i(p_f-p_i)x}}{\sqrt{r-r_H}}dx^4 \qquad (16.5)$$

rescaling r→r'+r_H=r and t→t'+(r_H/c)≡t to minimize the resonance energy in p_f-p_i. We then obtain::

$$S_{if} \equiv iZ\frac{1}{V}\sqrt{\frac{m^2}{E_f E_i}}\bar{u}(p_f,s_f)\gamma^o u(p_i,s_i)e^{ir_H q}\int_0^\infty \frac{\sqrt{r}e^{i(p_f-p_i)x}}{\sqrt{r-r_H}}dx^4 \equiv if(u)e^{iqr_H}\int_o^\infty \frac{\sqrt{r+r_H}\,e^{i(p_f-p_i)x}}{\sqrt{r}}dx^4$$

For from chapter 14 we have for integer spin $\frac{1}{\sqrt{1-\frac{r_H}{r}}} :\to 1+\frac{1}{r-r_H}$ so:

$$S_{if}\equiv if(u)\left[\int_0^\infty \frac{e^{i(p_f-p_i)(x'-r_H/2)}}{|x'|}dx^4 - \int_0^\infty \frac{e^{i(p_f-p_i)(x'+r_H/2)}}{|x'|}dx^4\right]\approx$$

$$if(u)e^{i(r_H/2)q}\left(\int_0^\infty \frac{e^{i(p_f-p_i)(x')}}{|x'|}dx'^4 - 2\pi(r_H)^3\right) \qquad (16.6)$$

Note that $\bar{u}(p_f,s_f)\gamma^o u(p_i,s_i) = (1-\beta\sin^2\frac{\theta}{2})$ =Mott scattering term with the $e^{i(rH/2)q}$ our resonance term. The other left side coefficients and inverse |x| part of S_{ij} comprise the well known Rutherford scattering term.
dσ/dΩ=$[(Z_1Z_2e^2)/(8\pi\varepsilon_o m v_o^2)]^2\csc^4(\phi/2)=1.6X10^4(\csc(\phi/2)/v_o)^4$. (Note that equation 16.5 applies to the $2P_{1/2}$-$2P_{3/2}$ state electron-electron interaction (i.e., neutron) in section 20.3). Here p_f-p≡q. Note in equation 16.6 the factor ie^{ikq}=i(coskq+isinkq**).** Here we find the rotational resonances at the $2P_{3/2}$ r=r_H lobes associated with maximizing the imaginary part which is icoskq to obtain absorption scattering (at kq=π), which here will then be the masses exchanged in inverse beta decay. Also a solution to the Dirac component is always a solution to equation 14.1 (but not vice versa) if we invoke an integer spin in this resonance term. Here also the p part uses the old De Broglie wave length to connect to the p=h/λ. In that regard recall that hν/c= h/λ=p and for a DeBroglie wave fundamental harmonic resonance we have λ_{rot}=2πr for a stationary particle of **spin 1**=L (ambient E&M field source gives L=1 De Broglie). Recall from section 16.1 that:
Proca equation J= **total J** =(for single particle exchange)=**spinψ+field.**
For high energy S state also J= **total J** = (for available two particle exchange of low energy P and S state particles) = **spinψ_1+spinψ_2+field**

1) For P state (eq.2.6, 4.11) =spin1+spin0. Recall for P states r_H→r_H/2,
   Thus field spin=0 and De Broglie 2r=2λ out and in states.
2) For S state=($spin0_1$+$spin0_2$)+ spin1. Recall from eq. 2.2 that for S states r_H→r_H(m_e/m_p),
   Thus field spin=1,0 and De Broglie 2r=2λ in state and 2r=2λ and 2πr=λ out states.

Thus for the S state below we have two such spin½ particles spread out over a diameter 2λ=2r being equivalent to one spin 1 particle with λ_{rot}=(L+1)πr and so h/πr(L+1)=p_{rot} which gives the $2P_{3/2}$ eigenfunction and its trifolium structure in which case we must be

in resonance with an individual lobe. The wavelength of an individual $2P_{3/2}$ trifolium lobe is $\lambda_{lobe}=\lambda_{rot}/3$ (i.e.,true P wave scateering).
Also from just above equation 4.11 (note 1±ε term there) we have $Z_{oo}=$ $k=\alpha\hbar c(1\pm\varepsilon)/2(m_pc^2)\equiv k_s$, with the spin 1 coming out of the triplet state and the 1±ε from equation 4.12. So for the S state two spin ½ particles in a traveling wave (of our S matrix) are physically identical to one spin 1 particle in circumferential motion scattering. Thus for L=1 hq=p=h/λ= h/diameter =(two wavelengths across diameter) $=(2)h/2r=(2\pi h/(L+1)\pi r)=2\pi(h/\lambda_{rot})=2(\pi p_{rot})$.with then $p_{lobe}=3p_{rot}$. Given for **S=1** we have Mc=h/2πr (because of the S state spin 1 Proca equation) we therefore have for the equation 16.2 first resonance phase at $\phi=\pi=k_rq=k_s(2p_{lobe}/\hbar)=$ $2k_s\pi(3p_{rot}/\hbar)=[(\alpha\hbar c(1\pm\varepsilon)/(2m_pc^2)][(3)\pi(Mc^2 2/((L+1)\hbar c))$(16.6a)
Formula 16.6a gives a LS para L=1/2 at 142Gev.so that J=S+L=0 so for minimal spin orbit interaction energy. Thus J =0 for this particle. Charge=0 as well. first we start with ksp=0 resonance condition. We plug the resulting mass term=0 into our Proca equation (section 16.1) and get the standard Maxwell equations!
The next resonance is at $k_sp=\pi$ and we solve then for the S and P state subcases in which the Proca equation then gives a massive spin 1 particle (W). Thus in the P state we can keep the λ as 2r but in the S state to make λwe need to make λ=2πr.
1) The P state ortho triplet states $\pi^\pm$and π^0. That singlet para K_o, which is both a particle and a antiparticle. Our state is still r=λ. Recall for P states you have a $r_H\rightarrow r_H/2$,
2) The S state ortho triplet states $W^\pm$,and Z_0. That singlet para at 142GeV (the spin0_2 above) should be both a particle and a antiparticle 2r=2λ. W,Z are out states 2πr=λ .
The quark top (the 6th P state) spin0_2 also originates just as the Kaon state also has a K+, K-.split and strangeness (bottom and charm P states are pumped using that harmonic oscillator mechanism coming arising out of that Taylor expansion eq.19.5).
Thus there is a quite interesting dichotomy here:
$\pi^\pm$, π^o, $K^o\rightarrow W^\pm$, Z_o,142GeV meson(s).
Note there should also be a resonance at $\phi=3\pi=k_rq$ gives a new W at 273Gev and thus a new high energy weak interaction causing new asymmetries in antiparticle-particle decay directions.

References

Pugh, Pugh, *Principles of Electricity and Magnetism*, 2nd Ed. Addison Wesley, pp.270
Bjorken and Drell, *Relativistic Quantum Mechanics*, pp.60
Sokolnikoff, Tensor Analysis, pp.304

16.2 ε Expectation Value In W Region

For the q s that maximize the above Im ie^{iksq}=coskq term for scattering in S_{ij}. Note the ± in equation 4.11.
Thus there is a plus and a minus solution to equation 16.3. The minus applied to negative components. With L=1 (so K=1) charge (+ε): $Mc^2=K2m_pc^2/(3\alpha(1+\varepsilon))=$ $\mathbf{M_W}$ =80.7Gev.
Alternatively with zero charge (-ε in equation 4.11)
$Mc^2=2m_pc^2/(3\alpha(1-\varepsilon))=137.026\circ 938.27Mev/(1.5\circ(1-.06))=$ $\mathbf{M_Z}$ =91.2Gev.
Also kq=0 obtain photon mass=0. Thus we have the *mass energy of the W and Z* involved in beta decay. Recall the central role ε played in decay in chapter 13. We take the expectation value of ε (E=107MeV) in chapter 1 operating inside the region occupied by

a W ($r\approx 1/100$ F). Thus in equation 16.3 G in the 4 body ε (in W volume) interaction operator is then given by EV= $\varepsilon(W_rF)^3$= 107MEV$((1/100)F)^3\approx 10^{-4}$Mev-$F^3$=G that must be used since the ψs are normalized for V in the 4 body Fermi interaction integral $\int\psi_1\psi_2 G\psi_3\psi_4 dV$ we got from applying inverse separability on the Dirac left handed doublet(section 2.2) using equation 3.2. Thus we have the interaction ε operating in W radius using the doublet of section 1.4.

In general then we have obtained an ortho triplet state here since we are merely writing the Clebsch Gordon coefficients for this addition of two spin ½ angular momentums: |½,½,0,-1>,.. |½, ½,0,0>,..|½,½,,0,1>,.. or +W Z_o, -W.

Thus we have the **ortho** states over Z_o, W^- and W^+ and the singlet **para** state at L=0, 182Gev (given by 1-2ε multiplication of the charged s L=1/2 state at ~142GeV in equation eq. 16.3).and 1+2ε at 125Gev.

If the scattering is $2P_{3/2}$ instead $m_p\rightarrow m_e$ and so S state 142Gev→135Mev for P state, the uncharged spin0 pion and the same ortho-para organization applies but at these far lower energies. Note the common denominator between the Fermi interaction term (the one with the G) and the W, Z mass scattering is the electron scattering in a $2P_{3/2}$ lobe: they are the same interaction analyzed two different ways. So we say that the W or Z were 'exchanged' in the Fermi interaction or that a left handed electron and left handed neutrino took part in that G, 4 body interaction, same thing.

The beautiful thing to be noted here is that for the doublet resonance with the $2P_{3/2}$ lobe at $r=r_H$ that minimizes energy you get the spin 1 W and Z and the value of the Fermi G! We have also shown that this doublet interaction corresponds to the exchange of massive spin 1 particles (recall spin ½ s forbidden by that j-1/2 factor).

Probability for $2P_{3/2}$ Giving One Decay 1S Product at $r\approx r_H$ In W Region

In equation 4.12 we note that invariance over 2π rotations using $(1+2\varepsilon)d^2\theta$ does not occur anymore thus seemingly violating the conservation of angular momentum. To preserve the conservation of angular momentum the additional angle ε must then include its own angular momentum conservation law here meaning intrinsic spin½ angular momentum in the S state case and/or isospin conservation in the $2P_{3/2}$ case at $r=r_H$. In any event we must also integrate to C=ε. Here we do the E&M component decay given by equation 3.2.

Plug in $S_{1/2}\propto e^{i\phi/2}$, $\frac{1}{2}(1-\gamma^5)\psi=\chi$ into equation 3.2. In that regard note that the expectation value of γ^5 is proportional to v ∝ Heisenberg equation of motion derivative of $2P_{3/2}\propto e^{i(3/2)\phi}$. We integrate <lepton|baryon> over this W exchange region where we note (~1/100)F for 90Gev particle, so $dV=((1/100)F)^3)$=VolW. Also $ck_o=\varepsilon$=106Mev from section 2.1. From section 1.5 on the vacuum constituents e and ν we note that $\iiint d\tau$=Vol, χ is defined as the vacuum eigenfunction. Vacuum expectation equation 4.15: Σ<|va_M>|ε|<vac_{M+1}|>=<| $\iiint\psi^*_\nu\varepsilon\chi_e dV$|>=<|Pot|>= εVolume of W. This application of eq.16.1 for example applies to the $2P_{1/2}$ -$2P_{3/2}$ electron-electron scattering state inside the neutron <Proton$2P_{3/2}$|Pot|Neutron$2P_{1/2}$ -$2P_{3/2}$>. Also we can get a weak, strangeness changing (second term below), decay from a $2P_{1/2}$-$2P_{3/2}$>m_p to the S state branch equation.1.9 expectation values from equation 3.2. $=\boldsymbol{\Sigma}$<lepton|vac>|ε|<vac|baryon> =Fermi interaction integral $=\int\!\!\int\psi_1^*\psi_2\psi_3 k_o c\chi dV=\iiint\psi_1^*(\varepsilon\text{VolW})\chi dV=\iiint\psi_1^*(\varepsilon\text{VolW})\chi dV$. Also dV=dAdϕ=Kdϕ.

So the square root of the probability of being in the final state is equal to the Fermi integral= $\int\int\psi_1^*(Pot)\chi dV = \int\int\psi_1^*\psi_2\psi\varepsilon\Delta V_W\chi dV =$

$$= \int K\left\langle e^{i\phi/2} \mid (\varepsilon\Delta V_W) \mid 1-\left(\gamma^5 ie^{i(3/2)\phi}\right)\right\rangle dtcdV = \int K\left[\varepsilon\left(\frac{F}{100}\right)^3\right]\left\langle e^{i\phi/2}-\gamma^5 ie^{i4/2\phi}\right\rangle d\phi$$

$$\varepsilon VolW = \int K\left[\varepsilon\left(\frac{F}{100}\right)^3\right]\left\langle e^{i\phi/2}-\gamma^5 ie^{i4/2\phi}\right\rangle d\phi$$

$$= KG_F\int\left\langle e^{i\phi/2}-\gamma^5 ie^{i4/2\phi}\right\rangle d\phi = KG_F\left(\frac{2e^{i\phi}}{i}\Big|_0^{2\pi+C} - \frac{2\gamma^5 e^{i4\phi}}{i4}\Big|_0^{2\pi+C}\right) \qquad (16.7)$$

with <initial|c|final>^{2} ≈ transition probability as in associated production with the separate 2P proton ground state transition being the identity (ΔS=0). Factoring out the 2 and then normalizing 1 to .97 simultaneously normalizes the 1/4 to .24 in equation 13.2. With this normalization we can set $\cos\theta_c$=.97 and $\sin\theta_c$ =.24. Thus we can identify θ_c with the *Cabbibo angle and we have derived its value.* We can then write in the weak current sources for hadron decay the **VA structure**: $|\cos\theta_C-\gamma^5\sin\theta_C|$. Thus with the above Cabbibo angle and this CP violation and higher order $(r_H/r)^n$ terms in equation 3.2 we have all the components of the CKM matrix. Note we have also derived the weak interaction constant G_F here.

Given the role ε plays here in decay we find the expectation value of energy ε within the S matrix scattering region in chapter 16.

Recall from section 1.2 the possible mixing of real and imaginary terms in that energy coming out of that first order Taylor expansion. There we found the 1+x and 1-x solutions cancel and we could ignore the 1+1=2 term as it is still a flat metric.

Also there are still extra terms provided by the 'small' higher order r^2 terms in that Taylor expansion so that "higher and lower" than the speed of light mixed condition still can exist (for ΔG≠0. See end of section 4.6 and 16.6). In that regard note for the next higher order Taylor term at largest curvature $d^2(1/k_{rr})/dr^2$ is large negative and r^2 is positive implying a net negative term and therefore a neutral charge (see case 2, of section 19.6)! In that case the perturbative squared r term appears to overwhelm the rest since the lower order terms then cancel. Note from the above we put these neutral conditions also into that decay since net charge is zero in the Cabbibo angle derivation. This then appears to be the beta decay condition *where the neutrino (higher than c) and the electron, (lower than c), decay from this neutral particle condition* (bottom of section 16.6). The beginning $2P_{3/2}$ ground state still exists however in the respective Cabbibo angle calculation. Thus those real and imaginary terms coming out of that Taylor expansion provide the explanation for beta decay.

16.3 Mass Hierarchy Problem

Note the $\sqrt{g_{rr}}$ approximation in equation 19.3 goes as $1+r/4-r^2/10+$..Thus the $r^2/10$ becomes comparable to r/4 when r≈2 which then corresponds to the maximum strangeness states (section 19.9) of maximum ~2GeV (2P state n=3) where the r/4 perturbation was used. Also the S state shares an electron giving a sp^2 hybridization, thus providing a charge (nonzero Z_{ooS}) even if the state is filled. We must then find the r'^2 (factorized) term that gives the $1+r/4+r^2/10$ polynomial (to move up further in energy to n=4,5,6) thus resulting in a $dE/r'=-kr'$ Hooke's law $E=\frac{1}{2}kr'^2$ potential energy term with S state hybridization giving a bare S state Z_{ooS} for scattering. Thus, given these proton nonrelativistic $2P_{3/2}$ state objects, we can construct a (crude approximation) harmonic oscillator Schrodinger equation with here then the 5^{nd} harmonic of twice the frequency (energy) of the next lower 2P 4^{th} harmonic state $.\hbar\omega_o(n+½)=4m_pc^2(n+½)$, where this $\hbar\omega_o$ is from section 16.1. Finally the last 2P state fills at the 6^{th} particle and so no free electrons are available to scatter, they are all paired analogous to the inert noble gas states. Set L =1/2 in equation 16.4 to get this mass. Thus the S state of equation 16.3 is exposed to scattering at the very high energy of 143Gev.

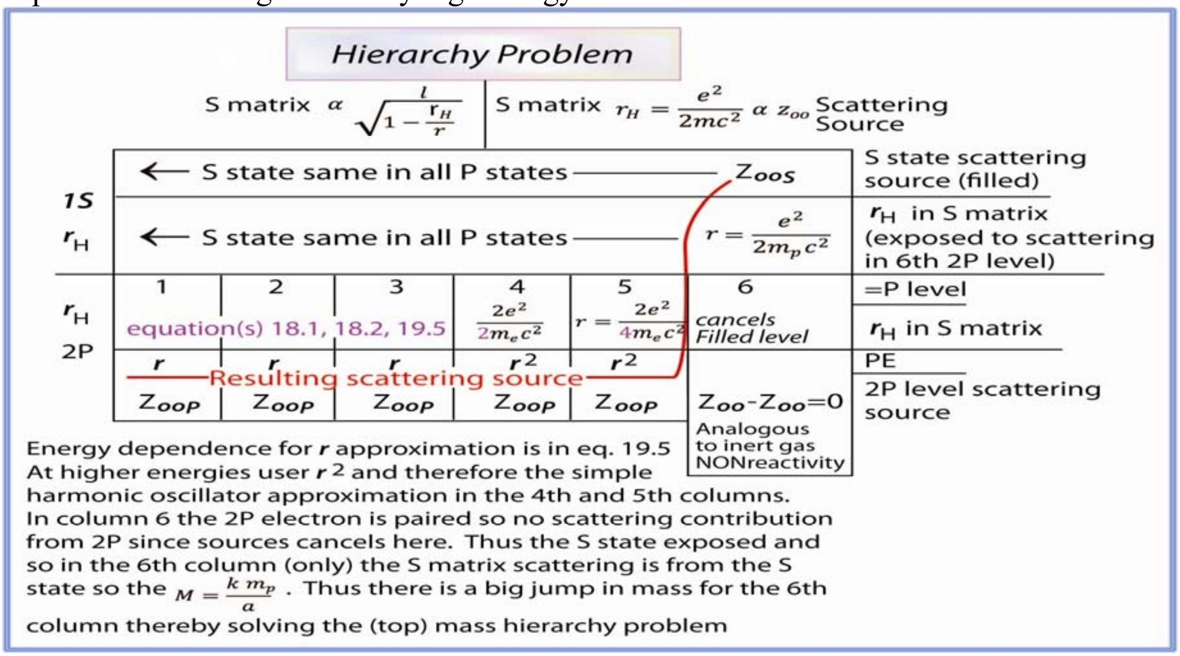

Figure 16-1 The Solution To the Mass Hierarchy Problem For the Top

Thus to chapter 3 we can add the solution to the mass hierarchy problem for the 6 th 2P state (top).

Note this mass hierarchy result also explains why no higher states than the 2P states are observed since that last energy level of the first 2P state is at 140 GeV.

16.4 No 3D, 4F,… States Until First principle Quantum Number Filled

In that Dirac doublet that comes out of eq.1.2d (also note section 1.5 above) there are two coupled equations. There is also that third singlet electron equation as well coming directly out of equation 1.2a.

Thus these three equations hold simultaneously. That is how I solve them in chapter 19. Note the doublet equations are coupled spinor equations, thus the answer to one effects the other as is the case with typical spinor equations. But the third singlet equation holds all by itself. For low energy and in free space the first two are solved separately from the third.

In the case of being inside r_H, when the full $1+\varepsilon+\Delta\varepsilon$ mass energy describes a single particle (instead of three separate particles outside r_H) those equations still are solved as two coupled spinor equations and one electron equation.

Some important consequences come out of this. For example we can still solve that single electron equation as a two body problem! Again the spinor equation is solved by itself.

The reason this is important is that we can still treat the proton as a two body problem even given a third (spinor) particle is inside r_H. Thus you can solve equation 18.1 as if it is a two body problem as is done there.
1) This allows us to get exact results for nucleon eigenvalues just as the two body hydrogen atom problem is for the most part exact.
2) Also the energy is a direct function of the principle quantum number as it is for the hydrogen atom and it cannot go down with higher J. Thus the next principle quantum number has even higher energy. This implies that the aufbau principle has to involve filling a given principle quantum number N first and then going on to the next principle quantum number. That does not have to happen in three or more body atomic physics. For example the next principle quantum number can only start filling after the t state is filled, at 140 GeV as above. This and the Lande g factor of section 20.3 explains why there are *no* 3D, 4F, 5G states filling ahead of the first principle quantum number states as occurs in atomic physics in 3 (or more) body systems. Thus we can focus our efforts on that $2P_{3/2}$ state at $r=r_H$ as we have throughout this book.

16.5 Electron E&M Component Of $\sum_M H_M=0=H_N+H_{N+1}$

Section 1.5 and in equations 11.2, 4.15 H_N is the E&M component of $\sum_M H_M=0=H_N+H_{N+1}$ and H_{N+1} is the neutrino component (recall $H_{N+1} \propto \sigma\bullet p$). Thus for the vacuum $\langle H_N+H_{N+1}\rangle=\langle\sum\hbar\omega+H_\nu\rangle \equiv\langle\sum\hbar\omega+\Delta\varepsilon_\nu\rangle$. Therefore if a set of nearby grounded conducting plates (V=0) were set up some of the harmonics in $\sum\hbar\omega$ (given by the distance between the plates and V=0 at the surfaces) between the plates would not exist since they don't satisfy the boundary conditions therefore there is less E&M $\hbar\omega$ energy density between the plates than on the outside. But the H_ν neutrinos would pass right through the plates therefore there would be a higher density $\hbar\omega$ (E) outside the plates than inside and this condition would be unaffected here by the H_ν neutrinos. Thus an inward force on the plates can be calculated. These excluded harmonics and the resulting inward force (dE/dx) are also the assumptions used to calculate the Casimir effect (Casimir,1948). Note that the Casimir effect would exist in this situation even though in equation 4.15. $\sum_M H_M=0$ exactly *outside* this excluded region (far from the region between the plates) in the vacuum. Thus the vacuum has a net *zero* energy [recall $\sum_M H_M=0$]. This means that there is *no net zero point energy* in free space. There are many other reasons for assuming zero net energy for the vacuum (such as the fact that space is essentially 'flat', with the "flatness" problem solved trivially here by $\sum_M H_M=0$) so this *reconciliation with the Casmir effect* is important. Using the above electron $\Delta\varepsilon$ and equation 4.15 for the vacuum again: $\sum H_N=H_M+H_{M+1}=0=\Delta\varepsilon-\Delta\varepsilon_\nu=0$ for homogenous isotropic background metric.

16.6 Nonhomogenous NonIsotropic Metric Gives Entangled States

By finding the implications of the entangled states in $(\sum H_N)\psi$ you can determine the physical properties of neutrinos. For example:

Entangled States and Chirality For Isotropic and Homogenous Metric

Recall we showed in section 4.6 that a isotropic homogenous space time implies $(H_M+H_{M+1})\psi=0$ (with entangled state eigenfunction $\psi=\psi_\nu+\psi_e$) which implies in turn the left handedness of the beta decay neutrino. See section 4.6 for the derivation of the left handedness.

Furthermore this nonistropic nonhomogenous metric analysis implied the results of the Casimir experiment. See section 16.5 just above for the derivation of this result.

Entangled States and Mass For NONisotropic NONhomogenous Metric

Recall also from section 4.6 that a nonisotropic nonhomogenous metric provides a source ΔG for $(\sum H_N)\psi= (H_M +H_{M+1})\psi=\Delta G\psi$ (instead of 0ψ) with $\psi=\psi_M+\psi_{M+1}\equiv\psi_e+\psi$. $H_M\equiv H_e$, $H_{M+1}\equiv H_\nu$. For the entangled state mass m of equation 2.5 the Δm in the KE gained from the gravity potential energy at the earth's surface is .25eV= GMm/r $=\Delta G$ (where M is the mass of the earth, r =earth's radius) and *this quantity ΔG also then multiplies the neutrino eigenfunction* ψ_ν. Thus in addition to the ΔG for the electron we have $H_\nu\psi_\nu =\Delta m\psi_\nu =.25eV\psi_\nu$.and so a electron neutrino mass in the earth's gravity field is .25eV. It is about 28 times this value in the sun's surface gravity field.

Entangled States and Amplitude a_i of ith Eigenstate For Nonisotropic Nonhomogenous Metric

Recall the neutrino eigenstates of that H_{M+1} Hamiltonian in section 4.6. Note again the entangled state giving all three ψ s there (muon, neutrino, electron neutrino, tauon neutrino in the $1+\varepsilon+\Delta\varepsilon\equiv$tauon+muon+electron term of eq.2.5 for $r>r_H$) with the ground state electron neutrino having the largest eigenstate amplitude a_1 at lowest energy. Thus any one of the three (nth) types of neutrinos have a nth Hamiltonian:

$H_o\psi=E_n\psi_n$

for normalized ψ_ns. We introduce a strong *local* metric perturbation $H'=\Delta G$ due to motion through matter let's say so that:

$H'+H=H_{total}$ where $H\equiv\Delta G$ is due to the matter and H is the total Hamiltonian due to all the types of neutrino in that H_{M+1} of section 4.6. Because of this metric perturbation $\psi=\Sigma a_i\psi_{Ii}$=orthonormal eigenfunctions of H_o. $|a_i|^2$ is the probability of being in the neutrino state i. The nonground state a_is would be (near) zero for no perturbations with the ground state energy a_i (electron neutrino) largest at lowest energy given for ordinary beta decay for example. Thus the passage through matter creates the nonzero higher metric quantization states (i.e., H' can add energy) with:

$a_k=(1/(\hbar i)\int H'_{lk}e^{i\omega lkt}dt$

$\omega_{lk} =(E_k- E_l) /\hbar$

Thus in this way motion through matter perturbs these entangled eigenstates so that one type of neutrino might seemingly change into another (oscillations) when *in actuality only that particular quantum state amplitude a_k is increasing*.

Chapter 17

17.1 Implications of g_{oo} =1-2e²/rm$_e$c² =1-eA$_o$/mc²v^o) For Small Relative v Low Temperature Limit

Next we use above equation 4.1 $g_{oo}=1-2e^2/rm_ec^2=1-eA_o/mc^2v^o)$ in the geodesics

$$\frac{d^2x^\mu}{ds^2}=-\Gamma^\mu_{\nu\lambda}\frac{dx^\nu}{ds}\frac{dx^\lambda}{ds} \qquad (17.1)$$

Or in general $$g_{ii}\equiv\eta_{ii}+h_{ii}=1-\frac{eA_i(x,t)}{m_\tau c^2v^i},i\neq 0, \qquad (17.2)$$

$A'_0\equiv e\phi/m_\tau c^2$, $g_{00}\equiv 1-\frac{e\phi(x,t)}{m_\tau c^2}=1-A_0'$, and define $g'_{\alpha\alpha}\equiv 1-A'_\alpha/v_\alpha$, ($\alpha\neq 0$) and $g''_{\alpha\alpha}\equiv g'_{\alpha\alpha}/2$ for large and near constant v. In the weak field $g^{ii}\approx 1$. Also use the total differential $\frac{\partial g_{11}}{\partial x^\alpha}dx^\alpha=dg_{11}$ so that using the chain rule gives us:

$$\frac{\partial g_{11}}{\partial x^\alpha}\frac{dx^\alpha}{dx^0}=\frac{\partial g_{11}}{\partial x^\alpha}v^\alpha=\frac{dg_{11}}{dx^0}\approx\frac{\partial g_{11}}{\partial x^0}.$$

gives a new A(1/v²)dv/dt force term added to the first order Lorentz force result in these geodesic equations (Sokolnikoff, pp.304):

$$-\frac{d^2x^1}{ds^2}=\Gamma^1_{11}v_1v_1+\Gamma^1_{12}v_1v_2+\Gamma^1_{13}v_1v_3+\Gamma^1_{10}v_0v_1+\Gamma^1_{21}v_2v_1+\Gamma^1_{22}v_2v_2+\Gamma^1_{23}v_2v_3+\Gamma^1_{20}v_2v_0+$$
$$\Gamma^1_{31}v_3v_1+\Gamma^1_{32}v_3v_2+\Gamma^1_{33}v_3v_3+\Gamma^1_{30}v_3v_0+\Gamma^1_{01}v_0v_1+\Gamma^1_{02}v_0v_2+\Gamma^1_{03}v_0v_3+\Gamma^1_{00}v_0v_0=$$
$$\frac{g^{11}}{2}\left(\frac{\partial g'_{11}}{\partial x^1}\right)v_1+\frac{g^{11}}{2}\left(\frac{\partial g'_{11}}{\partial x^2}\right)v_2+\frac{g^{11}}{2}\left(\frac{\partial g'_{11}}{\partial x^3}\right)v_3+\frac{g^{11}}{2}\left(\frac{\partial g'_{11}}{\partial x^0}\right)v_0+$$
$$\frac{g^{11}}{2}\left(\frac{\partial g'_{11}}{\partial x^2}\right)v_2-\frac{g^{11}}{2}\left(\frac{\partial g'_{22}}{\partial x^1}\right)v_2+0+0+\frac{g^{11}}{2}\left(\frac{\partial g'_{11}}{\partial x^3}\right)v_3+0-\frac{g^{11}}{2}\left(\frac{\partial g'_{33}}{\partial x^1}\right)v_3+0+$$
$$\frac{g^{11}}{2}\left(\frac{\partial g'_{11}}{\partial x^0}\right)v_0+0+0-\frac{g^{11}}{2}\left(\frac{\partial g'_{00}}{\partial x^1}\right)v_0+O\left(\frac{A_idv}{v^2dt}\right)=v_2\left(\frac{\partial g''_{11}}{\partial x^2}-\frac{\partial g''_{22}}{\partial x^1}\right)+v_3\left(\frac{\partial g''_{11}}{\partial x^3}-\frac{\partial g''_{33}}{\partial x^1}\right)+$$
$$\left(\frac{\partial g''_{11}}{\partial x^\alpha}v_\alpha+\frac{\partial g''_{11}}{\partial x^0}v_0\right)-\left(\frac{\partial g''_{00}}{\partial x^1}\right)v_0+O\left(\frac{A_idv}{v^2dx}\right)\approx-\left(\frac{\partial g''_{00}}{\partial x^1}\right)v_0+v_2\left(\frac{\partial g''_{11}}{\partial x^2}-\frac{\partial g''_{22}}{\partial x^1}\right)+$$
$$v_3\left(\frac{\partial g''_{11}}{\partial x^3}-\frac{\partial g''_{33}}{\partial x^1}\right)+O\left(\frac{A_idv}{v^2dt}\right)\approx\frac{e}{m_\tau c^2}\left(-\vec\nabla\phi+\vec vX\left(\vec\nabla X\vec A\right)\right)_x+O\left(\frac{A_idv}{v^2dt}\right)$$

Thus we have the *Lorentz force equation* form $\left(-\left(\frac{e}{m_\tau c^2}\right)\left(\vec\nabla\phi+\vec vX\left(\vec\nabla X\vec A\right)\right)\right)_x$ plus the derivatives of 1/v which are of the form**: A_i(dv/dt)/v²**. This new term A(1/v²)dv/dt is the pairing interaction. (17.3)

This approximation holds well for nonrelativistic and nearly constant velocities and low B fields but fails at extremely low velocities so it works when v>>(dv/dA)A. This constraint also applies to this ansatz if it is put into our Maxwell equations in the next section. Given a stiff crystal lattice structure (so dv/dt is large also implying that lattice harmonic oscillation isotope effect in which the period varies with the (isotopic) mass.) this makes the pairing interaction force $A_i(dv/dt)/v^2$. The relative velocity "v" will then be small in the denominator in some of the above perturbative spatial derivatives of the metric $g_{\alpha\alpha}$ (e.g.,the 1/v derivative of H2 $(A/v^2)(dv/dt)$). This fact is highly suggestive for the velocity component "v" because it implies that at cryogenic temperatures (extremely low relative velocities in normal mode antisymmetric motion) new forces (pairing interactions?) arise from the above general relativity and its spin 0 (BCS) and spin 2 states[i] (D states for CuO_4 structure). For example the mass of 4 oxygens (4X16=64) is nearly the same as the mass of a Cu (64) so that the SHM dynamics symmetric mode (at the same or commensurate frequencies) would allow the conduction electrons to oscillate in neighboring lattices at a relative velocity of near zero (e.g.,$v \approx 0$ in $(A/v^2)(dv/dt)$ making a large contribution to the force), thus creating a large BCS (or D state) type pairing interaction using the above mechanism. Note from the dv/dt there must be accelerated motion (here centripetal acceleration in BCS or linear SHM as in the D states) as in pair rotation but it must be of very high frequency for dv/dt (lattice vibration) to be large in the numerator also so that v, the velocity, remain small in the denominator with the phase of "A" such that A(dv/dt) remain the same sign so the polarity giving the A is changing rapidly as well. This explains the requirement of the high frequency lattice vibrations (and also the sensitivity to valence values giving the polarity) in creating that pairing interaction force. Other attempts have been made to put in a nonlinear addition to the Maxwell equations (see section 17.3) that only is observable at low temperatures. For example there are the nonlinear Schrodinger equation theories. But in these theories these nonlinear terms were postulated (Chern Simons), not derived as they are here.

Thus we finally understand the pairing interaction in SCs, still the deepest mystery in standard SC theoretical speculations.

Most superconductivity (other than the cuprates) is for single mass m but with alternating spin states between lattice points. Thus Niobium with possible lattice of tin or Germanium (Group 16 of the periodic table) or the nictides with iron in a lattice of arsenic or antimony (group 15). Thus here v is small because the atomic weights are the same. The correct lanthanum, fluorine, doping must be applied to give the morphology required.

Also note the v in the denominator of 17.1 and 17.2 and so possible singular behavior there at the lowest temperatures. Thus at extremely low temperatures there exists some of the same type of exotic singularity behavior (e.g., chapter 19) as exhibited near r_H and so seen in high energy scattering. You are studying some of the properties of the high energy extreme then at the very lowest energy extreme!

17.3 Weak Field Approximation

We adopt an ansatz (equation 10.1) $g_{oo}=e^{iAo}$ (or the Fourier series sum). Also recall from equation 1.7 that $g_{oo}g_{rr}$ is a constant. So we can do the equation 1.3 variation with respect to time (and not r) just as in classical Hamiltonian theory. So from equation 3.5 we have $\delta(g_{oo}g_{rr})=0=(\partial(g_{oo}g_{rr})/\partial t)dt=((\partial g_{oo}/\partial t)g_{rr})dt+((\partial g_{rr}/\partial t)g_{oo})dt=((g_{oo}\partial iA_o/\partial t)g_{rr})dt+(g_{rr}\partial iA_r/\partial r)(dr/dt)g_{oo}dt=(g_{oo}(\partial iA_o/\partial t)g_{rr}dt+(g_{rr}(\partial iA_r/\partial r)cg_{oo}dt$. Multiplying both sides by $1/cg_{oo}g_{rr}idt$ gives us:

$$\partial A_o/c\partial t + \partial A_r/\partial r=0 \qquad (17.1)$$

But from the Heisenberg equations of motion equation 10.1 $e^{iu}=e^{i\omega t}\rightarrow e^{i(\omega t-kr)}$ for observer motion v (with kr α vt)and so each g_{oo} and g_{rr} obeys a wave equation in t $\partial^2 g_{ii}/c^2\partial t^2$ - $\partial^2 g_{ii}/\partial r^2$ =0. For example in free space: $g_{oo}\partial^2 A_o/c^2\partial t^2 - g_{oo}\partial^2 A_o/\partial r^2 = 0$ and $g_{rr}\partial^2 A_r/c^2\partial t^2 - g_{rr}\partial^2 A_r/\partial r^2 = 0$ or

$$\partial^2 A_o/c^2\partial t^2-\partial^2 A_o/\partial r^2 =0 \quad \text{and} \quad \partial^2 A_r/c^2\partial t^2-\partial^2 A_r/\partial r^2 =0 \qquad (17.2)$$

So we have the (Lorentz gauge, (Pugh, pp.270)) weak field formulation of the free space E&M Maxwell equations in 2D and can generalize to 4D as before.

References

Pugh, Pugh, *Principles of Electricity and Magnetism*, 2nd Ed. Addison Wesley, pp.270
Bjorken and Drell, *Relativistic Quantum Mechanics,* pp.60
Sokolnikoff, Tensor Analysis, pp.304

17.4 Recall from section 2.2 The S State Fitzgerald Contraction

S state and equation 1.9: r_H is Lorentz contracted by just NONrotating, straight line $\sqrt{(1-v^2/c^2)}$ from the Lorentz transformation and is again given by $r\rightarrow r_H$ using equation 2.5 multiplication with 1+ε (i.e., gives that above N=2 m_p eigenvalue). So for S states and the multiple charges of the tauon, muon and electron:

$$r_S=(2e^2)/(2(1+\varepsilon+\Delta\varepsilon)m_p c^2) \qquad (2.4)$$

Also recall the 2,0,0 state hydrogen eigenfunction

$$\psi_{2,0,0}=\frac{2}{(2a_o)^{3/2}}(1-r/2a_o)e^{-r/2a_o}$$

Next find center of charge value of r=<r>=

$$\langle r\rangle=\int_0^\infty r\psi^*_{2,0,0}\psi_{2,0,0}r^2dr=\frac{4}{(2a_o)^3}\int_0^\infty r(1-r/2a_o)e^{-r/2a_o}(1-r/2a_o)e^{-r/2a_o}r^2dr=$$

$$4\frac{(2a_o)^4}{(2a_o)^3}\int_0^\infty r^3(1-2r+r^2)e^{-2r}dr=\frac{4(2a_o)^4}{2(2a)^3}\int_0^\infty\left(\frac{r^3}{8}-2\frac{r^4}{16}+\frac{r^5}{32}\right)e^{-r}dr=\frac{8a_o}{2}\left(\frac{6}{8}-\frac{48}{16}+\frac{120}{32}\right)=$$

$6a_o$ to find the position of an electron that gives the same QM state energy if put in the classical potential energy analogous to how the role the center of mass plays in torque theory. This is a different than the position at the peak of ψ*ψ, which is the Bohr radius for the 1,0,0 state. For this 2,0,0 state however the radius of the Bohr orbit is $4a_o$. $6a_o$ is measured from the Compton wavelength λ_c so $6a_o\rightarrow 6a_o+\lambda_c$. Recall from the position that it holds in the standard Dirac equation that the energy (in equation 2.6) goes as:

$$\frac{1}{\sqrt{\kappa_{oo}}}=\frac{1}{\sqrt{1-\frac{r_H}{r}}}=1+\frac{r_H}{2r}-\frac{3}{8}\left(\frac{r_H}{r}\right)^2-\ldots$$ evaluate at <r> for 2 charges (*2*e) to reduce to the ordinary large central mass Coulomb potential in the first order term. Again 1+ε==1.06. From section 3 of chapter 2 set total energy equal to $[2(1+\varepsilon+\Delta\varepsilon]m_pc^2$ and set k to get the

Coulomb potential energy for electron moving around heavy central mass

$$2\left((1+\varepsilon+\Delta\varepsilon)m_p c^2\right)/\sqrt{\kappa_{oo}} = \frac{2(1.06)m_p c^2}{\sqrt{1-\frac{r_H}{6a_o}}} = 2(1.06)m_p c^2 + \frac{\frac{4e2e}{2\left(1.06)m_p c^2\right)}}{2(6a_0)}2(1.06)m_p c^2$$

E_t=

$$-\frac{3}{8}\left(\frac{\frac{4e2e}{k2(1.06)m_p c^2}}{6a_o}\right)^2 2(1.06)m_p c^2 + ...$$

Note that a 2 gets canceled in the Coulomb term. We are left with $4e^2/r$ in that term and the mass of a tauon, muon, and two electrons plus the 3/8 term. Next subtract off the tauon, muon, masses and their respective $e^2/r + e^2/r = 2e^2/r$ potential energies leaving two electron masses and their $2e^2/r$ contribution. Then divide the 3/8 contribution and what was leftover in the other terms by two to get the single electron mass and standard Coulomb potential contribution. The second term is the ordinary Coulomb potential at $r=6a_o$ average electron distance for $\psi_{2,0,0}$.given by $e^2/r = e^2/6a_o$ for a electron moving around heavy central mass. Thus to get the hydrogen atom 2S state electron contribution coming out of this we apply this energy relation to just the electron mass energy component in the first term. The last term then equals:

$$\left(\frac{1}{2}\right)\frac{3}{8}\left(\frac{8\left(8.98X10^9\right)\left(1.602X10^{-19}\right)^2}{6\left(.\left(53X10^{-10}+2.42X10^{-12}\right)2(1.06)\right)\left(1.673X10^{-27}\left(3X10^8\right)^2\right)}\right)^2 2(1.06)\left(1.67X10^{-27}\right)\left(3X10^8\right)^2$$

$$=1.83X10^{-26}=$$

$$=hf = 6.626X10^{-34}27{,}400{,}000 \text{ so that f=27Mhz}$$

Recall also the 1000Mhz component is due to the electron zitterbewegung cloud itself taking up space which we get by adding the Compton wavelength directly into the Coulomb potential radius at $6a_o$.

Thus we account for the entire Lamb shift without evaluating any higher order diagrams as mentioned earlier in section 3.3. We don't need renormalization anymore. We also do not require renormalization and higher order diagrams for the derivation of anomalous gyromagnetic ratio as we see in the next chapter (ch.18). Even though, in principle, we do not need it in general it is better to use it since the fine structure constant α is all that is needed in that multi diagram method and α is accurately known. Recall we derived that old method in chapter 6.

17.5 S Matrix at Energies>>1TEV

As in equation 14.1 and section 16.1 even in the ultrarelativistic limit: total energy equals $\frac{dt}{ds}\sqrt{g_{oo}} \rightarrow \frac{1}{\sqrt{1-\frac{\alpha}{r}}}$ e^{ikr}=V where we have included the zitterbewegung oscillation ck here.

But the mass term must be subtracted to get the potential. With electron rest mass neglected. In this limit V is large and can be replaced with realV= $\left(\frac{dt}{ds}\sqrt{g_{oo}}-1\right)\cos kr$ =V so in the one vertex S matrix we have then to evaluate the integral of $\left(\frac{dt}{ds}\sqrt{g_{oo}}-1\right)\cos kr$ instead of the integral of the usual coulomb V as in standard QED.

In evaluating this integral we use the integrals in spherical coordinates $dVol = r^2 \sin\theta dr d\theta d\phi$. So in the one vertex S matrix the integral coefficient goes for the r component:

$$\int VdVol = \int\left(\frac{1}{\sqrt{1-\frac{\alpha}{x}}}-1\right)x^2\cos kx dx =$$

$$\int\left(\frac{x^2}{\sqrt{1-\frac{\alpha}{x}}}-x^2\right)\cos kxcdx = \int\left(\frac{x^{5/2}}{\sqrt{x-\alpha}}-x^2\right)\cos kx dx$$

But for k=p/h→∞we have a very rapid oscillation allowing us to write the integral for the envelope and then divide by 2 at the end to get an approximate value of the integral magnitude which is all we need here to demonstrate asymptotic behavior. Thus for k→∞ we can drop the coskx term.

So we have (recall $\int x^2dx=x^3/3$) we

$$\int\left[\frac{x^{5/2}}{\sqrt{x-\alpha}}-x^2\right]dx = \frac{x^{5/2}\sqrt{x-\alpha}}{3}+\frac{5\alpha}{6}\int\frac{x^{3/2}}{\sqrt{x-\alpha}}dx-\frac{x^3}{3} =$$

$$\frac{x^{5/2}\sqrt{x-\alpha}}{3}-\frac{x^3}{3}+\frac{5\alpha}{6}\left(\frac{2x^{3/2}\sqrt{x-\alpha}}{4}+\frac{3}{4}\frac{2\alpha}{\sqrt{-1}}\ln\left(\sqrt{x}+\sqrt{x-\alpha}\right)\right)$$

In the limit of high energy and closest approach impact parameter (so x→α) this equals $-\frac{\alpha^3}{3}+\left(\frac{3}{4}\frac{2\alpha}{\sqrt{-1}}\ln\left(\sqrt{\alpha}\right)\right)$ = constant cross-section with that underlying rapid coskx oscillation.

Including the effect of the usual resonances for proton, CBR photon interaction we must go one step further and equation 19.22 note $\frac{dt}{ds}\sqrt{g_{oo}} \rightarrow \frac{1}{\sqrt{1-\frac{\alpha}{r}}} \rightarrow \frac{1}{\sqrt{1-\frac{\alpha}{r}-\varepsilon'}}$ with ε'=(4/3)ε.

and the pion mass calculation=ε' resulting in equation 19.22 center of mass energy 1.08 GeV and so the Δ resonance pion photo-production put in:
(Pion photoproduction Energy)/CBRphoton energy= $2.23X10^{-11}/2X10^{-22}$=
GZK/(Proton rest mass Energy) =GZK/$1.5X10^{-10}$. So GZK=$1.04X10^{20}$eV.
Need to include pion photoproduction of the Δ energy in this S matrix for completeness.

P Wave Scattering and Jets In 100GeV Gold-Gold Collisions
Let <A'| represent the outgoing scattering wave immediately after a incident plane wave scatters off V. Let |A> be the $2P_{3/2}$ hyperon state for $r=r_H$ having the V. Thus at $r=r_H$ V itself will have the $2P_{3/2}*2P_{3/2}$ =ψ*ψ trifolium shape and thus commute with |A> since they constitute the same structure ($2P_{3/2}$ commutes with itself). So since V commutes with |A> **then <A' also is a $2P_{3/2}$ state** or we have <A'|V|A>=0 and so no scattering into such states. Thus a type of 'P wave scattering' results from an incident plane wave. Thus we explain the origin of the 'jets' that are otherwise ascribed to scattering off quarks.
Note that when the mean free path d during the interaction time is very short (d<<(1/3) $2\pi r_H$) there is no more smearing between the $2P_{3/2}$ lobes and we have scattering off of independent point particles and the $2P_{3/2}$ state ceases to be relevant in the scattering and so the jets disappear. (jet quenching). Thus at extremely high energy the scattering is from charge e (not 1/3e) again and there are no more jets above top energy. LEP actually observed this effect just before it was shut down.

17.6 Separation of Variables On Equation 1.9
Here we use separation of variables on

$$\Sigma_\mu(\sqrt{\kappa_{\mu\mu}}\gamma^\mu\partial\psi/\partial x_\mu)-\omega\psi=0, \text{ with } \kappa_{oo}=1/\kappa_{rr}=1-r_H/r \quad (1.9)$$

Note from chapter 5 we can begin the derivation of equation 1.9 with:
$ds^2=\kappa_{rr}dr^2+r^2d^2\theta+r^2\sin^2\theta d^2\phi-\kappa_{oo}c^2\,dt^2$
$\kappa_{oo}=1-r_H/r$ and $\kappa_{rr}=1/\kappa_{rr}$. Note in the linearization no κ_{ij}s will be in front of the angle terms. Thus we can show that we can separate out (i.e., use separation of variables) the angle terms and that the ψ will then be of the form ψ=F(r,t)Θ(θ)Φ(ϕ). Thus our $2P_{3/2}$ state at r_H result is indeed a solution to equation 1.9. We also can write:
$ds^2=\kappa_{rr}dr^2+r^2d^2\theta+r^2\sin^2\theta d^2\phi-\kappa_{oo}c^2\,dt^2=dr'^2+r^2d^2\theta+r^2\sin^2\theta d^2\phi-c^2\,dt'^2$

When the quantum operator condition is used $p_r\rightarrow\sqrt{\kappa_{rr}}\,p_r=\sqrt{\kappa_{rr}}\,\partial/\partial r\equiv\partial/\partial r'$. Thus using r' and t' we can do the standard separation of variables.for the standard Dirac equation. At the end the $\sqrt{\kappa_{rr}}$ s are put back in and we get for the radial component of the Dirac equation:

$$\left[\left(\frac{dt}{ds}\sqrt{g_{oo}}\,m_p\right)+m_p\right]F-\hbar c\left(\sqrt{g_{rr}}\frac{d}{dr}+\frac{j+3/2}{r'}\right)f=0$$

$$\left[\left(\frac{dt}{ds}\sqrt{g_{00}}\,m_p\right)-m_p\right]f+\hbar c\left(\sqrt{g_{rr}}\frac{d}{dr}-\frac{j-1/2}{r'}\right)F=0$$

We next take into account that r' denominator in the centripetal term. We do this by finding the gyromagnetic ratios gy for the spin polarized F=0 case. Recall the usual calculation of rate of the change of spin S gives dS/dt∝m∝gyJ from the Heisenberg equations of motion. We note that $1/\sqrt{g_{rr}}$ rescales dr in $\left(\sqrt{g_{rr}}\frac{d}{dr}+\frac{J+3/2}{r}\right)f$. Thus to have the same rescaling of r in the second term we must multiply the second term denominator (i.e.,r) and numerator (i.e., J+3/2) each by $1/\sqrt{g_{rr}}$ and set the numerator equal to 3/2+J(gy), where gy is now the gyromagnetic ratio. This makes our equation compatible with the standard Dirac equation. The effect of this r' term then is to alter the gyromagnetic ratio.from the nominal value of 2. This method is used in the next chapter. Note the direct derivation of the low temperature results (section 17.1) and high energy results summarized in chapter 3. See figure 17.1 for how this contrasts with the mainstream approach.

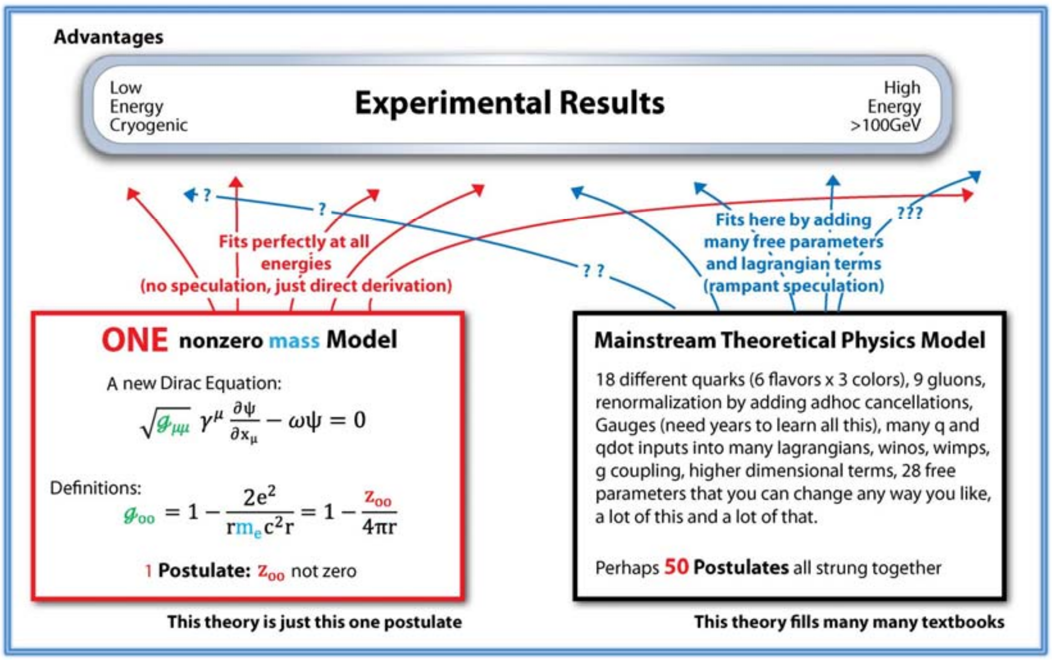

Figure 17-1 Comparison of new pde model with standard model and strings

17.7 Summary of Derivations From the New Pde

Even though there are no gauges in this theory the consequences of the SM standard gauges (such as SU(3)) can be derived from this theory as we have seen. In figure 17.1 below is a summary of these derivations. For example SU(3) comes from that new pde (equation 1.9) $2P_{3/2}$ at $r \approx r_H$. as we see in figure 17-2.

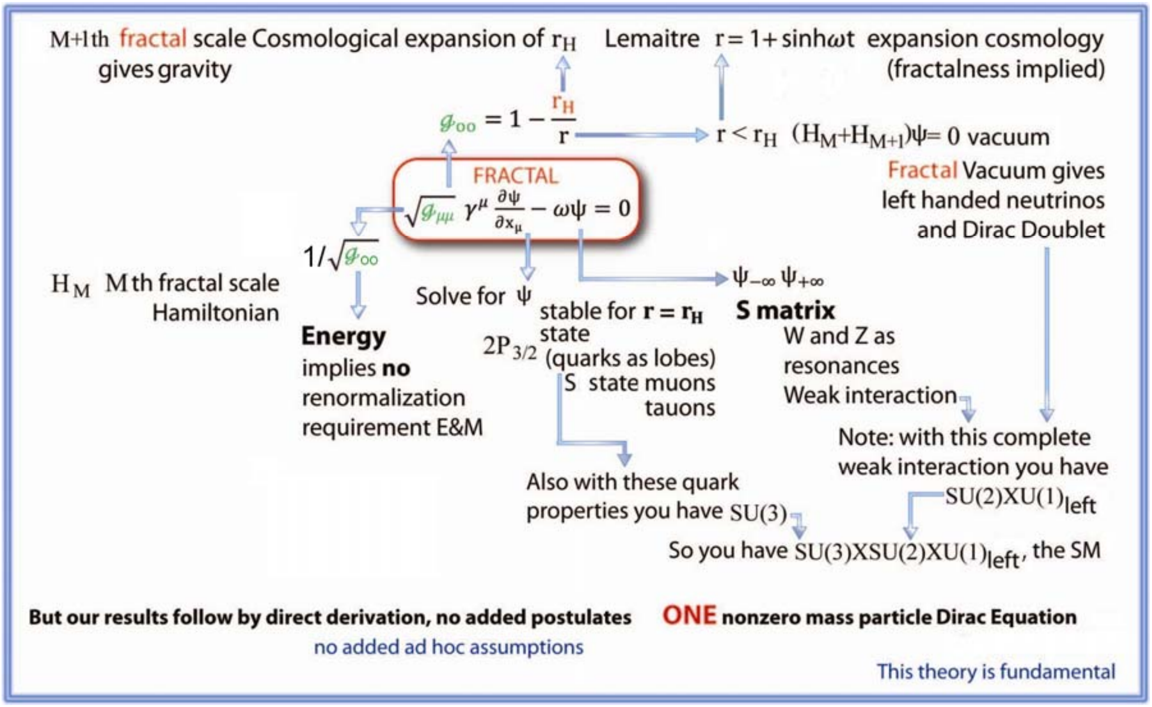

Figure 17-2 Summary of Derivations from equation 1.9

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[i] Weinberg, Steve, *General Relativity and Cosmology*, P.257