COMPLEX SPACE-TIME QUANTUM GRAVITY HYPOTHESIS

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Abstract. Classical field is defined by Einstein field equations, here I present derivation of field equations that take into account quantum effects. I do so by turning complex space-time into real space-time and making field independent of chose of coordinate system. To make so I expand Einstein equations and then by their contraction I will arrive at field equations for real space-time that is generated from complex space-time. Those equations are just Einstein field equations but derived from complex space-time.

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1. General physical field

Einstein goal of his theory or relativity was to combine all physical laws into one law regarding gravity field. But later in his life he was trying to unify all physical laws into one general field theory. My approach is that after all he was right about that quantum theory is incomplete theory, it's lacking one thing- consistency. So called measurement problem says that physical process of measuring state of the system is not included into laws that govern evolution of the system there is need for second law for measurement and measurement itself is not contained as physical action but rather as method of doing calculations right. So what if there is a more general field theory that adds quantum effects to classical field? This whole paper tries to answer that question with a yes, there is a general field theory that is more general than relativity and has all quantum effects build into it. To build theory like that there is strong need for generalisation of what wave function in quantum mechanics is, field itself has to contain dependence on object that has wave-like property. And that is in general spread across space and does evolve in time, this object will not live in normal space-time a real space-time but in a complex space-time. That idea of complex space-time is key to understand field itself that is just a generalization of simple statement:

All physical laws are same for each frame of reference.

From theory of relativity follows that speed of light is constant for all observers, this law should be only law that is left, first law that states all physical laws are equal in each frame of reference is just a statement that speed of light is constant for all observers. But a normal theory of relativity deals with real space-time, that is not full picture. To make it a complete picture I need to approach it from point of view of complex space-time [1] [2] [3] [4]. Still there is need for speed of light to be constant for all observers but this time for all complex observers. So general field should obey one rule:

Speed of light is constant for all observers living in complex space-time.

Now there would be nice to define an observer but observer is just another way of saying we have a clock that measures time and there is a rod that measures distance in space, more precise those are better the observer fits our definition. So in general observer is just a clock and a ruler that measures time and distance in precise way.

2. Complex space-time

All observers living in complex space-time will agree that speed of light is kept constant for all of them. But how build a mathematical model that has it all in one field equation? First I need to look at what is a wave function that lives in complex space-time and then try to generalize it. By generalization I mean process that has in common same action for all possible wave functions, so all wave function have in common only one thing, they are complex being turning into real fields when measured, where for now I will discard spin from wave function. So i just have a scalar wave function Ψ and its complex conjugate Ψ^*. When I do combine them I will get a real field $\Psi^2 = \Psi\Psi^*$, that complex field turning into real field is a process in general that is at heart of quantum physics. But still space-time is not a scalar quantity but in simplest form it has four directions so it should a tensor quantity. That degrees of freedom being four as far as we can tell from all experiments done, means that this field needs to come from field that itself has four degrees of freedom. And that would be a field that takes all possible vector fields and all possible covector fields so in more precise way it takes complex vector field and it's complex conjugate of field itself. Those two fields make a mixed tensor of $(1, 1)$ order that will have very interesting property, if I contract that field I will get a real scalar field and that is exactly what is needed to define a wave function complex scalar field. This operation can be written as very simple formula first off using tensor product of two fields, one vector field one covector field living in complex space-time:

$$\Psi^{\phi}_{\overline{\mu}} = \Psi^{\phi} \otimes \Psi_{\overline{\mu}} \tag{2.1}$$

Now contraction of this field leads to a real scalar field that is itself a key in this whole enterprise of finding a general field theory. I will define a real scalar field squared , where that field is contraction of vector,covector field in complex space-time:

$$\Psi^2 = \Psi^{\phi}_{\overline{\phi}} \tag{2.2}$$

This field itself is most general object that can be created in complex space-time that turns into a scalar field and has a physical meaning. In quantum physics meaning of that field is that is represents a probability of finding particle at given location but how to reverse it? What is probability made of? It is made of complex vector, covector field contraction. So a physical process is not measurement but complex vector field and it's covector field - that could be thought as a twin that combined gives measurement outcome but itself is a process that explains measurement.

3. Space-time interval in complex space-time

I will start by writing complex flat space-time metric:

$$ds^2 = \eta_{\mu\overline{\nu}} dz^\mu d\overline{z}^\nu \tag{3.1}$$

Now I can expand it first I will expand product of complex vectors:

$$dz d\overline{z} = (d\alpha)^2 + (d\beta)^2 = (d\alpha + i d\beta)(d\alpha - i d\beta) \tag{3.2}$$

$$\eta_{\mu\overline{\nu}} dz^\mu d\overline{z}^\nu = \left[\left(d\alpha^0\right)^2 + \left(d\beta^0\right)^2\right] - \sum_{i=1}^{3}\left[\left(d\alpha^i\right)^2 + \left(d\beta^i\right)^2\right] \tag{3.3}$$

For massless particles this equation takes form of equality:

$$\left[\left(d\alpha^0\right)^2 + \left(d\beta^0\right)^2\right] = \sum_{i=1}^{3}\left[\left(d\alpha^i\right)^2 + \left(d\beta^i\right)^2\right] \tag{3.4}$$

Where complex Lorentz transformation [5] are derive from need that:

$$ds^2 = ds^{2\prime} \tag{3.5}$$

$$\begin{aligned}&\left[\left(d\alpha^0\right)^2 + \left(d\beta^0\right)^2\right] - \sum_{i=1}^{3}\left[\left(d\alpha^i\right)^2 + \left(d\beta^i\right)^2\right] \\ &= \left[\left(d\alpha^{0\prime}\right)^2 + \left(d\beta^{0\prime}\right)^2\right] - \sum_{i=1}^{3}\left[\left(d\alpha^{i\prime}\right)^2 + \left(d\beta^{i\prime}\right)^2\right]\end{aligned} \tag{3.6}$$

If space-time is complex so has to be a metric tensor, so metric tensor is now function of two complex vectors, one vector and one it's complex conjugate so in general it's a complex tensor field, first I will write it in general for two complex fields it will create a metric:

$$ds^2 = g_{\mu\overline{\nu}} dz^\mu d\overline{z}^\nu \tag{3.7}$$

Where this tensor field has property it's transpose and complex conjugate is equal to itself:

$$g_{\mu\overline{\nu}} = g_{\overline{\nu}\mu} \tag{3.8}$$

Where this tensor field is defined:

$$g_{\mu\overline{\nu}} = \frac{\partial \xi^\alpha}{\partial z^\mu}\frac{\partial \overline{\xi}^\beta}{\partial \overline{z}^\nu}\eta_{\alpha\beta} \tag{3.9}$$

Last part is geodesic equation that changes from complex to real field created from complex vectors:

$$\left(\frac{d^2 x^\mu}{ds^2} + \Gamma^\mu_{\alpha\overline{\beta}}\frac{dz^\alpha}{ds}\frac{d\overline{z}^\beta}{ds}\right) = 0 \tag{3.10}$$

4. Basis relation with complex mixed field

Metric depends on basis vector chosen for representation of complex field. I can use equation that connect metric with basis vectors:

$$g_{\mu\overline{\nu}} = \hat{e}_{\mu} \cdot \hat{e}_{\overline{\nu}} \tag{4.1}$$

$$g_{\overline{\nu}\mu} = \hat{e}_{\overline{\nu}} \cdot \hat{e}_{\mu} \tag{4.2}$$

$$\hat{e}_{\mu} \cdot \hat{e}_{\overline{\nu}} = \hat{e}_{\overline{\nu}} \cdot \hat{e}_{\mu} \tag{4.3}$$

$$g_{\mu\overline{\nu}} = g_{\overline{\nu}\mu} \tag{4.4}$$

That proofs relation i wrote before. Complex mixed field can be written too with using of base vectors:

$$\Psi^{\phi}_{\overline{\mu}} = \Psi^{\phi} \otimes \Psi_{\overline{\mu}} = \Psi^{\phi}\Psi_{\overline{\mu}}\hat{e}^{\overline{\mu}} \otimes \hat{e}_{\phi} \tag{4.5}$$

Basis vector used in metric and used in complex mixed field are same vectors- it means that complex mixed field is expressed in some coordinates and from those coordinates that map wave mixed field I calculate metric. So depending on mixed complex tensor field I chose , there are different solutions for real space-time. In general coordinates should be chose this way to best map mixed tensor field. Basis vector can be written in another way as change of base vector or a covector:

$$\hat{e}_{\mu} \cdot \hat{e}_{\overline{\nu}} = \frac{\partial}{\partial \xi^{\mu}} \cdot \frac{\partial}{\partial \overline{\xi}^{\nu}} \tag{4.6}$$

Where those are complex curvilinear coordinates. So I can get metric tensor from mixed tensor field by changing one index of that field to covariant index:

$$g_{\phi\nu}\Psi^{\phi}_{\overline{\mu}} = g_{\phi\nu}\Psi^{\phi} \otimes \Psi_{\overline{\mu}} = \sum_{\phi} g_{\phi\nu}\Psi^{\phi}\Psi_{\overline{\mu}}\hat{e}^{\phi} \otimes \hat{e}^{\nu} \otimes \hat{e}^{\overline{\mu}} \otimes \hat{e}_{\phi} = \Psi_{\nu}\Psi_{\overline{\mu}}\hat{e}^{\nu} \otimes \hat{e}^{\overline{\mu}} \tag{4.7}$$

In this equation there is metric tensor, but used base vectors will lead to inverse metric tensor:

$$\hat{e}^{\nu} \cdot \hat{e}^{\overline{\mu}} = g^{\nu\overline{\mu}} \tag{4.8}$$

Now to get metric tensor not it's inverse I do change index but this time opposite way:

$$\Psi^{\phi}_{\overline{\mu}}g^{\overline{\mu\nu}} = \Psi^{\phi} \otimes \Psi_{\overline{\mu}}g^{\overline{\mu\nu}} = \sum_{\overline{\mu}} \Psi^{\phi}\Psi_{\overline{\mu}}g^{\overline{\mu\nu}}\hat{e}_{\phi} \otimes \hat{e}^{\overline{\mu}} \otimes \hat{e}_{\overline{\mu}} \otimes \hat{e}_{\overline{\nu}} = \Psi^{\phi}\Psi^{\overline{\nu}}\hat{e}_{\phi} \otimes \hat{e}_{\overline{\nu}} \tag{4.9}$$

$$\hat{e}_{\overline{\nu}} \cdot \hat{e}_{\phi} = g_{\overline{\nu}\phi} \tag{4.10}$$

5. Spin

Spin will be just a way of saying that manifold is cyclic if I move in geodesic path. It means that I will eventually get to a space point I started with. When I have two geodesic that are located at two points in space (t_A, x_A) and $(t_B, -x_A)$ and same two points in space but not same points in time (t_E, x_A) and $(t_F, -x_A)$. Then I use curvature tensor between those two points or more precise following path from that point to another for first two points in time and second two points in time I will get equality:

$$\int_{\forall P\left((t_A,x_A);(t_B,-x_A)\right)\in X} R^{\rho}_{\sigma\mu\nu} ds = -\int_{\forall P\left((t_E,-x_A);(t_F,x_A)\right)\in X} R^{\rho}_{\sigma\mu\nu} ds \tag{5.1}$$

Where $P\left((t_A, x_A);(t_B, -x_A)\right)$ represents a path in space-time from (t_A, x_A) to $(t_A, -x_A)$. This gives definition of rotation on a manifold, if I move in every direction on that manifold and follow a every geodesic going from space point x_A to $-x_A$ then from $-x_A$ to x_A I will get one positive rotation, If i do the opposite will get negative rotation. Both path integrals are equal to zero:

$$\int_{\forall P\left((t_A,x_A);(t_B,-x_A);(t_C,x_A);(t_D,-x_A)\right)\in X} R^{\rho}_{\sigma\mu\nu} ds = 0 \tag{5.2}$$

$$\int_{\forall P\left((t_E,-x_A);(t_F,x_A);(t_G,-x_A);(t_H,x_A)\right)\in X} R^{\rho}_{\sigma\mu\nu} ds = 0 \tag{5.3}$$

Where spin state is equal to a tensor field that takes curvature tensor that travels all possible geodesic paths in one direction or the other:

$$\uparrow^{\rho}_{\sigma\mu\nu} = R^{\rho}_{\sigma\mu\nu}\Big|_{\forall P\left((t_A,x_A);(t_B,-x_A);(t_C,x_A);(t_D,-x_A)\right)\in X} \tag{5.4}$$

$$\downarrow^{\rho}_{\sigma\mu\nu} = R^{\rho}_{\sigma\mu\nu}\Big|_{\int_{\forall P\left((t_E,-x_A);(t_F,x_A);(t_G,-x_A);(t_H,x_A)\right)}\in X} \tag{5.5}$$

It comes from fact that if I do rotation for every possible direction on manifold I will cover whole manifold. Spin probability is equal to:

$$\rho^2_{\uparrow} = \frac{\int_{\forall P\left((t_A,x_A);(t_B,-x_A);(t_C,x_A);(t_D,-x_A);\right)\in X} \Psi^2 d^3\mathbf{x}}{\int_{\forall P\left((t_A,x_A);(t_B,-x_A);(t_C,x_A);(t_D,-x_A);(t_E,-x_A);(t_F,x_A);(t_G,-x_A);(t_H,x_A)\right)\in X} \Psi^2 d^3\mathbf{x}} \tag{5.6}$$

$$\rho^2_{\downarrow} = \frac{\int_{\forall P\left((t_E,-x_A);(t_F,x_A);(t_G,-x_A);(t_H,x_A)\right)\in X} \Psi^2 d^3\mathbf{x}}{\int_{\forall P\left((t_A,x_A);(t_B,-x_A);(t_C,x_A);(t_D,-x_A);(t_E,-x_A);(t_F,x_A);(t_G,-x_A);(t_H,x_A)\right)\in X} \Psi^2 d^3\mathbf{x}} \tag{5.7}$$

6. Quantum gravity principle

In General Theory of Relativity there is principle that governs whole theory and that will be equivalence principle, but If I extend theory of relativity to complex space-time this principle has to change. Let's imagine I have a falling electron that is a four vector in complex space-time. That electron does oscillate in complex space and time, so from it's point of view falling down in straight line (geodesic) is not whole story- that oscillation is key change between classical and quantum world. One could say that electron acts just as classical wave but I will assume that this wave like property needs to be get rid of make a leap from complex space-time to space-time itself. So now I can build a quantum gravity principle, that will state:

For given complex covector or a vector field that represents a state of a quantum system there is a process that takes complex vector field turns into real field. That real space-time created out of this complex space-time is independent on how I chose coordinate system.

In general all units used will be Planck units. Complex vector or covector field needs to turn into real field to make gravity work and from it follows all cyclic effects of complex field need to vanish with complex space-time. That vanishing is turning complex field into real field so at the end I will get rid of cyclic effects and problem with looping of space and time. So turning complex field into real field is how I get from complex space-time into real space-time. But I need not only get rid of complex space-time I need to create a real space-time and to do so I need to assume that space-time is independent on how I chose coordinate system.

7. Measurement problem

Measurement problem is one of biggest if not the biggest unsolved problem in physics, normally interpretation is that I take complex normalized [6] mixed field contract it and get probability for given state. But still it does not explain why that function changes or collapses to just one position. So wave function is not enough to explain measurement there is need for additional rule for measurement. And we can never observe particle in two places at once but we can observe effects of it acting like it was in two places at once before preforming a measurement. But if I talk about gravity there is problem with this way of thinking, simple question arises, where does gravity field of wave function is localized in space? All gravity effects we see seem like there is always localized gravity field. So there is apparent problem here, if gravity field is always localized and it has to be in order to make gravity a real thing so why does particle before measurement is not? To solve that problem there needs to be an equation that predicts both states before measurement and after it. What is observed after measurement is just classical gravity field govern by Einstein field equations, before it there is some complex field and contraction of that field leads to Einstein field equations with probability. So after measurement real field needs to change so it means that probability scalar field will change after measurement and so will change Einstein field equation with probability scalar field. But how it will change? Probability needs to change to still explain particle in new state but Einstein field equations change simply- if start of my coordinate system is where particle is localized I can chose start of coordinate system for any point of space, then after measurement shift it to make that starting point at position of particle, so now I measure all gravity effects from point of view of that particle measured position, if I repeat this process in each small instant of time I will get full evolution of particle that will look close to classical trajectory. If I don't do measurement system will just behave like normal field equation but without localized particle. And probability contains all information about possible position of particle.

8. Field equation

To create a field equation I need to reduce is to Einstein field equations [7] [8] [9], where equation itself will be expansion of Einstein field equations that connects complex space-time with scalar real field:

$$\Psi_{\overline{\epsilon}}^{\beta} R_{\alpha\overline{\beta}\overline{\gamma}}^{\rho} - \frac{1}{2}\Psi_{\overline{\epsilon}}^{\beta} g^{\rho\overline{\kappa}} R_{\kappa\overline{\beta}} \delta_{\alpha}^{\overline{\beta}} \delta_{\overline{\beta}}^{\alpha} g_{\alpha\overline{\gamma}} = \kappa \Psi_{\overline{\epsilon}}^{\beta} T_{\alpha\overline{\phi}} g^{\phi\rho} g_{\overline{\beta\gamma}} \tag{8.1}$$

$$\Psi_{\overline{\epsilon}}^{\beta} R_{\alpha\overline{\rho}\overline{\gamma}}^{\rho} - \frac{1}{2}\Psi_{\overline{\epsilon}}^{\beta} g^{\rho\overline{\kappa}} R_{\kappa\overline{\rho}} \delta_{\alpha}^{\overline{\beta}} \delta_{\overline{\beta}}^{\alpha} g_{\alpha\overline{\gamma}} = \kappa \Psi_{\overline{\epsilon}}^{\beta} T_{\alpha\overline{\phi}} g^{\phi\rho} g_{\overline{\rho\gamma}} \tag{8.2}$$

$$\Psi_{\overline{\epsilon}}^{\beta} R_{\alpha\overline{\gamma}} - \frac{1}{2}\Psi_{\overline{\epsilon}}^{\beta} g^{\rho\overline{\kappa}} R_{\kappa\overline{\rho}} \delta_{\alpha}^{\overline{\beta}} \delta_{\overline{\beta}}^{\alpha} g_{\alpha\overline{\gamma}} = \kappa \Psi_{\overline{\epsilon}}^{\beta} T_{\alpha\overline{\phi}} \delta_{\overline{\gamma}}^{\phi} \tag{8.3}$$

$$\Psi_{\overline{\epsilon}}^{\beta} R_{\alpha\overline{\gamma}} - \frac{1}{2}\Psi_{\overline{\epsilon}}^{\beta} R g_{\alpha\overline{\gamma}} = \kappa \Psi_{\overline{\epsilon}}^{\beta} T_{\alpha\overline{\gamma}} \tag{8.4}$$

$$\Psi_{\overline{\beta}}^{\beta} R_{\alpha\overline{\gamma}} - \frac{1}{2}\Psi_{\overline{\beta}}^{\beta} R g_{\alpha\overline{\gamma}} = \kappa \Psi_{\overline{\beta}}^{\beta} T_{\alpha\overline{\gamma}} \tag{8.5}$$

$$\Psi^2 R_{\alpha\overline{\gamma}} - \frac{1}{2}\Psi^2 R g_{\alpha\overline{\gamma}} = \kappa \Psi^2 T_{\alpha\overline{\gamma}} \tag{8.6}$$

This equation is Einstein field equation for complex space-time. But still it's final product is a real space-time. Field itself is govern by first equation then this equation reduces can be reduced to Einstein field equation multiply by scalar field:

$$\boxed{\Psi_{\overline{\epsilon}}^{\beta} R_{\alpha\overline{\beta}\overline{\gamma}}^{\rho} - \frac{1}{2}\Psi_{\overline{\epsilon}}^{\beta} g^{\rho\overline{\kappa}} R_{\kappa\overline{\beta}} \delta_{\alpha}^{\overline{\beta}} \delta_{\overline{\beta}}^{\alpha} g_{\alpha\overline{\gamma}} = \kappa \Psi_{\overline{\epsilon}}^{\beta} T_{\alpha\overline{\phi}} g^{\phi\rho} g_{\overline{\beta\gamma}}} \tag{8.7}$$

$$\boxed{\Psi^2 R_{\alpha\overline{\gamma}} - \frac{1}{2}\Psi^2 R g_{\alpha\overline{\gamma}} = \kappa \Psi^2 T_{\alpha\overline{\gamma}}} \tag{8.8}$$

Those field equations relate vector, covector field with curvature and energy. For four dimensional space-time each part of equation has thirty unknowns, for higher dimensions this formula will not have equal number of unknowns there could be two possible reasons, this equation works only for four dimensional space-time or it works for higher dimensions just number of unknowns is not equal for each component so it creates some kind of symmetry between curvature tensor and rest of equation, where curvature tensor will have more independent components than rest of equation. From quantum gravity principle follows that I state law of physics this way that for any complex vector or covector field that will reduce to real field do not depend on how I chose coordinate system.

9. Meaning of field

There are two equations that fully represents this hypothesis. First one is complex space-time equation then contraction of this equation leads to Einstein field equations. But what is physical meaning behind those equations? In short it's simplest way to turn complex space-time into real space-time, first equation:

$$\Psi^{\beta}_{\bar{\epsilon}} R^{\rho}_{\alpha\bar{\beta}\bar{\gamma}} - \frac{1}{2}\Psi^{\beta}_{\bar{\epsilon}} g^{\rho\bar{\kappa}} R_{\kappa\bar{\beta}} \delta^{\bar{\beta}}_{\alpha} \delta^{\alpha}_{\bar{\beta}} g_{\alpha\bar{\gamma}} = \kappa \Psi^{\beta}_{\bar{\epsilon}} T_{\alpha\bar{\phi}} g^{\phi\rho} g_{\overline{\beta\gamma}} \tag{9.1}$$

Is simplest complex equation that has mixed tensor field in it and can be contracted to Einstein field equations multiply by a scalar field:

$$\Psi^{2} R_{\alpha\bar{\gamma}} - \frac{1}{2}\Psi^{2} R g_{\alpha\bar{\gamma}} = \kappa \Psi^{2} T_{\alpha\bar{\gamma}} \tag{9.2}$$

But those are not normal Einstein field equations, I use complex numbers and their conjugate as base for all calculations. Still i get a real field in the end but it has two values for each coordinate one comes from real field and one from complex field- it means that in reality space-time will be not four dimensional in our universe case but eight dimensional where additional dimensions come from complex field part- they are still real but are independent coordinates on their own. So whole field equation deals with simple yet complex idea when expressed in mathematical terms- complex space-time turning into real space-time. Where mixed tensor $\Psi^{\beta}_{\bar{\epsilon}}$ in first field equation will be responsible for off diagonal elements that will not reduce to a real field no matter what in general case. From fact that curvature tensor and Ricci tensor come from metric tensor and metric tensor will be a real tensor they will be a real field, so only change between real and complex space-time is mixed tensor field that contains information about field itself. That tensor will be reduced later when field is contracted and will vanish, this tensor needs to be normalized when contracted:

$$\int \Psi^{\beta}_{\bar{\beta}} d^3\mathbf{x} = \int \Psi^{2} d^3\mathbf{x} = 1 \tag{9.3}$$

Meaning of this tensor is that it represents a probability density of field, field is spread across space and how much is spread is define by this integral- whole field is spread over all space. Field equation would work without that tensor field but then it would not contain field density information, it could be contracted in field equation itself then it would be not a complex field at all. So as explained in first paragraphs of this chapter field equation is simplest to turn a complex space-time into real space-time and still preserving some kind of invariant property of complex field.

10. Measurement

Probability of finding particle for given volume of space is equal to integral over space of that scalar field:

$$\rho^2_{V\in\text{Space}} = \int_{V\in\text{Space}} \Psi^2 d^3\mathbf{x} \tag{10.1}$$

When I do measurement field does change, I just find particle in some volume, it comes from fact that field equation itself is multiply by this scalar so finding particle at some point but field equation does change- now all gravity effects are measured from that point where particle was found. So I need to solve not one equation by infinite number of equations for each point of space to get full solution. So before measurement I have field equation in state:

$$\Psi^2 R_{\alpha\overline{\gamma}} - \frac{1}{2}\Psi^2 R g_{\alpha\overline{\gamma}} = \kappa\Psi^2 T_{\alpha\overline{\gamma}} \tag{10.2}$$

After measurement scalar field does change so does rest of equation, changes this way that all gravity effects or particle is at point of measurement , so field shifts it's location to point of measurement so that point where particle is so it's zero point it is now equal to point of measured particle, where $\Delta\mathbf{x}$ represents point of measurement:

$$\Psi'^2 R_{\alpha\overline{\gamma}}\left(\mathbf{x}-\Delta\mathbf{x}\right) - \frac{1}{2}\Psi'^2 R g_{\alpha\overline{\gamma}}\left(\mathbf{x}-\Delta\mathbf{x}\right) = \kappa\Psi'^2 T_{\alpha\overline{\gamma}}\left(\mathbf{x}-\Delta\mathbf{x}\right) \tag{10.3}$$

This shifting of coordinates is what happens when state of particle is measured where key is that scalar field does change by measurement process to a new scalar field that represents that measured field probability Ψ'^2. For spin states before measurement there is Ψ field after there is Ψ'^2, so spin state after measurement chages to :

$$\rho^2_{\uparrow} = \frac{\int_{\forall P\left((t_A,x_A);(t_B,-x_A);(t_C,x_A);(t_D,-x_A);\right)\in X} \Psi'^2 d^3\mathbf{x}}{\int_{\forall P\left((t_A,x_A);(t_B,-x_A);(t_C,x_A);(t_D,-x_A);(t_E,-x_A);(t_F,x_A);(t_G,-x_A);(t_H,x_A)\right)\in X} \Psi'^2 d^3\mathbf{x}} \tag{10.4}$$

$$\rho^2_{\downarrow} = \frac{\int_{\forall P\left((t_E,-x_A);(t_F,x_A);(t_G,-x_A);(t_H,x_A)\right)\in X} \Psi'^2 d^3\mathbf{x}}{\int_{\forall P\left((t_A,x_A);(t_B,-x_A);(t_C,x_A);(t_D,-x_A);(t_E,-x_A);(t_F,x_A);(t_G,-x_A);(t_H,x_A)\right)\in X} \Psi'^2 d^3\mathbf{x}} \tag{10.5}$$

If i do first position measurement then spin, I will first change scalar field from Ψ to Ψ' then change it again to Ψ'' and this process can go as long as I do new measurement.

11. Summary

Field itself is background independent that comes from Einstein field equations So general idea goes like this:

(1) Take Einstien field equations with complex field:

$$\Psi^2 R_{\alpha\overline{\gamma}} - \frac{1}{2}\Psi^2 R g_{\alpha\overline{\gamma}} = \kappa\Psi^2 T_{\alpha\overline{\gamma}} \tag{11.1}$$

(2) Expand all components of field equation:

$$\Psi^{\beta}_{\overline{\epsilon}} R^{\rho}_{\alpha\overline{\beta}\overline{\gamma}} - \frac{1}{2}\Psi^{\beta}_{\overline{\epsilon}} g^{\rho\overline{\kappa}} R_{\kappa\overline{\beta}}\delta^{\overline{\beta}}_{\alpha}\delta^{\alpha}_{\overline{\beta}} g_{\alpha\overline{\gamma}} = \kappa\Psi^{\beta}_{\overline{\epsilon}} T_{\alpha\overline{\phi}} g^{\phi\rho} g_{\overline{\beta\gamma}} \tag{11.2}$$

(3) Solve expanded field equation.

(4) Contract it to first form so you get a scalar field:

$$\Psi^2 R_{\alpha\overline{\gamma}} - \frac{1}{2}\Psi^2 R g_{\alpha\overline{\gamma}} = \kappa\Psi^2 T_{\alpha\overline{\gamma}} \tag{11.3}$$

(5) Do a measurement, shift coordinate system change Ψ^2 to Ψ'^2:

$$\Psi'^2 R_{\alpha\overline{\gamma}}(\mathbf{x} - \Delta\mathbf{x}) - \frac{1}{2}\Psi'^2 R g_{\alpha\overline{\gamma}}(\mathbf{x} - \Delta\mathbf{x}) = \kappa\Psi'^2 T_{\alpha\overline{\gamma}}(\mathbf{x} - \Delta\mathbf{x}) \tag{11.4}$$

(6) Where probability of measurement is equal to:

$$\rho^2_{V\in\text{Space}} = \int_{V\in\text{Space}} \Psi^2 d^3\mathbf{x} \tag{11.5}$$

(7) If needed calculate spin state:

$$\uparrow^{\rho}_{\sigma\mu\nu} = R^{\rho}_{\sigma\mu\nu}\Big|_{\forall P\left((t_A,x_A);(t_B,-x_A);(t_C,x_A);(t_D,-x_A)\right)\in X} \tag{11.6}$$

$$\downarrow^{\rho}_{\sigma\mu\nu} = R^{\rho}_{\sigma\mu\nu}\Big|_{\forall P\left((t_E,-x_A);(t_F,x_A);(t_G,-x_A);(t_H,x_A)\right)\in X} \tag{11.7}$$

(8) With probability of each state:

$$\rho^2_{\uparrow} = \frac{\int_{\forall P\left((t_A,x_A);(t_B,-x_A);(t_C,x_A);(t_D,-x_A);\right)\in X} \Psi'^2 d^3\mathbf{x}}{\int_{\forall P\left((t_A,x_A);(t_B,-x_A);(t_C,x_A);(t_D,-x_A);(t_E,-x_A);(t_F,x_A);(t_G,-x_A);(t_H,x_A)\right)\in X} \Psi'^2 d^3\mathbf{x}} \tag{11.8}$$

$$\rho^2_{\downarrow} = \frac{\int_{\forall P\left((t_E,-x_A);(t_F,x_A);(t_G,-x_A);(t_H,x_A)\right)\in X} \Psi'^2 d^3\mathbf{x}}{\int_{\forall P\left((t_A,x_A);(t_B,-x_A);(t_C,x_A);(t_D,-x_A);(t_E,-x_A);(t_F,x_A);(t_G,-x_A);(t_H,x_A)\right)\in X} \Psi'^2 d^3\mathbf{x}} \tag{11.9}$$

(9) Change spin state of wave field again, from Ψ'^2 to Ψ''^2.

(10) For many measurements repeat steps from 5 to 10.

References

[1] https://mathworld.wolfram.com/ComplexVectorSpace.html

[2] https://mathworld.wolfram.com/SpecialUnitaryGroup.html

[3] https://mathworld.wolfram.com/UnitaryMatrix.html

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[5] https://mathworld.wolfram.com/LorentzTransformation.html

[6] https://mathworld.wolfram.com/NormalFunction.html

[7] https://mathworld.wolfram.com/RiemannTensor.html

[8] https://mathworld.wolfram.com/RicciCurvatureTensor.html

[9] https://mathworld.wolfram.com/EinsteinFieldEquations.html