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A New Theory of Time and an Interpretations for Quantum Mecahnics

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Abstract It's time to figure out time! We wish in this paper to answer what is time and how it works, as Einstein changed our whole idea about time, however, not even he answered this one question, which might seem of no importance, in answering it will change all of physics. This paper is bringing a whole new set of ideas, while one might think it is just about time, and that is the start and the original purpose of this paper, one will be shown that this paper will extend to much more beyond that, yielding some very excited and highly unexpected results, the paper will be based on a thought experiment, then going on to arguing and redefining what is time, by asking questions some are previously asked and others are not, then showing for starters how for instance the time dilation effect comes out naturally from this new definition of time both physically and mathematically, the paper then starts using its new ideas and applying it to some of the unsolved problems, however the biggest, unexpected, and most important result that will come out from this paper, **The Detection Property,** it will be shown how this property will lead not only to the interpretation of quantum mechanics, but a much more powerful effect will be produced, in that the detection property will even require the weird quantum behavior, it will be shown how one can start with simple classical world, and just by considering this new argument of time will be forced to introduce to it – in addition to special relativity - all the weird quantum behavior what will be most exciting about it, is that it will do so by the fact that all the phenomena of quantum mechanics like the measurement problem and Entanglement, and to go even further it will not only explain the phenomena of the Superposition and the wave function collapse, but it will even require its existence, this new definition of time along with the detection property will require that quantum mechanics behave in the way it does.

Keywords New, Theory, Time, Relativity, Quantum, Mechanics, Interpretation

1. Time as the Fourth Dimension

Thought experiment: let us consider a ball in an absolute static motion, meaning it doesn't appear to be moving from any perspective, the ball won't change at all not in shape or location, so time for the ball will appear static too, the ball will not appear to be experiencing the flow of time, but if the ball starts moving and changing its location in space then time will appear to be changing for the ball and the ball will appear to be experiencing the flow of time, if the ball changes it shape, then in this situation also, the ball will appear to be experiencing the flow of time, but a change in the shape of the ball is just the atoms of the ball changing its location, same goes for the aging of humans, humans age because of different chemical reactions in the cells which happens do to some movement of the cells and same goes for any chemical reaction or any reaction for that matter, now imagine that all the motion in the universe has vanished, everything, every single atom, every single wave, particle, just stopped moving and all became absolute static (we're ignoring now the uncertainty principle in quantum mechanics which forbids for such thing to happen), if this happens, then time will appear not to be existing at all, while space won't be affected, but time will disappear, from here we can arrive to a conclusion, time depends on motion, if motion isn't happening then time doesn't exist, and so time appears to be a way of measurement of motion or the rate of change in location in 3D space, BUT NOT A PHYSICAL THING.

But Einstein in his theories of special and general relativity [1] demonstrated and proved that the universe has four dimensions, doesn't our conclusion contradict this fact? , the answer is no, it doesn't, because the conclusion says that time doesn't exist, it doesn't say anything about the fourth dimension, so the contradiction is only a result of assuming that the fourth dimension is time, but now we arrive at a new perspective, and a new fact, we live in a world of four dimensions, three space ones and a fourth one WHICH IS NOT TIME, but if the fourth dimension isn't time then what is it, and how does it relate to our experience of time.

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2. What is the Fourth Dimension?

To answer this question, let us consider for simplicity a system with only 2 space dimensions and the third one representing whatever our fourth dimension is:

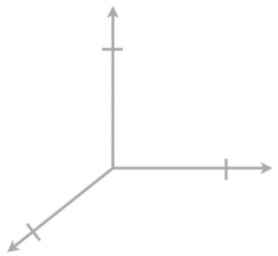

Figure (A)

The formula relating the third dimension, (the horizontal axis), to the two spatial dimensions, is a basic three dimensional function:

$$f(x, y) = m\sqrt{x^2 + y^2} + b \quad (1)$$

Where "m" is the slope, one can use polar coordinates and choose the right units to make "$b = 0$" to simply write

$$f(R) = m * R \quad (2)$$

The third dimension represents different layers of the other 2 space dimensions, so every point in the third dimension axis represent a plane (a layer in two dimensions) with all points fixed, when one applies the same logic for four dimensions, one finds that the fourth dimension represents different layers of the other three dimensions, each point in the fourth dimension axis is a volume (a layer in three dimensions) of the whole three dimensional universe with all points in space fixed, in a way it resembles the multiverse theory a lot and we will come back to that.

3. How the Fourth Dimension Affects Our Experience of the Flow of Time

As we discussed earlier, time can be thought of as a way of measuring the rate of change in location in space, but now comes the question, measuring the rate of change in location in space with respect to what?!

We now wish to derive a formula relates what we know as time to the Fourth dimension, test it, see if it's compatible with what we already know about time, and then study its new and further implications.

We start with equation (2), we are arguing that time is the measure of the change in location in the three spatial dimensions with respect to change in the fourth dimension, that means to time should be the slope in equation (2)

$$T = m = \frac{f(R_b) - f(R_a)}{R_b - R_a} \quad (3)$$

Taking the limit $\Delta R \to 0$, and defining "$\emptyset$" as the symbol for the fourth dimension:

$$T = \frac{d\emptyset}{dr} \quad (4)$$

We arrive at an equation that describes the flow of time as a consequence of change in location in space with respect to change in location in one more thing, and since dr is a dimension then $d\emptyset$ must also be a dimension, since we live in a four dimensional world, and dr is representing the motion in the three space dimensions, then $d\emptyset$ must be the only remaining dimension which is the fourth dimension, now we have constructed a mathematical description of what time is, that so far seems to be serving our main idea, because one can see from the equation that the flow of time requires motion in both space and the fourth dimension, and allows time to move at different rates, however we wish to examine the formula further, and see what its true power, and what will we gain by using it instead of using the old regular definition of time.

4. Introducing a New Principle

We concluded earlier through reasoning and thought experiment that what we experience as the flow of time depends on motion in the four dimensions, and one can see through equation (4) that if an object has no motion in any of the four dimensions then it will not experience the flow of time, so time cannot exist without moving in at least one of the four dimensions, and that time is not a physical thing but it could be thought of as another way to organize and measure distances, and the rate of change in location in space with respect to change in the fourth dimension , and from that we introduce a new principle that relates to *The flow of time* that its name will be ("*The TimeFlow principle*") and it will state:

In order to experience the flow of time between two consecutive points, they must be in different locations in both space and the fourth dimension.

5. Describing Types of Motions and Its Physical Meaning

We arrive to the second and most important definition: defining motion, and it's divided into two categories: motion for objects that have mass and can't reach the speed of light, and the second and more important category, massless objects that moves only at the speed of light, and we will get to why this sort of motion is very important and the implications it makes.

Definitions:

FourLine: *a diagonal line on the graph that represents the movement of the object in the four dimensions.*

Unit: *the piece of the Fourline that goes from one Dim4 point to the next, and it represents physically the passage of one second/minute/hour (depends on the units that are being used) in the proper time.*

There are three possible types of motion: motion only in space dimension/s, motion only in the fourth dimension, and motion in both space and the fourth dimension together.

1) The motion that causes the experience of the flow of time: this type of motion requires moving in both space and the fourth dimension, to put it more accurately, in order for an object to experience the flow of time between two

connected point, those two point have to be in different location in both space and the fourth dimension.

Let's consider two objects "A" and "B" moving along the four dimensions:

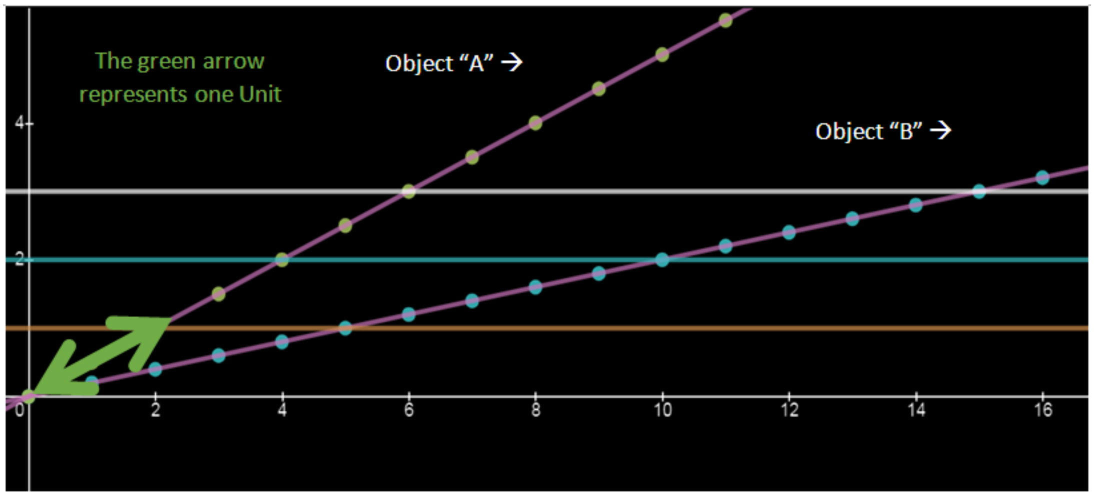

Figure (B)

In this picture we have a graph for two objects moving in the four dimensions at two different velocities: object "A" moving at V_1 and object "B" moving at V_2, more on velocity later.

The x axis represents location in space and the y axis represents location in the fourth dimension.

Meaning that covering larger distance in space across the same distance in the fourth dimension means higher velocity, from that one can tell from the graph is that the $V_1 < V_2$.

As for time, we argued that $T = \frac{dØ}{dr}$, that means time in the graph is the slope of the diagonal line, as humans we can only see three dimensions and we can't see Dim4, that means that when we are in a specific Dim4 point, we can only see inside the layer which this point represents, we can't see other layers, only the layer/volume/universe we're in, each observer will measure the second in his time as the one unit on his diagonal line, one unit at a diagonal line is defined as the piece of the diagonal line that goes from one Dim4 point to the next, hence one unit defines one second in the object's proper time.

Now we want to check with the graph how every objects measures the flow of time for him and the other object from his perspective:

Object "A": from the perspective of object "A", his unit on the graph represents one second of his proper time, and since the object's "B" Unit length is 2.5 times the length of object's "A" Unit, that means one second in object "B" proper time is 2.5 seconds in object "A" time, or one second in object "A" time will be 0.4 seconds in object "B" time, meaning that if object "A" was measuring time, he will measure that every second on his time is 0.4 seconds on object "B" time.

Let's take an example: suppose the two objects "A" and "B" are moving cars, inside each car a ball being dropped from the same height, and takes one second to reach the car's floor (second in the object's proper time), the same event is happening at both objects, from an observer sitting in car "A" perspective, his ball will take one second in his time and since from his perspective one second in object "B" time is equal to 2.5 seconds of his time then from his perspective he will measure that the ball in car "B" took 2.5 seconds to reach the floor of car "B", so every second in his time he will measure that the ball fell another 0.4 of the height until it reaches the floor of car "B" at second 2.5 in his (object "a") time.

Object "B": from the perspective of object "B", his unit on the graph represents one second of his proper time, and again since the object's "B" Unit length is 2.5 times the length of object's "A" Unit, that means one second in object "B" proper time is 2.5 seconds in object "A" time, or one second in object "A" time will be 0.4 seconds in object "B" time, meaning that if object "A" was measuring time, he will measure that every second on his time is 0.4 seconds on object "B" time.

And now we see the time dilation effect that is caused by the velocity getting higher, being displayed in the graph, more than that, we get a physical explanation for it: since we can only see three dimensions, we can only see what's happening in the three dimensional layer/volume that exist in the Dim4 point we're in, and we measure flow of time based on moving from one dim4 point to another, and since different velocities means different amount of spaces, being covered in one unit, and each observer thinks of his unit as one second, all those facts together not only allow, but actually requires the existence of the time dilation phenomena.

Furthermore, in the graph we see that the with the increase of the velocity, the FourLine gets more and more close to a straight line but never completely reaching a straight line (because that will violate the TimeFlow principle), that means for this type of motion there is a limit on the velocity, and thus one arrives at an additional physical law arising from the definition of the fourth dimension, the cosmic speed limit.

2) Motion only in space dimension/s: this motion describes an object “A” moving in a single layer of three dimensional space without moving in the fourth dimension, in this case, object “A” alone will be traveling in the layer while everything else is static, in this type of motion, the traveling object “A” can move from one point to another in a single four dimensional point, and since every other object is fixed in a single point, the speed of object “A” will appear the same from every perspective in that layer, however, from the perspective of the static objects that move along the four dimension, only when they are in this point in the fourth dimension will they see the object “A”, and they will see it in space in the point that the moving object “A” arrived to when the other objects arrived at this dim4 point, before or after they pass this point in dim4 they will not be able to see it, that means they only see it in one point in space in one point in dim4.

Furthermore, since this type of motion happens only in the three space dimensions and doesn’t include the fourth one, according to the TimeFlow principle, an object in this type of motion will not experience the flow of time.

3) As for the third type of motion, moving only in the fourth dimension while staying fixed in the three space dimensions, this type of motion cannot happen because it’s forbidden by Heisenberg’s uncertainty principle [2].

6. Examining How Different Types of Motion Interact with Each Other

After we discussed, explored and described two different types of motion let’s see how they interact with each other and what happens when they do.

Let’s consider an object “α” moving in the first type of motion (the motion that produces the flow of time), in a certain point the object begins to emit a particle “β” that moves in the second type of motion (the motion that takes place only in the three space dimensions) every second, well we know that in a single dim4 point object “α” will be static and fixed in one point, while object “β” will be moving freely in the three dimensional layer that represents that dim4 point, when object “β” is emitted from the object “α”, in the dim 4 point that the object “β” is emitted in, object “α” will be static no matter in what velocity object “α” is moving in the four dimensions, that means that object “β” will have the same speed no matter how it’s viewed or where it’s moving or what is the velocity of the system that he is moving in.

7. Labeling the Types of Motion and Resolving the Photon Problem

Obviously the first type of motion describes the motion of particles with mass or ***Fermions*** [3], and the second type of motion describes the massless particles or ***Bosons*** [4].

Let us now move on to a new issue that is undiscussed previously (as I have searched and not found any mention for it).

The photon problem: we learn from special relativity that that photons (and all massless particles for that matter) don’t experience the flow of time, yet they can move freely through space, but this fact gives rise the following question, if we think of time as the domain that is required for physical phenomena to happen, then if the photon doesn’t experience the flow of time, how could it move in space?.

The first time I learned special relativity I found this fact weird, but I thought there’s got to be an explanation for it, but as I dived deeper into the theory I discovered that not only the theory doesn’t answer that question, it doesn’t even ask it!!!.

It was weird and honestly irritating that nobody bothered even thinking about it, they just solve the equations, discover that when moving at the speed of light time becomes infinite, hence, since the photon is moving at the speed of light in order to resolve this problem conclude that the photon must not experience the flow of time, they arrived at the conclusion and just put it there, nobody bothered asking ***how***.

How does the photon moves in space without experiencing the flow of time, one can see that our new concept of time allow that very easily, by not restricting motion to the presence of time, but actually restricting time to presence of motion and even more, considering that the flow of time is just a consequence of a specific type of motion (The TimeFlow principle), one can see how this new perspective allows the photon to move in space without moving in time.

However, a very serious, important, and interesting conclusion rises from this, so far all we did was just taking already known physical phenomena’s and trying to explain it, yet now we arrive to the exciting part, discovering something new, using our new idea to arrive at a newly and undiscovered phenomena, and that has to do with the motion of the massless particles.

For now we will just identify it, and explore it, later we will dive more into the consequences of this phenomena, for we will discover that it’ll play a huge role in interpreting the puzzling features in quantum mechanics, and even require their existence.

The last section in this paper will be on interpreting the effects of quantum mechanics, one shall see how this new phenomena plays the key role in the solution, explaining how the measurement act on the article collapses the wave function into one value whether in position, momentum, spin and other, for now let’s get to the topic, first, naming, the new property will be called: ***Detection***.

8. The Detection Property

Based on what we discussed earlier, we can only see what’s happening in the Dim4 point that represents the 3D layer we're currently in, and we experience the flow of time and change in events when we move from one dim4 point to another.

Photons only travel in a single Dim4 point, the same photon can't travel from one Dim4 point to another, let's see what this means:

Suppose we have something like the sun and the earth moving in the same direction at the same speed, the distance between them takes light 8 minutes to travel.

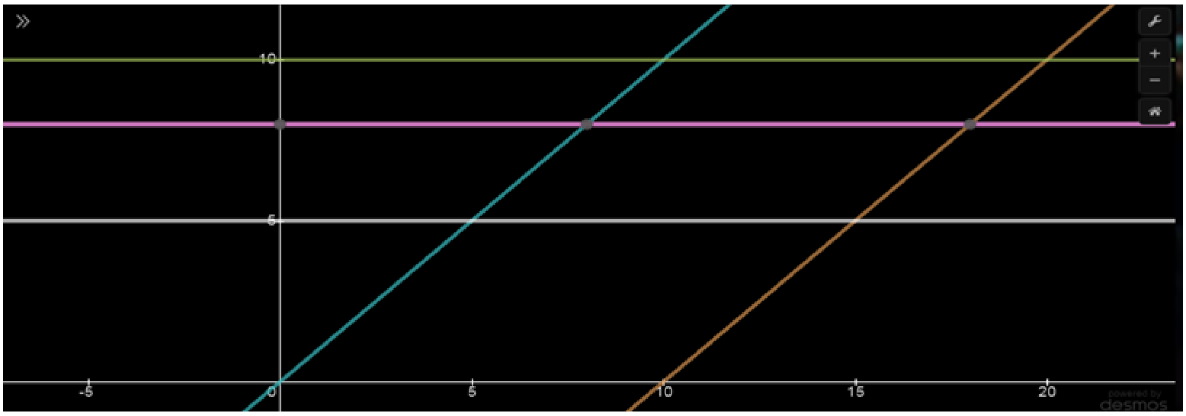

Figure (C)

In this graph the blue line represents the sun's FourLine and the orange line represents the earth's FourLine, the straight pink line represents "T = 8 min" —"T" here represents the number of minutes—the white straight line represents "T = 5" and the green straight line represents "T = 10".

The sun is emitting photons every possible time unit, (let's suppose it's one second), each time in one Dim4 point, the distance between the sun and the earth takes the photon 8 minutes to travel, let us consider when the sun emits photons at "T = 0", "T = 5", "T = 8", the earth comes along in "T=5".

In "T = 5" the photons that was emitted in this Dim4 point have covered the distance that light travels in 5 minutes, but haven't yet reached the location of earth, so an observer on earth in "T = 5" won't see light from the sun, for that matter he won't see the light from the sun before "T = 8", at "T = 8" the observer will see the light that was emitted from the sun at "T = 8", but at this point the sun have reached an emitted a photon in "T = 16" or more, so we actually seeing the sun 8 minutes in the past in its time.

And at each second we're actually seeing just the photons that we're emitted in this second, when we progress in time those photons remain trapped in the same second and don't progress with us.

So far on the largest scales, there's nothing new that we don't know already, just more explanations to what we already know, and nothing is observably weird.

The quantum realm however, is a very different story, because on the smallest scales is where this property becomes interesting.

Let us now suppose that we have a single particle that is emitting photons, the particle is emitting one photon at a time, now let's say we're measuring the release of the photons, we put a detector next to the particle and use it to measure how many photons this particle emits in four seconds, the detector is built to just receive the photon and trap it in, the detector detects each time a photons emitted and in "T = 4" —"T" here represents the number of seconds—registers how many photons it detected, in this case since the particle is emitting a photon every second one might expect the detector to measure 4 photons.

But as we discussed earlier, photons don't move from one second to another, so while the detector will measure at "T = 1" one photon, when the detector reaches "T = 2", the photon that the detector measured at "T = 1" won't travel with him to "T = 2", so the detector will reach "T = 2" photon free, then the detector will measure the photon that is emitted at "T = 2" and again will show that one photon has been emitted instead of two photons, the same thing will happen for second three and four.

When the detector reaches "T = 4" and the measurement ends, instead of showing four photons, the detector will register only one photon.

The same thing will happen for every "T = n", if the particle is emitting "m" photons at a time, the detector in the end will register only one photon being emitted, and that is **the Detection property.**

While not having any significant effect in observations on the largest scales, it certainly becomes very important and obvious on the smallest scales, and it will play the key role in the last section of this paper, **"Interpreting quantum mechanics".**

9. Velocity and Time Dilation

We wish to show the efficiency of our new description of time by showing how the effects of special relativity comes out naturally from it, we wish to do that by exploring velocity according to this new argument and see the consequences.

One starts by taking the definition of velocity and replacing the time factor with equation (4),

$$V = \frac{dR}{dT} = \frac{dR}{d\left(\frac{d\emptyset}{dR}\right)} = 2dR\frac{dR}{d\emptyset} \quad (5)$$

$$Vd\emptyset = 2dRdR \quad (6)$$

Taking the integral at both sides in (6) we get

$$\emptyset(R) = \frac{1}{V}R^2 \quad (7)$$

This is a very important result, and very satisfying, one first notices how since it's a quadratic function, the slope will differ at different points.

One can also see that the slope will be related to the inverse of the velocity, meaning that the higher the velocity the smaller the slope.

Hence, one can see that the physical phenomena of time dilation due the increase of velocity comes out naturally from this new argument, but now we wish to strengthen our argument by showing that the effect comes out not only physically but mathematically in a way that accurately agrees with the time dilation formula.

10. Deriving the Time Dilatation Formula

We explored previously by graph how the TimeFlow principle causes the time dilation effect, but now we want to derive the exact relation between two different time lines using mathematics and see what we get.

We will take two different objects moving at two different velocities, and then pick one of them to be the observer, because of the relativity principle that says every observer, moving or not, describes its self as stationary and the objects around it are moving, we arrive at the following:

Let us say that we are observing from object "A" perspective, and we're observing the time of object "B" which is moving at velocity "V_b", this is the graph that describes the Fourline of the two objects from object "A" perspective:

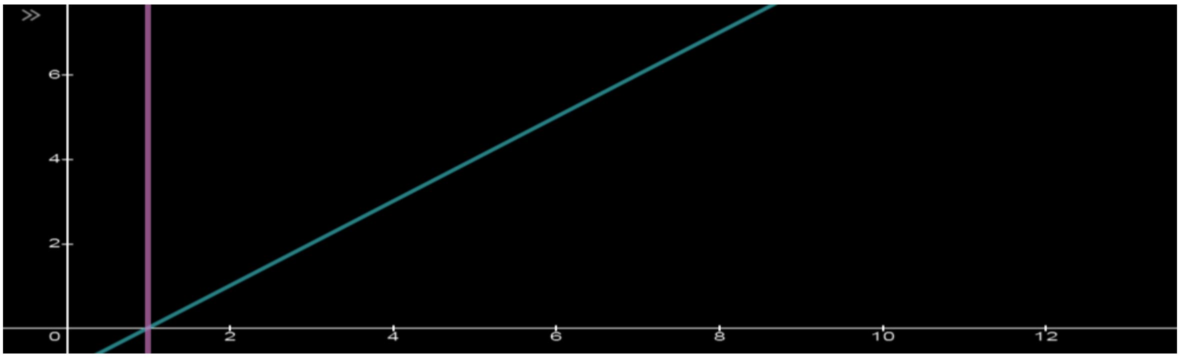

Figure (D)

The pink line describes object "A" FourLine and the blue line describes object "B" FourLine, when object "A" records "T_1" in his time he will see object "b" in "T_2", the relation between them is:

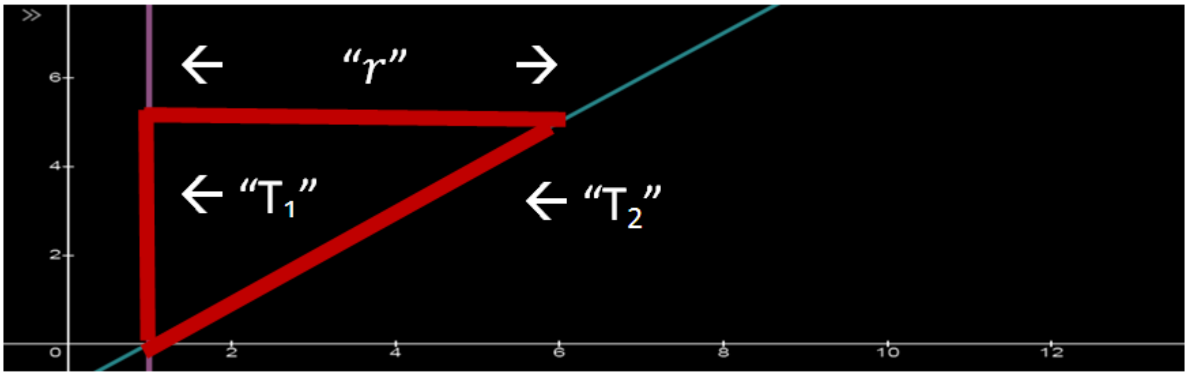

Figure (E)

Where "r" is the distance between the two objects

Setting the speed light "C = 1":

$$\frac{T_2}{T_1} = ??$$

$$(T_1)^2 = (T_2)^2 - r^2 \qquad r^2 = (V_b \times T_2)^2 = (V_bT_2)^2$$

$$(T_1)^2 = (T_2)^2 - (V_bT_2)^2 = (T_2)^2(1-(V^2))$$

$$T_1 = T_2\sqrt{(1-(V^2))}$$

$$\frac{T_2}{T_1} = \frac{T_2}{T_2\sqrt{(1-(V^2))}} = \frac{1}{\sqrt{(1-(V^2))}} \quad (8)$$

T_1 is our time(the observer time) so t, T_2 is the moving object time so t', :

$$\frac{t'}{t} = \frac{1}{\sqrt{(1-(V^2))}} \quad (9)$$

Define: $\gamma = \frac{1}{\sqrt{(1-(V^2))}}$

$$t' = \gamma t \quad (10)$$

$$\frac{t'}{t} = \frac{1}{\sqrt{(1-(V^2))}} \qquad t' = \gamma t$$

Amazing, just by defining the fourth dimension and applying the TimeFlow principle, we immediately get Einstein's time dilation effect [5] and the exact formula for it from special relativity that is already tested and proven.

It's like pieces of a puzzle coming together to complete a beautiful picture.

Of course we can get the speed of light factor in the formula easily just by adjusting the units of the graph.

11. Symmetry Transformations on the Fourth Dimension

We wish to define a new metric describing the new four dimensions in a way consistent with special relativity so we could search for symmetry transformations on the fourth dimension in this new argument.

Let us start by taking the Lorentz invariant, for our purposes we will only be taking one spatial dimension with the fourth dimension, it will be sufficient and easier to deal with than three spatial dimensions, and makes no difference in our argument.

$$s^2 = -c^2t^2 + x^2 \tag{11}$$

(we're following the (-+++) notation), let us now replace the time variable the new equation (12) from our new argument

$$s^2 = -c^2(\frac{\emptyset}{x})^2 + x^2 \tag{13}$$

If one now define the coordinates $(X^0, X^1) = (\emptyset, X)$, equation (13) becomes:

$$s^2 = g_{\mu\nu}X^\mu X^\nu \tag{14}$$

Where the metric is:

$$g_{\mu\nu} = \begin{pmatrix} -\frac{1}{x^2} & 0 \\ 0 & 1 \end{pmatrix} \tag{15}$$

We wish now to find continues and symmetric transformations on this new metric, let us define Λ such that:

$$\Lambda^T g\Lambda = g, |\Lambda| = 1 \tag{16}$$

The solution is:

$$\Lambda = \begin{pmatrix} \cosh\theta & x\sinh\theta \\ \frac{\sinh\theta}{x} & \cosh\theta \end{pmatrix} \tag{17}$$

One can use the following procedure to rewrite Λ, one can use the fact the origin point at the new coordinate after the transformation will always be zero to write:

$$0 = \frac{\sinh\theta}{x}c\phi + \cosh\theta\, x \tag{18}$$

$$tanh\theta = -\frac{X^2}{C\phi} = -\frac{X}{Ct} = -\frac{V}{C} \tag{19}$$

Using hyperbolic trigonometry, one finds that

$$cosh\theta = \frac{1}{\sqrt{1-\frac{V^2}{C^2}}} = \gamma \tag{20}$$

$$sinh\theta = -\gamma\frac{V}{C} \tag{21}$$

One now can rewrite Λ

$$\Lambda = \begin{pmatrix} \gamma & x\gamma\frac{V}{C} \\ \frac{\gamma}{x}\frac{V}{C} & \gamma \end{pmatrix} \tag{22}$$

The transformation from $(c\phi, x)$ to $(c\phi', x')$ becomes

$$c\phi' = \gamma(c\phi - \frac{V}{C}x^2) \tag{23}$$

$$x' = \gamma(x - \frac{V}{C}t) \tag{24}$$

One can first be satisfied with this result, for one can notice that by using the new argued definition of the time and the fourth dimension and using eq (4) to substitute ϕ with t, one gets back the original formulas from special relativity.

We wish now to use the new formula (23) to test how the fourth dimension transform when changing frames of reference.

12. Simultaneity

After formally deriving how the fourth dimension transforms, let us now use the only two rules we established in our new argument, to show how all the effects and consequences of relativity comes out of our argument of the fourth dimension.

Let us start with the first rule: an observer can observe only his point in the fourth dimension, and cannot observe what happens in a different point on Dim4.

Let us take two observers, at two Dim4 points, ϕ and ϕ', our rule states that the two observers can observe what happens only in their points, we wish to see the consequences of this rule mathematically, let us use eq (23) and demand that $\phi = \phi'$

$$c\phi' = \gamma(c\phi' - \frac{V}{C}x^2) \tag{25}$$

$$x' = \gamma(x - \frac{V}{x}\frac{x^2}{\phi}) \tag{26}$$

Using eq (7) in (26), one gets

$$x' = \gamma(x - \frac{V}{x} * v) \tag{27}$$

$$\frac{1}{1-\frac{V^2}{C^2}} = \gamma \tag{28}$$

$$\gamma^2 = \gamma \tag{29}$$

$$\gamma = 0, -1, 1 \tag{30}$$

γ Can't be smaller than one, so the only solution one can take is $\gamma = 1$, Let us study what this means physically, when $\gamma = 1, V$ the velocity for the frame of event ϕ', must be zero.

This means that, if two observers or two events want to live in the same dim4 point, their relative velocity must be zero, however this also works if $\gamma \approx 1$, meaning at relatively small velocities $V << C, \gamma \approx 1$ which means that the same thing can happen at relatively small velocities.

However, one can immediately see the problem, at relatively high velocities, the two events cannot live in the same Dim4 point.

Moreover, according to our new definition of time, those two events, can each record the same value in time, however they still won't be able to observe each other simultaneously.

One now can see the effect of our the argument of time and the fourth dimension on Simultaneity, for this argument allows for Simultaneity only for stationary or relatively slowly moving frames, however at relatively high velocities, one is forced to abandon Simultaneity.

This is an immediate consequence that comes out of this new argument about time and the fourth dimension, by abandoning our standard definition of time, we see how all the effects and consequences of relativity comes out naturally.

After deriving the transformation rule for the fourth dimension and exploring its consequences, we wish now to move to the important part, we wish to explore mathematically the implications and consequences of our new argument about the difference between TimeFlow motion and non-TimeFlow motion, and develop a relationship mathematically to the weird behavior of quantum mechanics.

13. The Quantum Realm

Let us once again combine the rules we established in our new argument with the derived transformation rule to give rise to the quantum behavior.

Let us start by exploring the first key difference, the non-TimeFlow motion, which is the motion only in the spatial dimensions in one point in the fourth dimension.

Let us take for simplicity the fourth dimension with just one spatial dimension, two FourLines [6], l_1 to be the FourLine of a propagating wave in some velocity V in both dimensions, l_2 to be the FourLine of an observer, and to be just a little diagonal, for it can't be completely vertical because that would mean that is absolute still in the spatial dimension which is forbidden by both the Heisenberg Uncertainty principle and the TimeFlow principle [7], (because we wish for the observer to be experiencing the flow of time), so instead we grant him a velocity that is extremely small and close to zero, that it can be negligible in calculations.

The wave, will start at $\phi = 0$, at a distance $\sqrt{2c}$, where C is the speed of light, one now can use eq (7) to find out that

$$\phi = \frac{1}{c}(\sqrt{2c})^2 = 2 \tag{31}$$

Note that this agrees with eq (13), where one can take the definition of massless objects trajectories by setting $ds = 0$, one reaches the following formula:

$$cd\emptyset = dx^2 \tag{32}$$

Where can solve for $\phi = 2$, and find out that $x = \sqrt{2c}$.

One can now see, that if photons come out of the wave every point in the fourth dimension starting at $\phi = 0$, the photons will reach the observer at $\phi = 2$.

According to our argument, photons can't travel in the fourth dimension, hence any photons before $\phi = 2$ that didn't reach the observer will never reach him, and for him they are lost like they never existed.

Starting at $\phi = 2$, the photons can and will reach the observer, however, in reality, the photons coming out of the wave, will not all come out of the wave at exactly the same instant, but there will be a slight difference in their emitting, that slight difference, as we will show now, will end up making a huge and significant difference in the outcome, and will lead to the behavior of quantum mechanics, especially the measurement problem.

We argued that our argument about time is so strong that it not only allows but actually requires the wave function collapse phenomena, let us now prove that.

14. The Inevitability of the Wave Function Collapse Phenomena [8]

Let us consider the wave at $\phi = 2$, coming out of the wave N photons, traveling to the observer.

The observer, when in $\phi = 2$, will only receive the first n photons that reach him, before moving to the next Dim4 point, in which case the other $N - n$ photons that didn't reach the observer will be lost as if they never existed.

As one can obviously see, having perfect knowledge of the exact number of photons that reflected of the wave and the exact emitting point of each individual photon is impossible, thus, the most one can do, is try and calculate the probability of detecting certain points on the wave, and because of the detection property, one will observe only one of this points, resulting in the wave function collapse phenomena.

One can check that for an observer, photons are stuck in one point in the fourth dimension, making their value of $\emptyset$ a constant, causing:

$$T = \frac{d\phi}{dx} = \frac{d(constant\ )}{dx} = 0 \tag{33}$$

Meaning that photons do not experience time flow, in agreement with relativity, however, our argument clearly allows for the photons to propagate freely in space and interact with time experiencing observers without the need to experience time themselves, resolving the photo paradox we introduced earlier.

Now the wave is not a straight line, the location of each point along the wave can is different, otherwise it would be a straight line, considering this fact, one can see that if certain points on the wave are $\sqrt{2C}$ far from the observer, there has to be points on the wave that aren't that distance far, but rather closer or further.

$$\phi = \frac{1}{c}(\sqrt{2c} + \Delta x)^2 \neq 2 \tag{34}$$

A wave propagating with photons reflecting from each point (Figure F), one can notice that there exists some distance between each set of photons (the green set and the red set), and even between the photons of each set.

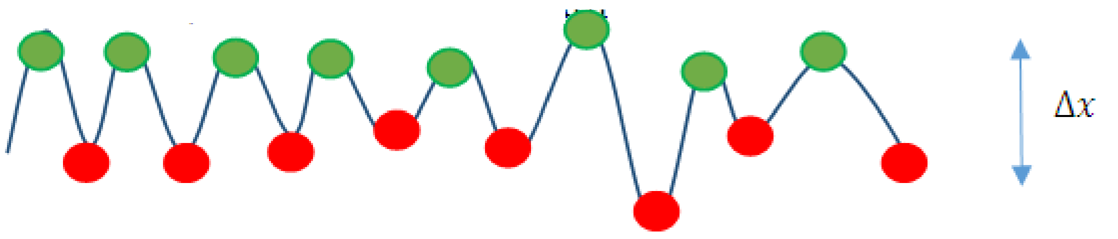

Figure (F)

As we established above, only photons that are $\sqrt{2c}$ away from the observer will reach him at $\phi = 4$, that means that form the N photons that were emitted from the wave, it is not possible for all them to reach the observer at $\phi = 2$, but only a certain percentage of them, corresponding to a certain point of the wave, hence the observer will only detect one point from the wave, and in no way can he detect the whole wave simultaneously.

Thus one can see one of the most powerful results of our new argument, the not only interpretation, but even requirement of the wave function collapse, and the entire quantum behavior, so just by answering the question how time works, we are lead to this unexpected result.

15. The Inevitability of Spin [9] Measurement Phenomena

We wish now to show how the quantum behavior of spin arises directly from our new argument, and that again, there is just no way round it, this new argument about time and the fourth dimension actually forces this weird behavior of spin.

Let us start by taking an arbitrary particle, an electron, let the arrow of the electron's spin be aligned at some arbitrary direction.

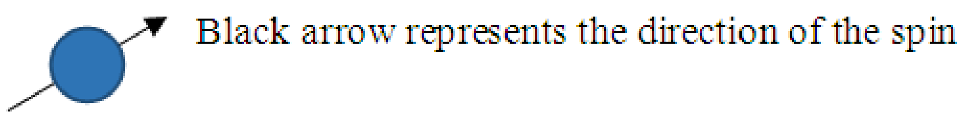

Figure (G)

Let us now impose a measurement act along a different direction

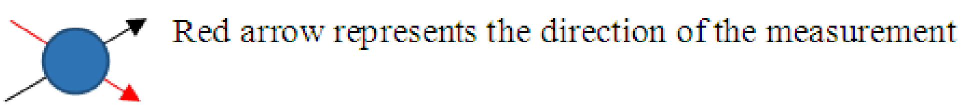

Figure (H)

One measures the spin of the electron by enforcing a magnetic field along the red arrow direction, and checking the deflection angle, meaning that we will depend on Stern-Gerlach experiment [10], however when one considers the experiment with our new argument about time and the fourth dimension, one is faced with the following:

Let us consider the electron from (Figure G) with spin in the black arrow direction passing in a magnetic field in the red arrow direction (Figure H), we know from quantum field theory [11], the way the electron interacts with the magnetic field is by exchanging the electromagnetic field gauge particle, which is the photon, there are two distinct situations

1. The spin axis of the electron is aligned with the measurement axis, either with same direction or the opposite, in other words, there angle between the two axes is either 0° or 180°: in this case, the photons, which are being emitted at every single point in the fourth dimension, will comfortably hit the electron and cause it to deflect, only the electron will propagate through time, the interacting photons cannot and will not propagate with it.
2. The two axis are at some angle between 0° and 180°: this is the important case, because in this case, the electron spin direction will want to align itself with the measurement direction, this is quickly and easily achieved for the electron because if it's small size and magnetic momentum in comparison with the applied magnetic field in the experiment, when the electron does so it emits photons during the process of aligning the two axes, however because of our argument, those photons will be trapped in the Dim4 point they are emitted in, when not detected in in that point, it will be as if they never existed.

From a time experiencing observer perspective, the only way of detecting the process of alignment of the spin axis with the measurement axis is not accessible to him because of the detection property, hence for him, the two axes will always look aligned, never in an angle.

This is the serious and inevitable consequence of our argument of the fourth dimension and the detection property acting on the intrinsic magnetic moment of the electron, producing the Stern-Gerlach results.

16. The Inevitability of the Entanglement [12] Phenomena

Lastly, we wish now to show that by considering this new argument of time and the fourth dimension, not only does it satisfy Bell Theorem [13] condition – gives and interpretation to the phenomena without the need of a hidden variable, but beyond that, in our argument about the fourth dimension and the detection property, there is no escaping the quantum entanglement phenomena:

Let us start by assuming a pair of two spin entangled electrons, when the pair is first constructed, the spin of each electron will be opposite to the other.

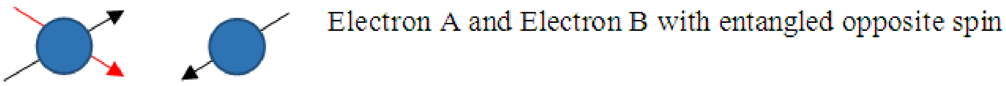

Figure (I)

Let us now take electron "A" and measure its spin along the red arrow direction, and let us consider what will be the result considering our new argument about time and the fourth dimension.

One first must realize that preserving that standard conservation laws of energy and momentum (we're assuming a the experiment in an inertial frame of reference), if the spin direction of electron "A" shifts, the spin direction of electron "B" has to shift by the same amount in the same direction, that is a consequence of the two electrons being governed by the same wave function.

When electron "A" spin direction shifts, it sends the information of the change in its angular momentum to electron "B", and here is when our new argument comes, the information, will travel in the form of a boson, in this case a photon - information is massless, according to QFT it travels in the form of photon or any other Boson depends on what charge is being conserved -, and according to our argument, photons follow the trajectory of massless particles, which don't experience the flow of time.

The photons will travel from electron "A" to electron "B" in one Dim4 point, which from a time experiencing observer, will appear simultaneously, thus producing the instantaneous exchange of information effect between the entangled pair.

One must note the following, the proposed electron pair, can spin at any arbitrary direction, and by no mean require a hidden variable as stated in the EPR paper [14], thus agreeing with Bell's Theorem.

One also notes how this argument is compatible with relativity, the information does not exceed the speed of light, however they only appear instantaneous because they do not travel in time, but only in one Dim4 point thus allowing for the entanglement phenomena without breaking relativity.

As we argued, the wave function collapse, the spin behavior, and entanglement, all are unavoidable and required by our new argument of time, however there is one extra feature that is important and comes out naturally form our argument that can be generalized, which is the notion of instantaneous.

17. Relativity and the Notion of Instantaneous

The notion of instantaneous transfer from one point to other in space in relativity is forbidden, because it requires a velocity greater that the speed of light, which is physically impossible.

However, one can see that this the case only by the conventional way of thinking about time, in our new argument of time and the fourth dimension.

When one considers our new argument about time, the fourth dimension, and the Detection property, one finds that this is no longer the case.

For massive objects in our argument, which experience the flow of time, for them the notion of instantaneous is prohibited by special relativity because they require exceeding the speed of light to achieve it.

For massless particles in our argument, that is no longer the case, the Detection property allows them to achieve the notion of instantaneous without the need to exceed the speed of light, thus not violating special relativity, this is the key feature that comes out of our argument and bores the quantum behavior.

18. The Inevitability of Quantum Tunneling

Lastly, the quantum tunneling effect describes how a particle in the quantum realm can tunnel from one point to another, however combining the arguments that we discussed above, that every particle in nature is actually a wave, with the Detection property, gives rise automatically to this phenomena, because while one can observe one point on a wave, when one observes the same wave more than one time, one will probably observe different points on the same wave in each observation, hence the illusion that the point particle is tunneling through space.

Conclusions

Time, the basis on which our physics stands, we use time in our derivations and our measurements, this paper aim to shatter one of the biggest rocks in the foundation of physics.

Physics is composed of two categories, physical principles and quantities, like space, matter, and derived quantities like temperature and entropy.

This paper is to argue that time, does not belong to the first category but to the second one, time, is not a dimension of the universe, it is by no mean a physical thing at all, but rather it is a derived quantity, that relies on the actual four dimensions of the space, and in considering this new argument that arises from a thought experiment, one can use it to solve an unnoticed problem in physics that we introduced in the paper and that can't be solved otherwise.

From that solution, the biggest most unexpected result comes out, an interpretation, a reasonable and effective and possibly testable - further papers will written on this - and simple interpretation for quantum mechanics, the power of this interpretation is that not only does it explain the quantum behavior, but it actually requires it existence, that is one of the most powerful points this paper is introducing, one can start with purely classical formulation of the universe, and just by considering this paper's argument, is forced then to introduce the quantum behavior.

Explaining and enforcing the quantum behavior is just the beginning for the detection property, it is ought to introduce significant changes in all of physics, I welcome anyone who wishes to collaborate with me for further papers regarding this feature's implications and testing.

19. The Classical Limit

In order for this new argument to hold, it is not enough to offer solutions and interpretations for unsolved matters no matter of their strength and importance, but it must also satisfy the classical notion of time and its behavior in classical the everyday events, it must not violate or contradict the usual behavior of time in the everyday limit.

Our definition of time helps interpret the quantum behavior, and solve the photon problem, but it should also give us our back at everyday intuition in the classical realm, we wish to show that this is the case:

Define: $\emptyset_n$ to be the "n" point in the fourth dimension, $\emptyset_n \equiv \emptyset = n$

Let us start by a considering huge source of light, source "A", and the range of points in the four dimension from $\emptyset_0$ to $\emptyset_{10}$, and let us analyze it according to our new argument.

The source is continuously emitting a huge number of photons in every point it exists in the fourth dimension, form $\emptyset_0$ to $\emptyset_{10}$.

Let us now assume an observer "A" at $\emptyset_0$, a distance from the source $\Delta x = \sqrt{5c}$, according to eq (7), such observer, assuming as we're doing in this situation that the observer came to existence at $\emptyset_0$, will start detecting photons coming from source "A" at $\emptyset_5$.

In this situation, the observer will not observe source "A" until $\emptyset_5$, at this point, the observer will see the source for the first time.

Let us now consider the point $\emptyset_7$, at this point, the observer will detect only the photons that came out of the source at $\emptyset_7$, let us assume the source is spherically symmetrical, and let us assume the following:

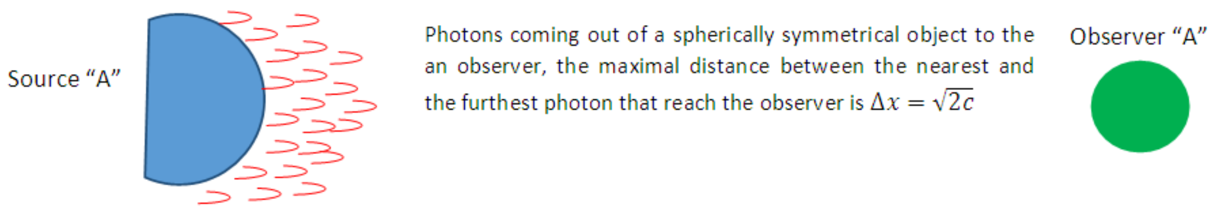

Figure (J)

In $\emptyset_7$, the last photon will reach the observer, and the observer will be able to see the whole of source "A", and from this point until $\emptyset_{10}$, the observer will see the source at every point, this is because the source never stops emitting photons from every point on it in the fourth dimension.

Let us now assume that the observer wishes to do any calculation that depends on the photons that are emitted from the source.

One first notices that according to our argument, if the observer wishes to do such calculations, he runs with the following issue:

Suppose that the observer "A", while being in $\emptyset_7$, wishes to calculate the evolution of the photons that he observed in this point, one might think that according to our argument this forces him to deal only with the photons that are in $\emptyset_7$ and not outside it, because according to our argument, any photons that live outside $\emptyset_7$, are not the same photons, because the same photon can't live in two different Dim4 points, thus one might conclude that one can't expect to gain the right result if he uses photons from different $\emptyset \neq 7$ point to calculate the evolution of $\emptyset_7$ photons n advice versa.

However, while this is true in many cases, (in fact as we argued above that is the whole reason of the weird quantum behavior), we wish to argue and show that in the classical limit, in everyday situations, and with the right conditions, this interchange is allowed and justifiable, which will lead to the classical notion of treating photons.

Let us start by imposing the following condition, if we consider la system of a source, an observer, and an attempt of observation and calculation in an interval in the fourth dimension $[\emptyset_n, \emptyset_m]$, where $n \neq m$, we must request that the source is constantly emitting photons at every point in the fourth dimension from $\emptyset_n$ to $\emptyset_m$.

Let us now consider two different photons, photon “A” at $\emptyset_7$, and photon “B” at $\emptyset_{10}$, an observer at $\emptyset_7$, can do his calculations regarding photon “A”, to find out its spatial location in $\emptyset_{10}$, however, if the observer wishes to actually verify his calculations, he will have to observe the spatial location of photon “A” when the observer is in $\emptyset_{10}$, which according to our argument, is impossible, for the observer has moved on while photon “A” is stuck behind with no way to detect it, the observer at this point, can only detect photon “B” (we’re picking the photon that the observer detects and labeling it photon “B”).

Assume that after the observer does his calculation, they reveal that photon “A” spatial location when the observer reaches $\emptyset_{10}$ must be at X_0, and let us also assume that the observer when in $\emptyset_{10}$ detects photon “B” at the spatial location X_1, we will argue that $X_0 = X_1$.

To show that is the case, one needs to consider the parameters and conditions that the calculation depends on, and verify that they are identical in $\emptyset_7$ and $\emptyset_{10}$, if they are, then the change between photon “A” and photon “B” in the calculation is perfectly justified.

The parameters and conditions are:

- The initial conditions of the photons at the emission points.
- The geometry of the road form the emission points to the detection points.

The location of the photons at the detection points will mainly depend on those two factors, and we impose for our argument that those two factors match in $\emptyset_7$ and $\emptyset_{10}$.

According to Noether’s theorem [15], almost any conserved quantity can be derived from a physical symmetry that depends on the geometry of the four dimensions in the road, which means if the geometry matches in both roads, almost any method of doing the calculations will be identical considering either $\emptyset_7$ or $\emptyset_{10}$.

This leaves the second factor, the parameters that are inserted in the calculation, this factor depends on the way the observer is constructing his theory, and there are two different options:

- If the observer is doing field theory: he will use lagrangian density in his calculations, which will depend on the geometry of the road, which in turn as we imposed is identical in $\emptyset_7$ or $\emptyset_{10}$, hence the lagrangian density will be identical, thus cause equal calculations and equal results in $\emptyset_7$ or $\emptyset_{10}$.
- If the observer is doing particle theory: he will use the intial conditions at the emission point of the photon as his parameters, which after imposing the matching of the first factor, will cause equal calculations and equal results in $\emptyset_7$ or $\emptyset_{10}$.

In such system with such imposed conditions, one can treat the photons in $\emptyset_7$ and $\emptyset_{10}$ as the same photon, and hence in the interval $[\emptyset_7, \emptyset_{10}]$, one can treat the photon in $\emptyset_7$ as evolving in time, since if we consider and treat the photons in $\emptyset_7$ and $\emptyset_{10}$ as the same photon, photon “C”, then according to the TimeFlow principle [16], photon “C” will experience the flow of time.

Then one can take eq (4), in eq (32) to get back:

$$\frac{dx}{dt} = c \tag{35}$$

Which gives back the classical motion of the speed of light.

One can see, that taken a case like the sun and the earth, perfectly satisfies these conditions, taking the sun as a source of constant emission of light, with a constant from of geometry (relatively constant) between them, one can treat light from the sun, or even a light bulb, as time experiencing.

This argument however, and this whole paper, leads to a significant and important conclusion, one that almost every modern physics theory is leading to, and our new argument is joining the party.

20. Determinism

The Holographic principle, String theory, Newtonian mechanics, and Field Theories in general, have a key feature in common, they inevitably lead to a highly deterministic universe, and our argument strongly aids this idea.

For our argument, let’s say the example of the sun and the earth, to work, the sun, will have to already emit every photon it could have emit in every point in the fourth dimension, meaning that every point in the fourth dimension already exists, past, present and future, what will happened in previous points in Dim4, and what happens in future points, all happened the same.

This is way beyond human intuition, one can barely describe it by words, and so for a lack of better expression, I leave you with what is in my opinion, the best way it was described:

The distinction between past, present and future, is only a stubbornly persistent illusion.

-Albert Einstein

The Fourth Dimension and the Multiverse

One can see that the fourth dimension idea automatically yields out the multiverse hypothesis, by stating that the fourth dimension represents different layers of the three dimensional universe, and the flow of time is just the motion from one universe to the other, so if the idea presented in this paper is right them the multiverse must exist.

It even says that unlike bosons, fermions are constantly moving between universes (because of their experience in the flow of time), so you and I are constantly moving in the multiverse, it’s actually a very beautiful idea.

And since the fourth dimension also gives interpretation to quantum mechanics, so that also means that in a way, the right interpretation for quantum mechanics is the multiverse hypothesis, with a few extra details of course.

The Fourth Dimension and String Theory

The main subject of this paper is time, the fourth dimension and how it relates to what we know as “Time”, and how it relates to the spatial dimensions, however the paper states that the flow of time depends on motion in the spatial dimensions, meaning that it only cares about the ***motion*** in the spatial dimensions, not the dimensions themselves, so "dr" which represents the spatial motion, could depend on any number of dimensions, one, two five or even ten, "$dr = \sqrt{\sum {x_i}^2}$" where "I" can be any integer, hence the fourth dimension idea can still work perfectly with the ten spatial dimensions of M-Theory, and doesn't prevent the existence of more than three spatial dimensions.

Supporting Arguments

We argued above how this new way of thinking of time and the fourth dimension offers a natural explanation to quantum mechanics, it does so through the detection property, and making the assumption that all the fundamental particles of nature are one dimensional waves, but one can't observe the whole wave simultaneously, but rather just one point on it at a time, which gives one the illusion of the zero dimensional one point particles, this arguments however depends on two new ideas, the detection property, and the assumption that all the one point particles in nature are not one pointed, but rather a one dimensional wave, we wish now to present two supporting arguments that uses experiments and proven theories, the Regge trajectories to support the one dimensional wave argument, and the Higgs field potential energy to support the detection property argument.

1. The Regge Trajectories [17], [18]

The Regge trajectories were introduced by Tullio Regge more than 50 years ago, the Regge trajectories link bound states and resonances with the same internal quantum numbers but with different values of the mass, m, and angular momentum, J. When the J values of the meson, or baryon, groups are plotted against the square of the mass linear trajectories result. They are known as Chew-Frautschi plots [19], the Chew-Frautschi plots shows that the relation between the mass of the particle and its angular momentum implies the fact that the particles are not points, but actually one dimensional, which is what causes the plots to be linear when plotting them as the angular momentum with the square of the mass, this supports the idea that particles in nature are not one pointers at all, but rather one dimensional waves, or strings, and that is just an illusion caused by the detection property.

2. The Higgs Field potential [20]

The SSB of the Higgs fields and its special potential (the famous Mexican hat potential) is what gives the fundamental particles of nature their mass, and saves the symmetries of the standard model Lagrangian [21], we discussed above in the "labeling types of motion" section, that Fermions travel through the fourth dimension while Bosons don't, if one wishes to study this idea, one finds the following, if an observer experiencing time normally, meaning that he's traveling through the fourth dimension, wishes to devise a potential plan for the particles, one first must recognize that for the observer, Bosons, which for him are stuck in one Dim4 point, and can't move in the fourth dimension, will appear to possess zero potential energy, but rather only kinetic energy, while Fermions will appear to possess a potential energy with a positive value "$U_p > 0$".

Furthermore, one must also recognize that duo to conservation laws, the observer has to agree that since Bosons can't suddenly gain potential energy and start moving in the fourth dimension, the point of zero potential energy, $U_p = 0$, will appear to the point of equilibrium reflecting constant high energy local maxima, since the particles living in this locally symmetric point will all appear to gain the same high speed, the speed of light, and as for Fermions, their will appear to be possessing a minimal amount of positive potential energy, $U_p > 0$ that can't disappear and forces them travel through the fourth dimension, forcing them to act and appear as if they have mass and experience the flow of time, what's more is that this local minima will be a wide range of different points that share the property of being symmetric, locally minima which makes them a state of preference for the particles, and have a limit they can't exceed.

If one next would to map this kind of potential after taking all those facts into consideration, such map will has to have the following properties: it will start with a maximum symmetric zero point high energy, then it will start sinking down until it reaches a positive locally minimum symmetric low energy closed range.

If one now considers the Higgs Field Potential map, one fins that it delivers all the conditions above, it is as if it exactly describes a world that obeys this way of thinking about time and the fourth dimension, the famous Mexican hat chart displays exactly all the conditions mentioned earlier.

That in turn, supports the Detection property, which is an unavoidable consequence of thinking about time and the fourth dimension in this way, and vice versa, the weird shape of the Higgs field potential has been a mystery since it has been proven by the discovery of the Higgs Boson particle with the LHC in 2012 [22], specifically why nature has chosen to take this shape of potential, this new arguments about time, offers an answer, it must be, that the Higgs Field, and the fourth dimension discussed in this paper, are very linked together in some way, if not being the same field.

REFERENCES

[1] Einstein A. (1916), Relativity: The Special and General Theory (Translation 1920), New York: H. Holt and Company.

[2] Heisenberg, W. (1927), "Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik", Zeitschrift für Physik (in German), 43 (3–4): 172–198, Bibcode: 1927ZPhy...43...172H, doi: 10.1007/BF01397280, S2CID 122763326... Annotated pre-publication proof sheet of Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik, March 21, 1927.

[3] Notes on Dirac's lecture Developments in Atomic Theory at Le Palais de la Découverte, 6 December 1945. UKNATARCHI Dirac Papers. BW83/2/257889.

[4] Notes on Dirac's lecture Developments in Atomic Theory at Le Palais de la Découverte, 6 December 1945. UKNATARCHI Dirac Papers. BW83/2/257889.

[5] Ashby, Neil (2003). "Relativity in the Global Positioning System" (PDF). Living Reviews in Relativity. 6 (1): 16. Bibcode: 2003LRR.....6....1A. Doi: 10.12942/lrr-2003-1. PMC 5253894. PMID 28163638.

[6] See this paper section “V”

[7] See this paper section “IV”

[8] Schlosshauer, Maximilian (2005). "Decoherence, the measurement problem, and interpretations of quantum mechanics". Rev. Mod. Phys. 76 (4): 1267–1305. ArXiv:quant-ph/0312059. Bibcode: 2004RvMP...76.1267S. doi:10.1103/RevModPhys.76.1267. [4] Bengtsson, Ingemar; Zyczkowski, Karol. Geometry of Quantum States: An Introduction to Quantum Entanglement (1st ed.). p. 301.

[9] Griffiths, David (2005). Introduction to Quantum Mechanics (2nd ed.). pp. 183–4.

[10] Gerlach, W.; Stern, O. (1922). "Der experimentelle Nachweis der Richtungsquantelung im Magnetfeld". Zeitschrift für Physik. 9 (1): 349–352. Bibcode: 1922ZPhy....9..349G. doi:10.1007/BF01326983. S2CID 186228677.

[11] Peskin, M.; Schroeder, D. (1995). An Introduction to Quantum Field Theory. Westview Press. ISBN 978-0-201-50397-5.

[12] Schrödinger E (1936). "Probability relations between separated systems". Mathematical Proceedings of the Cambridge Philosophical Society. 32 (3): 446–452. Bibcode: 1936PCPS...32..446S. doi:10.1017/S0305004100019137.

[13] J. S. Bell, On the problem of hidden variables in quantum mechanics, 1966, reprinted in J. S. Bell, Speakable and unspeakable in quantum mechanics, Cambridge, 2004, p. 1—13.

[14] Einstein, A; B Podolsky; N Rosen (1935-05-15). "Can Quantum-Mechanical Description of Physical Reality be Considered Complete?" (PDF). Physical Review. 47 (10): 777–780. Bibcode: 1935PhRv...47..777E. doi:10.1103/PhysRev.47.777.

[15] Noether, E. (1918). "Invariante Variationsprobleme". Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen. Mathematisch-Physikalische Klasse. 1918: 235–257.

[16] See this paper, section “”, “Introducing a New principle”.

[17] T. Regge, Nuovo Cimento 14,951 (1959).

[18] Regge, T. (1959). "Introduction to complex orbital momenta". Il Nuovo Cimento. Springer Science and Business Media LLC. 14 (5): 951–976. doi:10.1007/bf02728177. ISSN 0029-6341. S2CID 8151034.

[19] Chew GFP, Frautschi SC. Regge tra jectories and the principle of maximum strength for strong interactions. Phys Rev Lett 1962; 8: 41-4.

[20] Higgs, Peter 1964. Broken symmetries and the masses of gauge bosons. Physical Review Letters 13 (16): 508–509.

[21] R. Oerter (2006). The Theory of Almost Everything: The Standard Model, the Unsung Triumph of Modern Physics (Kindle ed.). Penguin Group. p. 2. ISBN 978-0-13-236678-6.

[22] "LHC experiments delve deeper into precision". Media and Press relations (Press release). CERN. 11 July 2017. Retrieved 23 July 2017.