Many World Quantum Interpretations of Scattered State and Resonance to Black Hole Information Paradox:

Lost or Alive

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Abstract

In Black Hole studies, Information paradox is one of the most confused topics that physicists have ever had. I think of it with the interpretation of Many World Theory, thinking of quantum systems get scattered by the potential phase shift. By that I came up to decision that firewall theory is certainly right up to a high degree and we get scattered by the potential dwell up. And information is therefore must be preserved in quantum mechanics, so belief in the very world of Everett, I am putting forward a thought experiment with mathematical explanation for why information should must be conserved in order to balance the quantum nature of black holes. And there is all pretty right to have that systems purely quantum because they do not violate either Energy Conservation or State Conservation.

Keywords – Quantum Cosmology; Black Hole

1. Introduction

Information Paradox is quite of like physics where we try to find out whether the information is alive when it gets into or around the Black Hole (BH). Many quantum theories are still trying to get around this problem. In Many Worlds Interpretation Theory (MWIT) [1, 2], we see universe as wave function ψ, when doing this interpretation on BH, we hope to see the BH to be the part of wave function. Quantum Physics bets that information can't be lost at any cost. So while doing MWIT on BH, we try to recover the information, but it is very hard intuitively and mathematically. So instead of information ingoing we gets a wall that protects the BH from information entering to it. Seems weird but in 2012 a theory was published on this idea [3] and shows that it can be true to say that information doesn't really go inside the black hole. We don't have any this thing, we have another difficulties while dealing with BH Information Paradox which is Hawking Radiation [5, 21]. Gauge/Gravity Duality supports this approach of Hawking's with beautiful insights. Testing this theories is not any possible and war between Quantum Theory and Relativity only left with us is Choose. So my choose on basis of MWIT is that "*Information is purely conserved and protected"*. And experiments shows [4] that, if any bit of information once entered and then comes as Hawking Radiation, external observes can't have any illegal quantum cloning (No Cloning Theory). So it is confirmed that either way you can't have clones of information. My idea puts forward that any BH have potential blow up or dwell up that causes any particle to follow the quantum rules to either scatter off or be the part of the resonance. I am treating relativity here to no level right now, because things gets too messy with that. So MWIT provides a wave function to each state and says wave function collapse is don't necessary, so if any wave function gets to potential dwell up from zero potential (0-R), it gets scattered or

stored as a resonance that causes time delay t'. We have been successful in replacing classical geodesics with Quantum Bohmian Trajectories [6] and have quantized Schwarzchild Metric [6,7]. But the problem is that we have no zero potential but only solution that physica is that say Black Hole Event Horizon (BHEH) potential is arbitrary large as compare to normal space-time, indeed it is true. It is suggested that with quantum potential there can't be total evaporation and that is by quantum definition Resonance. Information basically don't have any special precise time to come out but there can be delays [7]. But at the whole, there can be even that we don't really go inside the black hole and my theory stand by this on a good scale.

2. Quantized Black Hole Situation

Before jumping into calculations, let us have a thought experiment describing the situation and results. This all have to be done in a quantum manner. So basically, in this space-time, there may be infinite numbers of singularities. So see our universe as a quantum state with certain wave function, now plot its event horizon with a great ever potential maybe Infinite Square Well [9], and now I am introducing you my friend **Alice** with some other wave function by MWIT, now Alice has been dragged to the event horizon by the greatest force and **Bob** observing her. So as it reaches to the event horizon Alice is experiencing great things like time transformation and other. Bob is seeing the slow motion Alice, now Bob suddenly see that Alice is vanished and disappeared. And we are second observers of Alice, and Bob also. We see that Alice didn't disappear on singularity but on another place.

Now this part of thought experiment may be some kind of non-intuitive, but Bob had taken a lot of years to observe maybe millions or even billions years, and we too. Now as per Hawking Radiation, Alice can be back with radiation, but not. In our case Alice didn't make it inside the black hole, in our case, Alice is still in this Energy-Momentum tensor.
To understand that thing we have to jump to calculations.

3. Role of Potential

$$\frac{d\theta}{d\lambda} = -\frac{1}{2}\theta^2 - R_{ab}k^a k^b + \epsilon\hbar^2 h^{ab} R_{;a;b} + \hbar^2 h^{ab}\left(\frac{\square R}{R'}\right)_{;a;b}$$

Quantum Raychaudhri Equation [6] is essential for null surfaces and because we are dealing with event horizon we have to give it a permit to the paper. But not in this section.

From MWIT, we are allowed to assign an wave function for our universe in multiverse.

$$\langle x|\psi\rangle$$

And for event horizon we have potential V different around different places. So here we get Alice a greater effect of potential in respect to that smaller potential of space time.

$$V_0 \gg V',$$

V' for regular potential in regular space-time.

Now according to Quantum Mechanics (QM), we can have three situations.

Situation 1: According to scattering principle, Alice would be scattered around the event horizon, with some certain kind of phase shift. And Firewall theory says too, we get burned around the event horizon and my theory says we get scattered off, if only in MWIT, with

$$\psi_i = e^{ikx} + \frac{e^{-ikx}}{2} = sinkx$$

Initial wave function for Alice,

$$\psi_f = e^{i\delta}\sin(kx + \delta)$$

Final wave function delta shows phase shift caused by potential shift. And now scattered state can be figured out by the difference between final and initial so,

$$\psi_s = e^{ikx} e^{i\delta} sin\delta$$

$$\psi_s = \psi_f - \psi_i$$

This scattered state is **alive** and floating around in the form of scattered state around the BHEV, may be disk of Black Hole. By this we can say that Hawking Radiation is not possible but the energy around the BHEV is scattered state present in form of energy. But the pure and true form of information of Alice is destroyed, even though because of Second Law of thermodynamics and recovery principle it is kind of not possible to recover the initial wave function. But information is still present but in other state not in the previous state. Hence Firewall theory is right in this situation and Information paradox says Information is **Alive** but not in its pure form.

Situation 2: Although there can be scattering but there can be transmission and reflection too. That says R+T = 1, where R is reflection and T is transmission.

$$\psi = \begin{cases} Ae^{ikx} + Be^{-ikx} & ,I \\ Ce^{ik2x} + De^{-ik2x} & ,R \\ Fe^{ikx} & ,T \end{cases}$$

Initial (I), Reflected (R), Transmitted (T). It is purely observed in Ramsauer-Townseed Effect [8, 9]. Here too, the role of potential is essential. But, here the some information with wave function R, have been reflected back to normal space-time and information with wave function T have been transmitted to black hole, and there is no scattering effect, and the transmitted information can be back out from BH of temperature

$$\frac{\hbar k}{2\pi p} \approx 10^{-6} (M\blacksquare/M)^{\circ} k$$

Where k is surface gravity of black hole, then transmitted information can be out of the black hole with hawking radiation and then mass of black hole would decrease. The metric for this system is of course Schwarzchild Metric [10], this metric deals with null surfaces and here is our case the event horizon.

$$ds^2 = -\left(1 - \frac{2M}{R}\right) dt^2 + \left(1 - \frac{2M}{R}\right)^{-1} dr^2 + r^2(\sin^2\theta d\phi^2 + d\theta^2)$$

Which is simply Schwarzchild Metric, so at conclusion we have information back, but Reflected Information and Transmitted then Evaporated Information are not of same kind or same information. Both of information will show different code and different meaning. But information is back and hawking radiation says the information is alive but not in one form, but in distinct different form. So some part of Alice state will be back by reflection of firewall and some will be back by hawking radiation. So both Firewall and Hawking Radiation is right in this case.

Situation 3: There is chance of Resonance [12], as we are in MWIT, QM allows us to pick resonance as other situation, and we should look at it. As Theory of Resonance implies that there can be time delay for reflection, may be 100 years or 1000 years or we don't know. But chances of negative time delay is so less, although we don't have theory of quantum gravity, but gravity will not allow the information with negative time delay. But there are large possibilities of positive time delay here. Note: Resonance and Hawking Radiation isn't the same thing. Resonance theory supports Firewall more than Hawking Radiation, because Resonance theory clearly shows us mathematically that information reflects, and there couldn't be transmission at all. The role of potential well is again important and plausible.

The classical view of this dilemma is not even possible and with different quantum approach, it seems like silly idea. But In MWIT, we can choose information as energy packet, with some energy E and can calculate solutions with Schrondinger Equation (SEQ) [11], which are:

$$\langle x|\psi\rangle = \begin{cases} Asink'x, & 0 < x < a \\ A\, sink'a\, coshk(x-a) + Bsinhk(x-a) & \\ e^{i\delta}, & X > 2a \end{cases}$$

where 2a is point of one of the two potential barrier, k' wave number for 0-a (range), kappa wave number for a-2a and k for x>2a, and the chronology of solutions are same like that chronology.

And time delay [18] in a potential shift can be calculated by:

$$2\hbar \frac{d\delta(E)}{dE}$$

And in case of Resonance this can be more described by,

$$\Delta t = -\frac{2m}{\alpha\beta\hbar} = 4\gamma$$

With phase shift,

$$\delta = \tan^{-1}\frac{\beta}{\alpha - k}$$

where k being the wave number, alpha and beta are some numbers on k and gamma the width of the famous Breit Wigner Distribution [13] in terms of Energy.

So time delay depends on the first derivative of Phase Shift. The more the derivative, the larger the time delay. But eventually the packet would be release, but there is no any chance or possibilities to take out information before time delay parameter.

This applied on BH Event Horizon can be seen like, a larger potential at the door of BH Event Horizon is causing time delay to some packets (information), but eventually releases the packet. So exclusive information is precisely secured for some time as resonance, but information is been only caught insider or near BH Event Horizon not inside the hole and this again proves the Firewall Theory.

Conclusion for Situation: All three situations singly put out the vote for Firewall Theory. The main composition for all situations is simply ingoing information but in Situation 1, information is scattered in different form, in Situation 2, some information reflects from the wall and some transmitted and then back in space as Hawking Radiation in different form, in Situation 3, information is caught up near BH Event Horizon and then back in space after the time delay caused by phase shift.

Situation 2 and Situation 3 are more likely same but Situation 1 is totally different, either Situation 2 and 3 or Situation 1 is right. Intuitively Situation 2 and Situation 3 violates the information statement that Information is destroyed, but in Situation 1, information is not destroyed but the entropy has been increased totally, so been in Situation 2 and 3 can save your some information but in Situation 1, your information is totally changed. The major difference between Scattering and Resonance that Scattering do its work on Real Plane but Resonance kind of use Complex Plane for works. We have compare Scattering and Resonance as one, but I am putting here in two form, one fully depend for resonance while reflection and one being scattering while ingoing to black hole.

I am in favour of Situation 1 because of its flexibility and loss of determinism by such large astronomical body. But this do not means that Situation 2 and Situation 3 are false, they are right but violates current understanding of universe. And in the later part of this paper you will encountered only Situation 1, which I am calling Scattered Information Situation (SIS).

4. Scattered Information Situation

We have already discussed this situation where information is changed into another language and been scattered throughout the universe. Indeed, in many experiments this has been noticed, but not that nice. In this SIS, information can be back to original form but not with now-days or near 1 millions year technology, we would need a superb information reverser machine.

If we know go for a look for its credibility for conservation of states and energy, it is just as perfect. When any information is converted into different scattered states, no any outer information can be mixed up or not any information can be destroyed out, and this is easily and perfectly supported by Levinson's Theorem [11], which can be described as conservation of bound states when potential is changed and this gain implies that QM won't allow you to destroy information.

$$N = \frac{1}{\pi}\,(\delta(0) - \delta(\infty))$$

Levinson Theorem [11] clearly says that "States never lost or create", only in the case of non-relativity and because we are only discussing pure quantum theory, we would not go for relativistic proof of conservation, and in MWIT, our information is states, more about Levinson Theorem in Appendix 1.

We may get to see some time delay in SIS, the larger energy, the bigger information, the larger time delay and can be calculate using the equation;

$$\Delta t = 2\hbar \frac{d\delta(E)}{dE}$$

Now the major difference between time delay in SIS and Resonance Situation is that in SIS we get the scattered state as a part of time delay to be reflected back in normal space-time but Resonance capture the normal information when normal information do reflects, means middle in the road of reflection. Although Wave functions for both are non-normalizable.

Conservation of States leads us to Conservation of Energy, because of no state is added or deleted, total energy is balanced, although forms of energy are changed.

Potential Shift can be vague if it is off the real axis, and SIS seems to be good for this statement. We see, SIS is perfect for BH Information Paradox and quite of a balance of QM and Relativity too. In SIS, we have Scattering dilemma where we do calculations with relativistic Swarchzchild Metric, and at the same out, we have MWIT that tells us the very measure and quite of approve Firewall Theory.

It is not that, MWIT is only interpretation to study Black hole, we can also deal with Copenhagen Interpretation but the problem is we can't have this much large information to be scattered with precise determinism. And this also not meant that MWIT is full of determinism. We can't say how to reverse the information to previous state, how to know that information is still present, because SIS implies that information cannot be back in the normal space-time. These are some limitation of SIS.

5. Dealing with Black Hole Event Horizon and Firewall

As I see, Firewall and Event Horizon are two different things, Firewall is gate and Event Horizon is a room. You have to first pass the Firewall to reach Event Horizon, technically, there may be thousands more firewall after Event Horizon, the first firewall before Event Horizon may be lesser strong, so in SIS, it is widely possible that information get scattered by first firewall and then reach event horizon. Now because of gravity caused by Event Horizon, there is not any chance to go for next firewall after Event Horizon, this can be seen as:

$\langle x|\psi\rangle$, this is ingoing wave function, for say the information that crosses first firewall, and becomes

$$\langle x, t|\psi_s\rangle = \frac{1}{\sqrt{n}}\,\phi_1(x) + \phi_2(t) \ldots..$$

the superposition [14, 15] of different information over x and time. Important to note is that, information is in both x and time dimensions, so practically in 3 dimensional space, it is travelling in all three dimensions and one time dimensions. Like one bit of information in x dimension, second bit in y and so on. It is too hard to tell which information in which dimension, because of scattered situation. Now after being scattered, it is around Event Horizon but can't pass the event horizon because the state

$$\langle x, t|\psi_s\rangle$$

Which is in scattered situation is widely disturbed by gravity. And because any firewall after event horizon would barely allow scattered information to pass. Now here, my theory which is purely quantum and Classical explanation of black hole are kind of co-operating , because in Classical theory of Black hole, classical gravity of BH tear the object and in this quantum explanation, it is also been scattered. This is good as because QM and Classical theory is maintaining its friendship over this theory.

So information in partial states been around Event Horizon with time delay that I have mentioned above, after this time delay, black hole may be burst out

leaving information to pure 4D Space-Time. But we won't be able retrieve the information, because of alterations during the stay around Event Horizon. Now, it is quite interesting to ask that, is time delay for information to be back and black hole lifetime are same, because we have seen that Higgs Boson lifetime is easily calculated with gamma being the width of distribution and time delay. We could have experimental tests in future to check out that. But different information enters at different time, that's mean if lifetime of any black hole is less than time delay of any state,

$$lifetime\ of\ black\ hole < \Delta t$$

after the burst of Black Hole, that information can be sent to another universe's BH Event Horizon through wormholes [16, 17] that was quietly suggested by some physicists. So it can possible that information can travel from one universe to another universe and decode there, and we are in MWIT, we are free to think about it. This will release exciting and shocking results that we wouldn't think using now-days physics.

6. Possibility and Prediction from Scattering Information Situation

This is the most exciting section of this paper. There is wider possibility of SIS to be right on large context. But while applying String Theory on this can cause some damage to credibility of theory, but for quantum gravity my candidate that support this theory in 4D without any problem is **Quantum Loop Gravity** [19]**,** but String Theory [20, 22] thing also capture this situation by proving that energy-momentum history from a dark gravity is not possible. But implying Quantum Loop Gravity, yields us extra potential results, like loops can be inferred by information or vice versa, but it is too hard to show this statement because of our partial understanding of Quantum Loop Gravity.

Many predictions can be made on the basis on Quantum Theory at alone. SIS tells us about Einstein-Rosen Bridge [16] (mentioned in section 5), in this sense QM and General Relativity(GR) is quite linked, although this theory have not any guts to be a candidate for unification of QM And GR, but this theory can be incorporate with any candidate, but it is hard. Another prediction on the basis of Quantum Nature of Black Holes, it is pretty hard to reach the singularity, but this theory don't tell us pretty much about what will happen when BH is only thing in a stable universe.

Going with Quantum Theory, SIS tells us it is widely possible to make a worm-hole with large potential, much large than any anything. SIS predicts the information changer machine which is BH, so much pretty confirm that other astronomical object would do of course same thing as Black Thing, spoiler they don't.

Proving this thing is quite of challenge because of large potential, we can't build up that potential in any machine at Earth, but SIS can be proven if a black hole is constantly observed over a large time. SIS not only implies to BH Information Paradox, but many theories can be rebuild and rethink with this situation or situation 2 and 3 (mentioned in sec.3).

But if, any Quantum Gravity is found, one have to reformat this theory, however this theory have a lot of character from Grand Unified Theory and can be use if one knows how to deal with mystery.

7. No-Firewall Theory

It is widely possible that scattering is caused by potential and there is no any firewall or wall. This would mean than Black Hole would eat the information and will evaporate with later, so called Hawking Radiation.

While applying SIS to the view of Hawking Radiation, it is simply non-vague and non-intuitive and tells us that black hole are the reasons for scattering, but we don't know the role of the potential here, it tells us more about Worm Holes connecting Scattered packets to different universe using MWIT. This could also obey the classical gravity situation or even quantum gravity, where object is torn apart and then fall to black hole. This would certainly create new prediction like, what happens to information

when they fall to black hole, one may answer Hawking Radiation, but that's not right to a certain level. And we will be again back to the question from we started this paper "What happens with Information?"

8. Conclusions

Let's take a look through all, first we created a thought experiment by building up a infinite square well or maybe even bigger potential, then we written all situations which were pure quantum with the help of Many-Worlds Interpretation Theory which were 1) Scattered Information Situation, 2) Reflection-Transmission Situation, 3) Resonant Situation, then we picked Scattered Interpretation Situation. SIS, because of its credibility, then we proved how the information was saved but in another form, then we figured out the conservation principles with far-discovered physics. Then SIS was like, there is not any situation where Black Hole have eaten the information, it is blocked by firewall after Event Horizon, but easily pass maybe if there is a firewall behind the Event Horizon. Then, information changed and devoted to one dimension from any 4 dimension, then time delay was figured for this packet, we get that Information can be back in normal space-time after time delay, but it hard to tell than in which dimension they will back up.

Then there are predictions that indeed Wormholes or Einstein-Rosen Bridge can be found, because if the lifetime and time delay don't co-operate, the only solution for information to be saved is that, because in QM, you are not allowed to distort information. Another prediction is Firewall, Information theory, but sadly Hawking Radiation is kind of disagree with this because we have seen that information do not go inside the black hole, quoting "No Drama Situation". But that do not means Hawking Radiation is false, because if Situation 2 is right, we can purely account Hawking Radiation. And in some sense Firewall seems to be false because much greater gravity caused by singularity, but as far this theory is right there might be a wall or another force that is causing to stay around only event horizon. But firewall seems to be plausible with this quantum nature of BH by MWIT.

This do not defy any of Hawking's idea, but try to put forward a whole new situation, this idea of having scattered situation is like those theories, which can define perfectly when only quantum gravity is proved.

So we come now, to end of this paper by quoting, "A Black Hole may scatter or eat, but more important is the idea that Black Hole actually do something, that we humans are not capable of testing or no, not in near future for sure".

Appendix 1 (Levinson Theorem)

Levinson Theorem accounts for non-relativistic cases of scattering phenomena, in which it balances the conservation principle in pure quantum theory.

We start with N states, then states being influenced under sudden peak in graph around k', causing potential shift, but potential don't cause any damage of number of N states. It balances the overall number of states, that don't hurt any physics energy principle.

$$N = \frac{1}{\pi}(\delta(0) - \delta(\infty))$$

Technically that equation is derived by introducing a big potential and relates the number of N states to the potential to the excursion of the phase from E = 0, E to infinity.

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