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Nature of Time in Quantum Mechanics

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We have an uncertain future continuously coming into existence relative to the instant absorption and emission of photon energy. The future is a blank canvas that we can interact with forming the possible into the actual. And the future we are dealing with is from our point of reference. The future is unfolding with each photon-electron interaction with the respective elements of the periodic table and the individual waves formed by the electromagnetic spectrum. It's a process of energy exchange that forms reality. If we look at the quantum world, the 'past' is represented by anti-matter annihilation which maintains a balance between matter and anti-matter showing a balance between the future and the past. In the Delayed Choice Quantum Eraser Experiment, time is unfolding photon by photon within the experiment, within our frame of reference. But we have an infinite number of reference frames coming in and out of existence with a timeline for each object. What is our past might be the future to an observer from a different frame of reference. Everything is relative.

If we take all the infinite reference frames into consideration, n-dimensional spacetime, then quantum particles are not to be considered as 3d spacetime particles anymore. They are in an n-dimensional spacetime. Just like how we in terms of classical physics can see / live / understand only 3d of spacetime, when we go to the quantum realm; these particles are in an n-dimensional spacetime with information of all reference frames.

We are only considering the measuring setup of the system in 3d environment. For ex, in Quantum eraser experiment, the experimental setup is in a 3d environment and the observer is also present in 3d and is observing from one frame of reference. But what if the quantum particles do have information of n-dimensional reference frames, including our 3d world. And they can process the information according to the reference frame of the spacetime dimension they are measured in, which we call the observer's frame of reference/ (observer's "current" time). The results are based on the spacetime dimensions we currently live in. The quantum particles respond to the spacetime dimensional properties. For the 3d spacetime, the result upon measurement should be a particle. Until measurement, the quantum particles are not just in a superposition like a 3D wave. Each quantum particle is in an n-dimensional wave which spreads in n dimensions. Based on the observer's frame of reference, upon the act of measurement, the quantum particles would give the results. For example, in the double slit experiment, if the two slits are replaced with three slits and then with four slits and so on, then the single quantum particle will still cause an interference pattern based on the number of slits. Quantum superposition takes place here. In other words, the quantum particle's wave is spread in a n-dimensional spacetime (up to infinity!) and is omnipresent with the knowledge of all the reference frames.

Energy is a source of information exchange to the quantum particles to be aware of the dimension of observation. For example: If we take the quantum eraser experiment, or the Bell's inequality experiment, it is a system setup in a 3-dimensional environment specific to an observer's frame of reference. Only upon the act of measurement, the information exchange happens about the 3-dimensional system and hence the results are shown relevant to the observer's frame of reference. Considering the quantum particles as n dimensional waves could resolve the observation problem.

We can better understand if we think of this as a water wave in classical terms. The individual water molecules are particles in classical terms and do not exhibit wave like properties until we combine many such molecules and form a sequence of images of a wave structure to understand it as a wave. When looked separately, the molecules are in individual moments of "now" and don't provide complete information of the wave. But when we play the sequence of images, various moments of "now", in an order to give it a meaning- "a wave". It is then we can see the complete picture and get more information about the overall nature of the water wave.

How is Time treated as one full dimension to define Spacetime continuum? I believe it should be ½ dimensions.

If space has three dimensions — up/down (1st dimension), left/right (2nd dimension), forward/backward (3rd dimension), then let's think about time. To call it a one dimension of time, we should be able to go up and down. But no, we can only go up (future) and not down (past). So, it should technically be ½ dimensions.
We are forever trapped in a one-way direction of time within our frame of reference.

Or should I say, we technically do not have a time dimension? I have a logical reason for saying so. Contradicting my above statement, I can even say that I can't even travel to the future. I am forever stuck in the current moment which we call "now". So not even up, not even down; we are stuck in a given point in time called "now". Yet, that current moment keeps shifting towards the future. We feel we are travelling on time dimension, but we can't go back from our point of reference.

The First Dimension (1D) of Time:

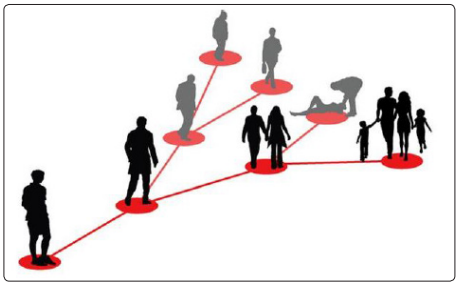
We now know that if we were able to travel to the past and future, then it is the first dimension (1D) of time.

Which means, I could go back to a time when I was 8 years old and redo the same candy crush experiment with more precision? Wow! That's exciting.

What would be the Second Dimension (2D) of time?

The 2D of time means going up (future) and down (past) and also left and right, which means we can multitask in different realities. Imagine me being an author in one reality, a teacher in another, and so on.

If we could shift from multiple realities and still go back and forth in time in each of those super positioned realities, we can call it the 2D of time. (Figure 5)



Now comes the tough part. **What would be the 3D of time**?

In the 2D of time, we are still on Earth and with the known laws of physics. If we enter a reality where there are unknown dimensions/realities, where we cannot even imagine the kind of laws there might exist there, and then we can shift from those multiple realities and the parallel realities on Earth. We can still go back and forth in time in each of those super-positioned realities; we can call it the 3D of time and then comes the 4D of time and so on. Technically, there are an infinite number of dimensions in spacetime.

For example, imagine people of a 2D spacetime world. It would be as if they were on a flat screen television, never knowing the Z axis which we use to represent the 3rd dimension. Imagine that they are completely unaware of the 3rd dimension. If we passed a ball into their world from the top, they would simply see a dot when the ball first touched their world. It would then gradually turn into a straight horizontal line which grows to a point and then starts gradually decreasing in length and finally disappears. There is no way they are going to know that it is a circular object, and neither can they understand the complete picture. We are familiar with 3D spacetime. But let's take this very simple example. Imagine a cube. We all know that it is a 3D object.

Photo courtesy from Wikipedia:

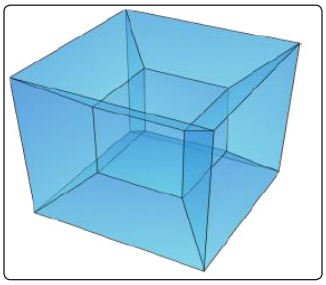


Figure 6: Tesseract or 4-cube

If we look at (Figure 6), it is a Tesseract or a 4-cube which is a 4-dimensional object. The dimensions keep increasing to infinity. Time related thought experiments often lead to paradoxes. According to the Theory of Relativity, time travel is possible both to the future and to the past.

Let's discuss a famous time travel paradox. Imagine that a time machine is built by a person, Mr.X, and he goes back to a time before he built a time-machine. He then kills his past self. The paradox here is that Mr.X existed and went back in time, which means he was alive in the future and went to the past. But if he killed himself in the past, then questions arise such as: How did he go back in time? Who killed him? Where does he exist now? Did he ever really exist? It's a paradox. If the Superposition suggests a possibility of multiple realities happening at the same time (the Many Worlds interpretation), then there is a possibility of solving this paradox.

Winning Path/Losing Path: Does Quantum Entanglement and Wave Function Collapse decide "which way" information flows and hence my future? A bigger question I have regarding Quantum Entanglement is whether the future is already predetermined. If entangled partners on a faraway planet can influence events on Earth instantaneously, then wouldn't the effect precede the cause? According to the relativity theory, if I travel in time to the future and I see myself there, does that mean the future is already predetermined and that the future is also happening now? Isn't everything part of the same entanglement process from the Big Bang Theory? Entanglement is so common that happens in nature, but we hardly notice it. The photons that originate from the Sun could be entangled. Would it be possible that everything in the Universe is entangled? Let's look at some examples of quantum particles to understand the nature of time better.

A proton is made up of two "up" quarks and one "down" quark, and a neutron has two "down" quarks and one "up" quark. We are familiar with electrons having mass and a negative electrical charge. Protons undergo a transition due to a weak force and become neutrons. This also releases some other subatomic particles like neutrinos.

There are W and Z bosons that are force carriers. There are photons and gluons that are less mass but exhibit forces. And very interestingly, there exist anti-particles to these particles which we call Antimatter. These have equal but opposite variables of the source particles. For example, the electron's antimatter counterpart is positron. Positron has a mass that is exactly equal to an electron, but the charge is positive whereas an electron charge is negative. Do not confuse this with a proton. A proton is heavier than an electron and has more mass. Antimatter also has a positive mass and is not to be misinterpreted as having negative mass. Negative mass does not exist (or has not been found yet!).

There are some interesting facts about anti-particles because they are often going backwards in time. Because of their so-called opposite "spin", they are travelling in reverse. When matter and antimatter annihilate, it will lead to gamma radiation. We still have a grey area where these particles originate and where they disappear. Perhaps there is another dimension.

Let's look at an example:

We know that a proton becomes a neutron or vice versa due to decay. If a proton is comprised of two up quarks and a down, and neutrons

are comprised of two down and an up, how can a neutron be both a proton and electron? Simple question, right? But the answer in quantum mechanics is that particles can appear and disappear or change into other particles. With the neutron, one of the down quarks can decay and change into an up quark by emitting a W boson, thereby turning into a proton. The W boson quickly decays into an electron and an electron antineutrino. The new up quark didn't exist until the down quark changed into it. The W boson is what is called a virtual particle. It doesn't exist in the classical sense, it's just kind of there in the ambiguous region of spacetime where the decay occurs. The electron and antineutrino didn't exist until the decay. These subatomic particles seem to have clear control over spacetime and its dimensions in order to travel across dimensions of space and time. If we look closely at the ½ spins, the full spins, and the negative spins of these particles (the antimatter particles), then all these suggest that some of these particles are travelling backwards in time. As discussed in the earlier sections, it's not the 3D of space and the 1D of time, but instead, it's the 3D of spacetime where the 3D of time also exists, and that opens the possibility of infinite dimensions. In fact, it should non-dimensional because the number of dimensions can be infinite. This can be explained using the below mathematical derivations.

Position series:

S1 or $|\Psi\rangle = (1/\sqrt{e1|a1\rangle})^2 + (1/\sqrt{e1|a2\rangle})^2 + (1/\sqrt{e1|a3\rangle})^2$

$+ (1/\sqrt{e4|a4\rangle})^2 + \ldots\ldots\ldots..$

-- Represents probability of all locations

$$\int_{-\infty}^{\infty} |\psi|\,2\; dS1 = 1$$

Change of basis to Momentum gives

Momentum Series:

S2 or $|\Psi\rangle = (1/\sqrt{e2|b1\rangle})^2 + (1/\sqrt{e2|b2\rangle})^2 + (1/\sqrt{e2|b3\rangle})^2$

$+ (1/\sqrt{e2|b4\rangle})^2 + \ldots\ldots\ldots\ldots$

-- Represents all probabilities of momenta

$$\int_{-\infty}^{\infty} |\psi|\,2\; dS2 = 1$$

Change of basis to spin gives

Spin Series:

S3 or $|\Psi\rangle = (1/\sqrt{e3|c1\rangle})^2 + (1/\sqrt{e3|c2\rangle})^2 + (1/\sqrt{e3|c3\rangle})^2$

$+ (1/\sqrt{e3|c4\rangle})^2 + \ldots\ldots\ldots\ldots$

-- Represents all probabilities of Spin direction

$$\int_{-\infty}^{\infty} |\psi|\,2\; dS3 = 1$$

All eigenstates are in superposition upto infinity until observation/measurement. Each of the 3 coordinate's position; momentum and spin are represented in the infinite series S1, S2 and S3 above.
Probability density function:

$$|\psi|^2 = \Psi^*\Psi = (e1\text{-}ia1)\,(e1\text{+}ia1) = e1^2\text{+}a1^2$$

At any given point in time, there are only 3-bit combinations of S1, S2 and S3. For n bits, the combination is 2n.The possible set of eigenstates for all series is 2n+2n+2n+……...
For the above example $|\Psi\rangle$ combined for S1, S2 and S3 and so on, at a given point in time, is derivative of time t times the probability of the given eigenstate,

$$\rceil\Psi\rangle = (đ/đt) * 2^n \left(\int_{-\infty}^{\infty} |\psi|\,2\; dS1 + \int_{-\infty}^{\infty} |\psi|\,2\; dS2 + \int_{-\infty}^{\infty} |\psi|\,2\; dS3 + \ldots..\right)$$

$$|\Psi\rangle = (đ/đt) * 2^3\,(1\text{+}1\text{+}1\text{+}.....)$$

According to Ramanujan's infinite series theorem, 1+2+3+4…… = -1/12
$= (b/đt) * 2^3(-1/12) = -⅔ * (đ/đt)$
Or alternatively,
$= (đ/đt) * 2^3(1\text{+}1\text{+}1\text{+}1\text{+}1\text{+}1\text{+}.....)$
$= (đ/đt) * 2^3(1\text{+}1\text{+}2\text{+}3\text{+}.....)$
$= (đ/đt) * 2^3(1\text{+}(-1/12)) = (đ/đt) * 22/3$

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