A New Quantum Model

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Abstract

In contradistinction to the Copenhagen interpretation of quantum mechanics [1], Louis DeBroglie considered the wave function and the particle as two distinct quantities[2]. David Bohm followed up on this to provide a deterministic ontological description of quantum mechanics [3]. This paper builds on the above to posit a 'mechanical' model for quantum mechanics. An interpretation of superposition, entanglement and the nature of time is proposed.

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I. INTRODUCTION

A much earlier paper[4] (as well as work by Vigier[5]) suggested that space-time itself was stochastic. (Although we could also consider it chaotic as opposed to stochastic. This allows the resultin quantum theory to be deterministic; Bohm's version of quantum mechanics is deterministic. But considering the elements of space-time to be point-like (i.e. 'events') is problematic; Points, having no extent, would be unlikely to be able to tesselate the space-time manifold. We therefore consider space-time to be granular[7]. The grains which we call venues (as opposed to zero-volume 'events) have a volume of the order of a Planck length cubed times a Planck time.

II. GRANULARITY

Granular space-time suggests a mechanism to explain the constancy of the speed of light:

We suggest (and this is highly speculative) that frame-dragging occurs whenever a mass (non-zero rest mass) moves through space-time. Photons, as their rest mass is zero, moves without frame-dragging. This (as we will see) allows an argument showing the constancy of c.

Consider an object (here, the black circle) moving at high speed in the direction of the arrow. The object moves through the venues (here represented by the white rectangles). But due to venue frame dragging at high velocities, the venues are pushed ahead of the moving object. But venues are constant in volume, and the only way that they can 'pile up' is by contracting in the direction of motion (and expanding in other dimensions). The object must move through these venues. As the object's speed increases, the contraction increases (rather in the way a 'curvature well' becomes ever deeper). To an external observer (making contravariant observations), the objects increase in velocity slows until it stops completely where the venue dimension in the direction of motion approaches zero. To that observer (as can be seen in the diagram above) the object is accelerating (which because of the Equivalence Principle, is under the influence of gravity). This establishes that a mass has a limiting velocity.

We have postulated then, that a particle with non-zero rest mass drags along (empty) venues as it moves, Photons, having zero rest mass, do not drag venues.

So, if a particle moving with respect to the local privileged reference frame emits a photon, the photon does initially travel with a velocity of c plus the velocity of the particle. But the particle is dragging venues. As the venue contracts in the direction of motion, since its volume is constant, it expands in the time dimension. And this makes the time a photon takes to pass through the venue constant. The photon has more venues to pass through than it would have if the particle were not moving. Because of the additional distance (i.e. number of venues) the photon needs to travel, its speed at the detector, would be a constant, which is to say c.

If the detector were extremely close to the emitter (on the order of Planck lengths) one would measure a value of the velocity greater than c. This length scale is too small to measure so the velocity greater than c is unobservable.

III. MEASUREMENT

There are a few points/speculations to be made about measurements. First, to be a true measurement, there must be a latch (e.g. a flip-flop) so that the 'film' cannot be run backwards. As an example, consider the two slit experiment with electrons. If a measurement device is placed at a slit, there is no interference pattern. But when an electron goes through a slit, the orbital electrons in atoms of the wall of the slit will be distorted by the passage of the electron. This distortion is *almost* a measurement. But when the electron passes through the slit, the orbital electrons become un-distorted. The interference pattern is still produced because there is no latching of measurement information. A latch could be some mechanical contrivance, or even human (or non-human) memory. A fruit-fly observing at a slit will kill the interference pattern, but only for the fruit-fly. We think the process should be transitive; A human observing the fruit-fly's memory will cause the interference to be killed for the human as well. This is the idea behind Relational Quantum Mechanics (RQM)[6]. In RQM, there is no universal wave function collapse that everyone agrees about. RQM interprets QM by viewing the state of a quantum system as fundamentally observer dependent.

A measurement forges a connection between the thing being measured and the measurer forcing them to have the same relative now. In the macro-world, virtually everything observes (via photons) everything else, forcing that macro-world (or a portion thereof) to have the same relative now. And measurements forces time to have tracks. Not that time is frozen, but looking back to a particular time will show uniquely what the world looked like at that time. E.g., if one were to do high-speed filming of particle 'tracks' in a cloud chamber, one would see the time-tracks.

Observation, a crucial part of a measurement, is conducted via photons. We speculate that *all* measurements are via photons (or, equivalently, by the electromagnetic field).

IV. SUPERPOSITION

We accept the DeBroglie idea that (in contradistinction to the Copenhagen interpretation) a particle is distinct from its wave. And the wave is a fluctuation of space time, i.e. the collective oscillation of venues. We further suggest that superposition applies only to waves, and not to particles. And those waves are fluctuations of space-time (i.e collective oscillations of venues). This therefore, says that Schrodinger's cat is either alive or dead but not both. In the case of the two-slit experiment, the particle unambiguously goes through one slit, which one depends on the initial conditions (as Bohm maintains[3]). Further, as the wave-function wave is a mathematical convenience, there is no collapse on measurement.

V. THE NATURE OF TIME

As we are treating space stochastically, for covariance we would like to treat both space and time similarly. To do that, we then let the stochasticity apply to time as well as space. This leads to an obvious problem: If a venue contains mass, then migrations can position the mass so it appears at multiple positions in space at the same time. E.g. A venue containing mass could migrate one unit backward in time, then one unit forward in, say, x, then one unit forward in time, resulting in the mass being at both (x,y,z,t) and (x+1,y,z,t). Preventing this necessitated a change in how we view time.

First, let's consider the idea of the 'world-line'. Moving forward from the present, we are predicting the future. And with quantum uncertainties (as well as with the intervention of outside forces) that future cannot be predicted according to classical determinism. And if there is no completely deterministic trajectory going forward, then arguably neither is there one going backward in time. The world-line then, seems to have limited utility in quantum mechanics. Instead of a world-line, we consider a 'world-double-cone', with its apex at 'now' that widens as one moves forward or backward in time. So while quantum mechanics lets us probabilistically predict the future it also lets us probabilistically predict the past.

We suggest that for the quantum world, t is not the (real component of the) fourth dimension, and that t is an emergent quantity, if not merely a human construct based on memory. The time coordinate, t, is a defined quantity in the laboratory frame whereas we suggest (below) another quantity, τ (tau-time) is appropriate in the quantum domain.

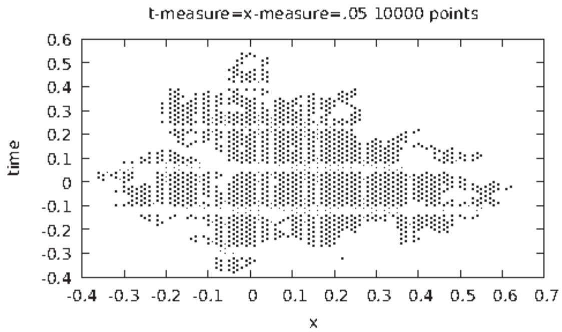
We'd like to treat the time dimension, t, in the same way as we treat spacial dimensions. But there is a big difference between a space and time coordinate: Consider the graphic below:

A particle (the black disk) starts at x=0, then moves to x=1, then 2, then 3. (We are considering space-time to be granular, hence the coordinate boxes.) There is a single instance of the particle.

But time is different:

A particle at rest is at t=0, then moves to t=1, etc. But when it goes from t=0 to t=1, it also remains at t=0. There are now two instances of the particle, etc. In other words, a particle at a particular time is still there as time advances, and the particle is at the advanced time as well.

Consider the graph (of 10000 points) below. (The vertical and horizontal lines are artifacts of the graphing software.) The graph represents the path of a a single venue migrating in x and also in t, both with a measure of 0.5, where the coordinate axes are laboratory x and laboratory t.

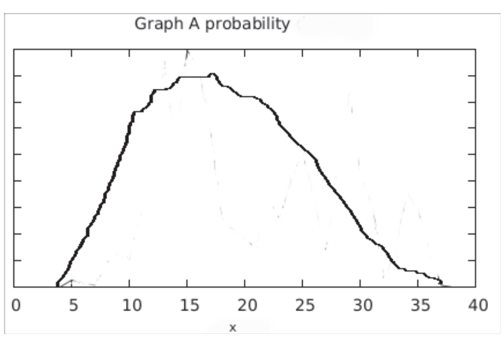


(The gaps in the graph are false; the result of the graphing program.)

There is an immediate problem:

Consider what the graph signifies: At any given laboratory-time t, the same venue will (simultaneously) be at a very large number of x coordinates. If there were mass/energy at the venue, this would be very problematic as causality and conservation of mass would be violated.

We can still consider the graph but we'll interpret it differently: If we take any (horizontal) time (τ) as a 'now', A venue (containing a mass) stochastically flits forward and back in space, and forward and being stationary (not backward) in time. So that at 'now' there is one and only one particle. But where it is cannot be predicted. However, the likelihood of the particle being at a particular x (+/- dx) position is determined by the relative number of times the particle is at that position. In the case of the graph, if we take as 'now' the τ-time slice at -0.2, for example, we find (by examining the data) the following probability curve:



This is analogous to $\Psi^*\Psi$. But the graph is a construct. It represents, but is not actually, the particle. When the particle is measured by, for example, being absorbed in a detector, it freezes (no longer moves stochastically). It no longer flits through time and space so the graph 'collapses' to the measured position. (that position is only determinable by the measurement.) This is analogous to the collapse of the wave function, but here (as the graph is merely a mathematical construct) there is no collapse problem.

The Time Leaves No Tracks concept implies that there are multiple futures, and they all 'happen'. (This is somewhat redolent of the Everett many-world interpretation[8].) In this model, an observation from the laboratory will select a particular future (making a track).

In the above, if the particle were in a potential well with perfectly reflecting walls, the above graph would (after a time) represent the probability density of finding the particle at a particular position in the well.

Again, the particle has always existed at only a single venue, but the venue migrations happen roughly at the rate of the Planck time, making the particle appear (in some sense) to be at multiple positions at a particular time. Further, (because of the properties of Wiener Processes) the particle appears to spread. If the particle were not constrained by the well, (because time is moving forward and back) the graph would evolve (spread) arbitrarily rapidly. In that case the curve would represent the relative probability density of finding the particle at a particular position. The curve then would represent DeBroglie's 'ghost waves that guide the particle'[5].

VI. THE DIFFUSION AND SCHRÖDINGER EQUATIONS

We'll use the non-relativistic diffusion equation to derive the non-relativistic wave equation (the Schrödinger equation).

The model is essentially a description of diffusion of space-time. As such, one might think that the diffusion equation, $\frac{\partial\varphi}{\partial t} = D\frac{\partial^2\varphi}{\partial x^2}$ would be part of that description. This, the one-dimensional diffusion equation, is easy to derive.

First consider the 'flux' ,j, (in the x direction) of a quantity through a section perpendicular to x (per unit area and per unit time). We ignore the bulk motion of the carrier (assume fluid). And let φ be the 'concentration' of the quantity.

We can see that $\frac{\partial\varphi}{\partial t} = -\frac{\partial j}{\partial x}$.

We can also see (Fick's first law[9]) that $j = -D\frac{\partial\varphi}{\partial x}$ where D is the Diffusivity coefficient.

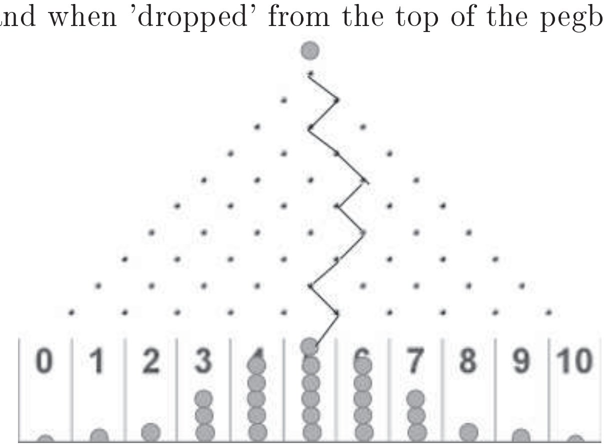
(D is a proportionality factor between the diffusion flux and the gradient in the concentration of the diffusing substance. The higher the levels of diffusivity of a certain substance to another, the faster the diffusion rate by both of the substances. It is given the unit of length squared per unit time.)

So $\frac{\partial\varphi}{\partial t} = \frac{\partial}{\partial x}\left(D\frac{\partial\varphi}{\partial x}\right)$. And if D is constant, that yields the above diffusion equation, $\frac{\partial\varphi}{\partial t} = D\frac{\partial^2\varphi}{\partial x^2}$.

The equation is very similar to the (potential free) one dimensional Schrödinger equation, but with several significant differences: The 'diffusion constant' in the Schrödinger equation is complex, and the interpretations of the solutions differ. In the Diffusion equation, the solution, φ, (the concentration) can trivially be interpreted as a probability density (of a test particle having diffused to another position in space), whereas with the Schrödinger equation, it is the *square* of the solution that corresponds to the probability density. And significantly, the diffusion equation, while it describes diffusion in space, does not describe diffusion in time.

We'll attempt now to include diffusion in time to see how that effects the solution of the diffusion equation.

We start by observing that the probability of a particle starting at $x_0 = t_0 = 0$ arriving at a point $x = x_1$ is proportional to the number of ways the particle in a fixed number of steps, n, (corresponding to n time increments in the laboratory frame) can arrive at point x_1. And we'll calculate it from the 'laboratory' frame where time is granular but not stochastic. As an example, consider the following diagram. The pegboard represents where a 'particle' will land when 'dropped' from the top of the pegboard.



First we consider the cases where there is no time diffusion.

The jagged line in the above diagram represents a typical path of the ball at the top of the diagram dropped down on the 'pegboard'. If many balls are dropped, the balls will fall into bins as above, and their numbers in each bin will result in a binomial distribution. (The Binomial distribution is equivalent to the Gaussian distribution when the number of axis points is large.)

In the diagram, we can consider the height the time axis (increasing downward) and the horizontal the x axis. The top ball then is initially at t=0, x=5. As it falls, at each time interval (when it encounters one of the pegs), it can move either one x unit to the left or right.

We can represent the typical path above as follows:

t:	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1

x:	+1	-1	+1	+1	-1	+1	-1	-1	+1	-1

Again, summing over all possible paths (with time increasing one unit per point of direction determination), the probability (here, the binomial) distribution results.

Now if we consider also diffusion in time, the top row of the table will no longer be all +1. The numbers in the top row will have the same number of variations as in the second row. So the number of paths will be the square of the number of paths of the non-time-diffusion paths. And so the probabilities of (the balls being in a particular bin) in the time diffusion paths will be the *square* of the number in the non-time-diffusion paths. In other words, the solution, φ, of the diffusion equation represents the square root of the probability density. (In our Brownian motion model where only one direction at a time migrates, the square property holds over three dimensions and not just over the one-dimension case above.)

Now, having included time-diffusion in the (interpretation of) the diffusion equation, we turn our attention to including the possible effects of complex time.

First regarding $\frac{\partial \varphi}{\partial t} = D\frac{\partial^2 \varphi}{\partial x^2}$, Nettel in 'Wave Physics'[10] says: "If we are to have a solution to a first order differential equation, that solution will have to be an exponential function rather than a trigonometric one. Moreover, to avoid having the solution go to infinity or be exponentially damped as t goes to either plus or minus infinity but rather to get waves, the exponent in the solution will have to be imaginary. As the reader can easily check (if we include i in the equation), we get the solution $\psi(x,t) = e^{i(kx-\omega t)}$."

The diffusion equation is for diffusion in 3-space (although we've interpreted it as a diffusion also in time). Taking guidance from the above, we will introduce another coordinate axis, an imaginary-time axis perpendicular to the real-time axis.

We take imaginary time to be rolled-up. It's coordinate then continues to increase, rolling around to zero, etc. This gives a complex frequency $e^{i\upsilon}$, where we can let υ be $kx - \omega\tau$.

So, now having an imaginary axis for υ-time, we'll again define a 'total time' T which will be the combination of τ-time and υ-time, T = τ + iυ.

$\frac{\partial T}{\partial t} = 1$ and $\frac{\partial T}{\partial \upsilon} = i$

We have then, $\frac{\partial \Psi}{dT} = \frac{\partial \Psi}{\partial \tau} * \frac{\partial \tau}{\partial T} * \frac{\partial \Psi}{\partial \upsilon} * \frac{\partial \upsilon}{\partial T}$.

Substituting gives, $\frac{\partial \Psi}{\partial T} = \frac{\partial \Psi}{\partial \tau} * \frac{\partial \Psi}{\partial \upsilon} * (-i)$.

What can we say about $\frac{\partial \Psi}{\partial \upsilon}$?

As υ is periodic, then so to is $\frac{\partial \Psi}{\partial \upsilon}$, and the period is at the Planck scale.

Now the Diffusion equation, though working in the macro (and to some extent) quantum domains, might not be expected to work at the Planck scale. We 'blur' the time in the Diffusion equation (i.e., take over a short (but not too short) time, then $\frac{\partial \Psi}{\partial \upsilon}$will average out to a constant. And as the solution depends on details of the physical situation, that constant, here called k, is (at least most all of the time) not zero.

We will use the 'total time' T, rather than τ in the equation. So now, we have, $\frac{\partial \Psi}{\partial T} = ik\frac{\partial \Psi}{\partial \tau}$ and the Diffusion equation becomes, $-ik^{-1}\frac{\partial \Psi}{\partial T} = D\frac{\partial^2 \varphi}{\partial x^2}$

Of course, we could have just used Schrödinger's argument (about needing i for there to be waves) to arrive at his equation. The above argument though is intended to provide a physical (i.e. geometric) description.

VII. ZITTERBEWEGUNG

The Dirac equation predicts that Fermions move at the speed of light. To justify this, the particles are posited to move rapidly back and forth at velocity c, with average velocity in accord with the particle's movement through space. We suggest that the oscillations occur roughly at the Planck time. But this begs the question, why doesn't the speed increase the mass in accord with special relativity. We suggest that nothing is instantaneous, i.e. every action has a short delay before the reaction. And If another action happens in the delay, the actions are additive. This would essentially give the particle an effective speed far less than c.

VIII. NOTES ON ENTANGLEMENT

Entanglement has much in common with superposition (and the two slit experiment).

Entangled particles were initially close together (and interacting).

Superposition (spin up, spin down). Consider a two-particle superposition of spin-up and spin-down. Measurement of one spin state determines the other.

The above superposition model is not deterministic. An alternative deterministic approach would be very high frequency spin-up, spin-down oscillations, too high a frequency to allow one to prepare a desired state. The connection between the entangled particles could travel arbitrarily fast while the (e.g. spin) information could travel (i.e. DeBroglie-like) at a subluminal velocity. Since we assume that time progresses stochastically (or chaotically) there are a number of possible entanglement mechanisms.

IX. POSTSCRIPT

This paper is an amalgum of ideas of David Bohm, Louis DeBroglie, and myself. It is intended to provide an ontological basis of quantum mechanics rather than just a set of defining equations that admitedly work exceedingly well.

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