Part IV
4D *IS* Quantum Mechanics

Chapter 21

21.1 QM is The Result of 4 Dimensionality

Review: Copenhagen interpretation is merely 4D
Recall in Chapter 1 we postulated a 2D geometric point dZ=dr+idt. We add 2D observer to 2D object to get 4Degrees of freedom and the new (Dirac) pde

$$(\Sigma_\mu \sqrt{\kappa_{\mu\mu}}\gamma^\mu \partial\psi/\partial x^\mu - \omega\psi = 0) \text{ with its } \psi.$$

Thus in adding the 2D observor you have collapsed the wave function to the observed ψ: hence the Copenhagen interpretation of QM is essentially a 4D theory. Also this postulate does not allow hidden variables because that point postulate 1.1 is fundamental, can't get any deeper into some hidden variable realm lets say. Thus the introduction of the observer results in 4D and the collapse of the wavefunction to ψ. Thus the

Copenhagen interpretation of quantum mechanics is really a statement of 4D.

By the way this is all well and good in free space since the $\kappa_{\mu\nu}$ s are trivial then. But in general the eq.1.5, 1.6 constraints on the $\kappa_{\mu\nu}$ s make this still a minimally 2Degree of freedom theory.

21.2 Contrast with Other QM Interpretations

We begin by defining:

U=time development operator=$e^{-iHt/\hbar}$.
$\uparrow$=spin up
O_i =initial observer state
O_{uf} =state of observer for spin up after observation

For the moment we return to the nonrelativistic approximation to the Dirac equation, the Schrodinger equation representation. Thus in that representation, if an atom is originally in a superposition of $\alpha(\uparrow)+\beta(\downarrow)$, then the state resulting from the observer interaction is:

$$U((\alpha(\uparrow)+\beta(\downarrow))\otimes|Oi\rangle = \alpha|\uparrow\rangle\otimes|O_{uf}\rangle + \beta|(\downarrow)\rangle\otimes|O_{df}\rangle$$

If $\alpha|\uparrow\rangle\otimes|O_{1f}\rangle$ is what is then measured then in the (dominant) Copenhagen interpretation $\beta|(\downarrow)\rangle\otimes|O_{df}\rangle$ is just (arbitrarily) dropped and we say that the wave function has collapsed to the final measured value $\alpha|\uparrow\rangle\otimes|O_{uf}\rangle$. Unfortunately in this interpretation this postulated wavefunction collapse by definition happens instantaneously over all space so implies nonlocality and superluminal communication. In many worlds (MWI) on the other hand we don't drop the second term and simply ignore it (call it the second world of many such possible worlds if you want, (Tegmark 1997) even though the second state adds energy to the system (these are not virtual states) and so *leads to a violation of the conservation of energy*. But we still do avoid those wave function collapse conundrums with MWI since the wave function doesn't collapse at all, but at what a cost. In Bohm's interpretation we add adhoc hidden variables to the system along with other adhoc complications (recall we don't allow for hidden variables here anyway). Thus all three QM interpretations appear either adhoc or incorrect. There is a 4^{th} way with no such liabilities that is discussed extensively in the first part of this book. Just note that we can construct the Copenhagen interpretation by bringing in the 2D observer and therefore the collapse to ψ. The Copenhagen interpretation just becomes 4D, a simple, elegant understanding of what otherwise, over the past 70 years at least, has been taken to be a pretty mysterious concept. Furthermore the Schrodinger equation is nearly parabolic differential equation and so boundary conditions appear to apply (nearly) instantaneously whereas the Dirac equation is near hyperbolic and the path integral gives light speed limited information propagation. Since the Schrodinger equation is a special low energy case of the Dirac equation then velocity of information transmission is still limited to below c propagation by the Dirac equation. Thus entangled states do not give information moving faster than c. This won't let us get away (anymore) with claiming that superluminal communication is a result of wavefunction collapse created by bringing in the observer to create the 4D. Also we needn't postulate wave function collapse since bringing in the observer gives 2+2=4 degrees of freedom which are then restrained by saying the Schrodinger boundary conditions are responsible and thereafter constraining them by the Dirac equation.

Klein paradox: does not occur with equation 4, that generalized Dirac equation. There are always reflection eigenfunction solutions at very high potential barriers that are smaller amplitude than the input eigenfunctions which is not true for the old Dirac equation.

21.3 Review Of Covariant Gaugeless Quantization of the Electromagnetic Field

The standard quantization of the electromagnetic field treats the vector potential very differently from the scalar potential so the standard method is not covariant. Also, that method requires the Coulomb gauge 3D divergence and gives a sum of plane wave solutions at the end and thus there is no hint of the pulse nature, lets say of a gamma ray photon (click on a Geiger counter lets say) even though we obtain the second quantization creation and annihilation operators from this method.

Clearly something is wrong if there is not covariance and **from my own work** something is also wrong if you even require a gauge (Section 12.3). Note for spin 1 photon with left and right helicity $[a_R(k), a_R^t(k')] = [a_L(k)] = [a_L(k), a_L^t(k')] = \delta_{kk'}$

Recall you need the commutation relations for the R,L helicity creation-annihilation operators to give the Bose Einstein statistics associated with the photon. The reason for doing the quantization of the electromagnetic field is to derive creation and annihilation operators of individual photons (analogous to the creation annihilation operators for the Dirac particles) in: $H = \Sigma\hbar\omega_k\left(a_R^t(k)a_R(k) + a_L^t(k)a_L^t\right)$.

Our method for introducing covariance is to set the D'Alembertian =0 requiring that we add a scalar potential term to the standard vector potential (Merzbacher QM, page 556, 2nd ed. Wiley) quantization term; i.e., sum to 4 *instead* of 3 in:

$$V^{(=)} = \sqrt{4\pi\hbar c^2}\,\frac{1}{L^{3/2}}\sum_{k=1}^{4}\frac{1}{\sqrt{2\omega_k}}\left[a_1(k)e_k^{(1)} + a_2(k)e_k^{(2)}\right]e^{ikr}$$

Also given the Heisenberg equations of motion (chapter 10)

$$i\hbar\frac{da(k,t)}{dt} = [a(k,t),H] \tag{21.1}$$

we create a new factor $e^{i(kr-\omega t)}$ in the potential.

The 4 vector quantization of the electromagnetic field

$$V^{(=)} = \sqrt{4\pi\hbar c^2}\,\frac{1}{L^{3/2}}\sum_{k=1}^{4}\frac{1}{\sqrt{2\omega_k}}\left[a_1(k)e_k^{(1)} + a_2(k)e_k^{(2)}\right]e^{ikr}$$

then goes to the time dependent form

$$V^{(=)} = \sqrt{4\pi\hbar c^2}\,\frac{1}{L^{3/2}}\sum_{k=1}^{4}\frac{1}{\sqrt{2\omega_k}}\left[a_1(k)e_k^{(1)} + a_2(k)e_k^{(2)}\right]e^{ikr-i\omega t} \qquad (21.2)$$

where the usual 3 vector potential components are given by

$$A^{(=)} = \sqrt{4\pi\hbar c^2}\,\frac{1}{L^{3/2}}\sum_{k=1}^{3}\frac{1}{\sqrt{2\omega_k}}\left[a_1(k)e_k^{(1)} + a_2(k)e_k^{(2)}\right]e^{ikr-i\omega t}$$

with the scalar component is given by

$$V^{(=)} = \sqrt{4\pi\hbar c^2}\,\frac{1}{\sqrt{2\omega_k}}\frac{1}{L^{3/2}}\left[a_1(k)e_4^{(1)} + a_2(k)e_4^{(2)}\right]e^{ikr-i\omega t}$$

In the vector potentials the creation annihilation operator vectors can be rotated, since they are first rank tensors, so the polarization direction is perpendicular to the k vector as is required for the spin 1 E&M field. Thus we have new operators $a_1^t(k)\cos\theta + a_1^t(k)\sin\theta$ and $-a_1^t(k)\sin\theta + a_1^t(k)\cos\theta$. The coefficients in the scalar potential and the angle θ are chosen (also as if originating in a 3D a rotation) so that the D'Alembertian box, instead of the divergence, doted into the four potential is zero. Since scalar V can be in general be time and space dependent this *angle can be dynamic*, changing in both space and time (x,t) to keep the D'Alembertian equal to zero. In any case you get the covariant Lorentz gauge condition instead of the noncovariant Coulomb gauge condition where the $e^1{}_4$ and $e^2{}_4$ are defined so that, along with the usual transverse polarization vectors (to the k vector), the orthogonality of the 4 vectors e_k and k results in

$$\square\bullet V_\mu = \nabla\bullet A(r,t) - \partial V/\partial t = 0 \qquad (21.3)$$

The $e^{ikr-i\omega t}$ term implies a wave equation given by (also in section 1 of Ch.16):

$$\left(\nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right)V = 0, \left(\nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right)A = 0 \qquad (21.4)$$

Which appears to be the old Lorentz gauge formulation of the Maxwell equations. In that regard note as usual B=∇XA, and E =-∂A/∂t (Faraday's Law) using the A. This result is put into $H = \Sigma\hbar\omega_k\left(a_R^t(k)a_R(k) + a_L^t(k)a_L^t\right)$ converting it into an integral over E^2 in the usual way.

So why is 21.3 and 21.4 gaugeless as well? In that regard I found a generally covariant generalization of the Dirac equation that does not require gauges (http://davidmaker.com).. The $\kappa_{rr}\kappa_{oo}$=1 equation (eq.1.5), after taking derivatives and using the Heisenberg equations of motion, becomes the Lorentz gauge form of the Maxwell equations. This result then forces those θ angles in that rotation of the at1 creation operators to be dynamic, changing with time as we discussed earlier. Note also that these Maxwell equations use four potentials instead of E and B fields even though you can still form the E and B fields in the usual way (curlA=B, dV/dr=E) . Thus in this theory the Lorentz gauge is not a gauge anymore so indeed *we do have a covariant, gaugeless quantization of the E&M field*. As you recall Ahronov-Bohm implies such a potential, as opposed to field dependence of physical reality. Note that 21.3 and 21.4 is the Lorentz gauge explicitly covariant form of the Maxwell equations (section 16.2). But 16.2 are the actual physical (Maxwell) equations in potential form (special case of electroweak field equations) and so are not gauged here (section 12.3). Thus, this is a gaugeless and covariant quantization of the electromagnetic field. In any case you get the covariant Lorentz gauge condition instead of the noncovariant Coulomb gauge condition and in the end obtain the second quantization condition for the electromagnetic field: $H = \Sigma\hbar\omega_k\left(a_R^t(k)a_R(k) + a_L^t(k)a_L^t\right)$.

Origin of Quantum Mechanics

historically we note that the rigorous development of mathematics begins with the development of the real numbers which Peano discovered starts with the:

postulate of the real number one

(e.g., Peano's inductive method(1)) which can also be algebraically defined by:

$$z=zz$$

Thus 1=1X1 but 2 does not equal 2X2. If you continue this way you **obtain mathematics** which is just algebra and numbers after all. But we have postulated the "real" number 1 as in "I measure the length of this table to be 1 meter" so we include (finite real# variance) measurement error. Thus we have for some z that $\delta|1-z|^2=0$ (sections 4C,11C) and so we have a real error C in:

$$z=zz+C \qquad (1)$$

Solution To Equation 1

The solution to quadratic equation 1 in general is a complex number z. So the error C implies error (ansatz) $dz=dr+idt\equiv\Delta z$ with $|z-1|\equiv|dz|$. Thus $\delta|dz|^2=0=\delta((dr-idt)(dr+idt))$ =$\boldsymbol{\delta ds^2=0}$ (ie., we have ds^2 invariance. Also see sect.4C). Note this $ds^2\equiv dr^2+dt^2$ implies the polar coordinate circle mapping $dz=dse^{i\theta}$ and its Riemann surfaces if extrema ds=|ds|. Also note for a random (ie.,uncorrelated) second point (variances add, so $\Sigma ds_x ds_y$ diagonalization): $ds_z^2=ds_x^2+ds_y^2$ (1a) as in z=x+y.

Extrema Implied By The Circle Mapping

Given |dr+dt| has extrema on the 45°-225° and 135°-315° diagonals on this circle (appendix A) it then can be set equal to ds since ds=|ds|. So using the elementary diagonal geometry of $\delta|dr+dt|=0$ and the $\delta ds^2=0$ circle invariance we then have positive extrema line element ds' to a single *poin*t

$$dr+dt=\sqrt{2}ds' \qquad (2)$$

on that 45° diagonal implying a new extremum δ(ds')=0 (with ds'and ds^2 each having its own variance oval). Also |dr+dt|=√2ds' has an extremum at 135°. Note as well that |dr+dt| implies both positive and negative dr+dt solutions for the ds^2 extremum at 135°. Since ds in a given quadrant has a single value this also implies, given our values of θ at 45° and 135° in $dz=dse^{i\theta}$, that there is only one value of the product ds^2dz and ds'dz. Also some other possible dr,dt extremas for other functions $f(r,t)=ds^2$ are included in the functionality of tensor κ_{ii} in equation 3 below. Note δ(ds')=0 so that ds' is a separate extrema and is positive due to that |dr+dt|. So ds' can be set to this radius ds on the circle.

Maintaining ds² Invariance

Again note $\delta(dr+dt)=0=\delta((dr-\varepsilon/2)+(dt+\varepsilon/2))\equiv\delta(dr'+dt')$. We can then define $\varepsilon= r_H\equiv 2e^2/m_ec^2$ thereby defining charge e. Also in the above complex dz=dr+idt term we can then for ε<<dr define $\kappa_{rr}\equiv(dr/dr')^2\equiv(dr/(dr-\varepsilon/2))^2\equiv 1/(1-r_H/r)$ which is a 1D tensor in the real component (see sections 7c,13c). Note that ε<<dr is needed in

$$ds^2=\kappa_{rr}dr'^2+\kappa_{tt}dt'^2=(dr-\varepsilon/2)^2+(dt+\varepsilon/2)^2=dr^2+dt^2-\varepsilon dr+\varepsilon dt+\varepsilon^2/2 \qquad (3)$$

to maintain the above ds^2 invariance. Also we are allowed a ξdr≡H added to ε in eq.2 so that ξ defines the (invariant) rest mass m term if $dr=ds_r$ invariant (also define ħ using H≡ħ/c).

Chain Rule Application

Furthermore near $\theta\approx45°$ that circle constraint implies for angular displacements $d\theta$ that in radians $d\theta=\sin\theta\partial r/\partial s+\cos\theta\partial t/\partial s$. Also $d\theta=(\partial\theta/\partial r)dr+(\partial\theta/\partial t)dt$. For the r component of dz (eg., in eq. 3a below) then $dr=\partial r$ and $\partial s\equiv ds_r$ in $(\partial\theta/\partial r)dr= -\sin\theta\partial r/\partial s$ (since θ CCW). Thus $\partial\theta/\partial r=-\sin\theta_o/(ds_r)=-(dt/ds)/(ds_r)= (dr/ds)/(ds_r) \equiv v/(ds_r)$. Note C in eq.2 is uncertainty so $\pm\Delta s\equiv ds$ so $1/ds_r$ is a finite number. So from the chain rule $\partial dz/\partial r= (\partial dz/\partial\theta)(\partial\theta/\partial r)=idz(v/ds_r)$. Thus $vdz= -i(ds_r)(\partial(dz)/\partial r)$. So multiply both sides by $\xi=m=h/(cds_r)$ and get $mvdz=-i(\hbar/c)/ds_r)ds_r d(dz)/dr= -i\hbar d(dz)/cdr$. So in the velocity v cancel the c in $dr/ds\equiv dr/(cdt_o)$ and get finally (operator formalism)

$$p_r dz=-i\hbar d(dz)/dr \qquad (3a)$$

Note both

$$dz=dse^{i\theta} \text{ and } dz=dse^{-i\theta} \qquad (3b)$$

have the same ds^2 second derivative (don't change ds^2dz which again is single valued) and the same for the second point (see below discussion) so for the second point we have a total of four different dz multipliers for the ds^2 case (still satisfying the constancy of ds^2dz) and only 2 dz multipliers for the ds case.

Other Points Are Inside Intervals of Nonzero Measure (Since The Real Numbers Are Cauchy) Including a second point ("observer"), as for example a point in a Cauchy sequence, to the eq.2 line element ds' adds two more degrees of freedom (r',t') so $(dr+dr')+(dt+dt')=\sqrt{2}ds'$ so 4Dof (For next point *outside* of ds region see sect.9C). Note that if inside this ds error region these r',t' become random variables allowing coefficients γ in $dr'\gamma^r =dr''$ since dr'' is still random. Note in figure 2 that by adding the second point inside the ds random error interval dr is split into dr=dr'+dr'' and dt is split into dt=dt'+dt''. Given above that dr' and dt' are both random then since the both dr'+dr'' add to the same number then dr'' (and dt''+dt'=dt) have to be random as well making all primed components of $\sqrt{\kappa_{rr}}\gamma^r dr'+\sqrt{\kappa_{oo}}\gamma^t dt'+...$ random. So given (eq.2) $ds'^2\approx ds^2$ and eq.1a we *require* the Dirac γ^μ coefficients to diagonalize:

$$ds^2\approx(ds')^2\equiv((\sqrt{\kappa_{rr}}\gamma^r dr'+\sqrt{\kappa_{oo}}\gamma^t dt'+..)/\sqrt{2})^2=\kappa_{rr}dr'^2+\kappa_{oo}dt'^2+.. \quad (3c)$$

Applying The Postulate For This Second Point

Recall the above postulate (eq1) implies $\delta ds^2 =0$ and $\delta ds=0$ implying line element invariance $ds=(\sqrt{\kappa_{rr}}\gamma^r dr'+\sqrt{\kappa_{oo}}\gamma^t dt'+..)$ from eq.3c and the uniqueness of equation 2. Note this solution must be the positive component of ds inside of the absolute value $|dr+dt|$, given $dr+dt=\sqrt{2}ds$, since ds is a radius here and this ds is not squared. So we multiply this line element solution by our single dz/ds and use the above required operator formalism (here $\omega/c=1,\hbar=1$). This then implies a generally covariant generalization of the Dirac equation that does not require gauges, our new lepton pde:

$$\sqrt{\kappa_{\mu\mu}}\gamma^\mu\partial\psi/\partial x_\mu=(\omega/c)\psi \qquad (4)$$

See the proof of the covariance of eq.4 in backup section1C below. Note equation 4 is a requirement of the above mathematics. It is not an option implying our postulate eq2 gives a physics theory in contrast to just a math theory. Also we are still on the Z plane since two points and the origin still define a plane.

Equation 4 Implications Of The ds^2 Invariance In Equation 3: $ds^2=dr^2+dt^2-\varepsilon dr+\varepsilon dt+\varepsilon^2/2$ Again $\varepsilon<<dr$ is needed in eq.3 for ds^2 invariance. But ε does not have to be zero for that to occur. For example at 135° dr=dt in eq.2, so that $ds\neq0$, then the two terms $-\varepsilon dr+\varepsilon dt$ in eq.3 cancel anyway so ε can be larger (charged) and still maintain that ds^2 invariance. If instead at 45° dr=-dt in eq. 2 so that ds=0 then the two terms in $-\varepsilon dr+\varepsilon dt$ in equation 3 cannot cancel so ε must be infinitesimal (chargeless). Also the ξ ($\equiv H/r_H=H/dr$) in $\xi(t)dr$ in κ_{rr}, which added to ε, defines the (r invariant) rest mass term. ξ would not be invariant in the κ_{rr} if it was a function of r. That

ds=0 light cone invariance √2ds=0= (dr+ξdr+dt) =dr+dt then obviously implies ξ=0. (Also see Ch.2 for rotational ambient metric requirement for a local ξ to be nonzero if ds≠0). Thus at 135° ds ≠0 so the second point can be inside the error interval ds (variable) noise region. Therefore dr',dt' have to be variables and so dr'+dt'=√2ds≠0. Hence we have derived the nonzero charge ε and mass ξ electron of equation 4. Again from the equation 3 invariance discussion above, if the second point is outside ds at 45° we are still on the light cone with ds still zero mass ξ (and again chargeless ε≈0) eq.4 neutrino. Note in this z plane the –dt (opposite quadrant) gives the respective new pde antiparticle. Eq.1a gives 2 dz s for each ds^2. Equation 2 gives one dz for each ds'.

The 45° case (instead of the equation 2 ds) of the ds^2 iteration is therefore also on the light cone since ds=0 implying mass=ξ=0 and charge=0. So multiply $ds^2=dr^2+dt^2$ by dz_i (i=r or t component) where we again must apply the above operator formalism thereby obtaining second derivatives. That and the corner drdt invariance (below paragraph) then gives us the Maxwell equations and so the massless, chargeless photon boson at 45° (appendix C9, Also see figure 3). But for the ds^2 application on the 135°-315°diagonal the absolute power extremum in |dr+dt| implies maximum positive dr+dt or maximum negative dr+dt. Thus both +dz and –dz (ie.,$dz^{\pm}$) can be used in that ds^2dz multiplication since ds is squared and so the minus sign on ds then is irrelevant. So instead of our dr+ε/2+dt-ε2 we have +dr+ε/2+dt-ε/2 and –dr-ε/2-dt+ε/2 solutions. Multiply the second equation by -1, then add the two resulting equations, then divide by 2 and get dr+ε/4±ε/4+dt-ε/4±ε/4 so that ε→ε±ε. So we multiply each of the two ds^2 cases (above |dr+dt| discussion) by its own dz, each with its own $\kappa_{rr}=1/(1-\varepsilon/r) \rightarrow 1/(1-(\varepsilon\pm\varepsilon)/r)$ (sect.16.2) implying 2 charges ε-ε=**0**, ε+ε=2**ε** and so two Proca equation massive W,Z.

Recall from just below equation 3a that 4 dz multiply the dr, 2 dz multiply the ds so we see in figure 2 that the total areas ds^2 drdt giving us these Proca equations at 135° and also Maxwell's equations at 45° (see section 14C for the details of this derivation). Section 9C also shows how the other allowed option, the above 2 point ds sum over quadrants I and II (instead of in each quadrant by itself respectively as above), then implies the weak interaction left handededness. Also from section 1 at 135° given ds=r, $\xi dr=H=drE/m_ec^2=hc/(m_ec^2)$ implying the well known relation E=hc/λ =ħω. Given that the new pde eq.4 implies $\lambda=2\pi r_H$ is a wavelength (in the zitterwebegung oscillation term) we have then also derived the Compton wavelength λ implying given that we can't take the limit to be smaller than r_H at 135°. But at 45° for ds=0 we can take the limit dr→0 and dt→0 and so localize (this pulse) to a space-time point r,t. Thus ξdr≡hc/E does not do anything to the light cone relation ds=0 and yet still dr/dt=c. Therefore ξ is a localizable energy on the light cone and we have then derived the well known relation ; ξdr=H $=drE/m_ec^2=hc/(m_ec^2E/m_e$ or E= ħω energy of the photon. **Therefore we have derived the photon** (as observed in shot noise Poisson statistics and the photoelectric effect). See section 11C also.

The figure 2 $|dr+dt|^2 = (dr+dt-i(dr+dt))(dr+dt+i(dr+dt))$ invariance ds (ψ) iteration relationship with ds^2 (χ) implies the V-A (since then $\frac{1}{2}(1\pm\gamma^5)\psi=\chi^{(\pm)}$) generalized 4point interaction. Also if the mass terms ξ(r) and ξ(t) are 0 (as at 45°) then each of the two terms ξ^2A_μ and □•A are trivially zero (as at 45°) so we have derived the Maxwell equations. **Thus our Z plane contains the electro-weak model WS.**

So we indeed are on solid ground (per above introduction).

Note this is a *unique mapping to the WS* on a given Riemann surface since other choices of dr, dt (eg., $\gamma' dr^3$, $\gamma'' dr^{1/2}$) in equations 2 and 3b yield dr,dt powers other than the $dr^2 + dt^2$ in eq.3b implying all such other γ',γ'' s have to be zero. In contrast string theory maps to 10^{500} different physics theories with possibly some parts of the WS coming out in one of those maps. Here also the branch cuts and higher order Reimann surfaces yield the strong interaction and gravity physics (next paragraph). New and interesting physics predicted by this theory in this regime is being discovered observationally as we speak (see rest of book). For example:
Equation 4 Implications Of The Branch Cut of Reimann Surface Circle Mapping (sect.12c) In addition the Reimann surface branch cut at $r=r_H$ (so time component $\kappa_{oo}=1-r_H/r=0$), implies baryonic stability. Also at $r=r_H$ that new pde $2P_{3/2}$ state fills first so each lobe of its $\psi^*\psi$ 3 lobed trifolium has average (1/3)e (fractional charge), lobes can't leave (asymptotic freedom), 6 P states (6 flavors of quark), P wave scattering (jets). Hence we have derived the strong interaction. Also the above $\delta(ds^2)=0$ implies relativity (ie.,is a Lorentz transformation requirement sec13c.) Thus including the **branch cut** our Z plane contains not only the electro-weak model (previous section) but the entire Standard Model Of Particle Physics (GSW). Given that C is also an extremum for the additional points ds these Reimann surfaces actually exist and must also be fractal (sect.5C). So we have derived a fractal cosmology (eg.,Ch.2,12)..
Thus we have the origin of quantum mechanics in that C of equation 1.

1.1 that we look at higher derivatives $\partial^M(\delta d\theta)/\partial\theta^M$ giving nonlocal (non point) effects and an added (observer) 2 degrees of freedom dr',dt' and resulting generally covariant generalization of the Dirac equation that does not require gauges, that new pde equation 4. The new pde explicitly then is not give the ψ without the observer and we will have derived the Copenhagen interpretation of quantum mechanics.

Metric Quantization Planck's Constant
Recall for metric quantization uncertainties in distances can be on the order of millions of light years instead of nanometers. So for metric quantization to work we require a new Planck's constant h' for the gravitational N+1 h fractal metric interactions. We found the gravitational interaction from 10^{40} X scale change in chapter 1 implying a spatial scale ratio of $ke^2/Gm_e^2=10^{40}$. From section 2.3 our new Planck's constant is then $\hbar'\equiv(ke^2/GN^2m^2)\hbar=N^2 2.26X10^6$ Js where N is the multiple of the electron mass for the given particle interaction with the background metric. $\Delta x\Delta p\geq\hbar'=N^2 2.26X10^9$ Js. $\Delta x=NX2X10^6X5.8X10^{12}X1.6X1000=N2X10^{22}$.
$\Delta p=Nhc/\lambda=N6.65X10^{-34}3X10^8/10^{-13}=2N10^{-13}$ so that our cosmological metric quantization uncertainty principle reads as:
$\Delta x\Delta p=(N2X10^{22})(N2N10^{-13})= N^2 2.26X10^9$ J-s= $\hbar'$.

Explanation of Figure 21-1: dr+dt=constant and δ(ds)=0 Implies |dr|=|dt|
Recall section 1.1.

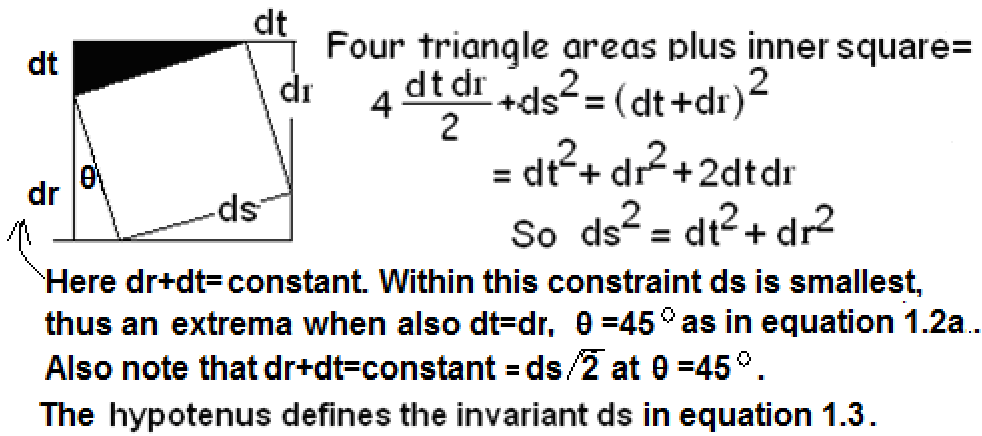

Figure 21-1

Note when dr+dt= constant and δ(ds)=0 and so constant=ds√ 2 and dt=dr.

Short Summary

Here is that summary of the physics: solve z=zz+C with $\delta|1-z|^2=0$

There can be no more rigorous or fundamental ways of doing theoretical physics!

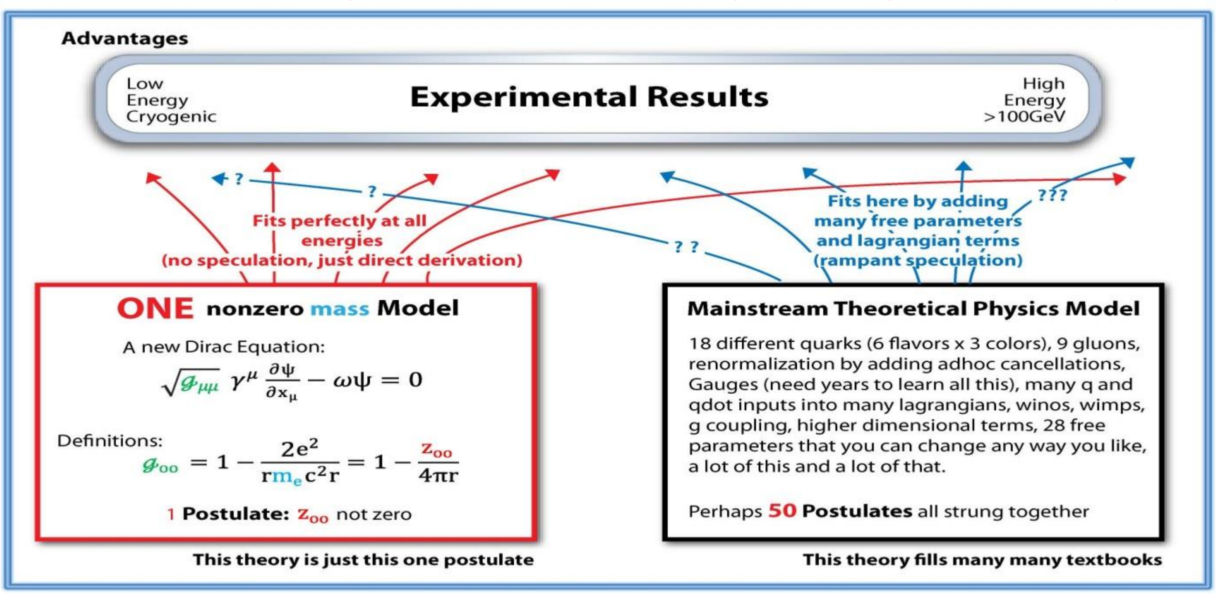

Figure 21-2

References

Bell J.S., *Speakable and Unspeakable in Quantum Mechanics*, 1987, Cambridge, pp.84

Max Tegmark 1997,arXiv:quant-ph/97/09032v1 15Sept 1997