

Wave-particle duality, decoherence, and the consequential cosmic censorship of supermassive relativistic systems and black-holes

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This paper attempts to explicate the wave-particle duality in the vicinity of supermassive gravitational fields and thus, proposes a new understanding of cosmic censorship in black-holes. The author tries to approach this congruity by using a supposed photon as an instance and devises a thought experiment. Consequently, the thought experiment is elucidated by Bohmian mechanics, demystifying the fragmentation of an image of a black-hole. In this method, emission is explained by how photons at different situations lose coherence and therefore, merely show a partial image of a relativistic singularity e.g. black-holes, being also interpreted as image fragmentation. Hence, it is contemplated that singularities would be partially naked in formative emissions. Analogously, the findings are validated by inspecting the GW170814 reception by LIGO.

Index terms: Wave-particle duality, cosmic censorship, GW180814, binary system of black-holes

I. INTRODUCTION

Since the theoretical breakthrough in 1998 regarding the accelerated expansion of the universe [1], cosmologists have embarked their quest to properly elucidate this phenomenon. Accordingly, many approaches have been taken including the cosmic background radiation [2,5], the gravitational lensing effect [3,5], galaxy clusters [4,5], and so forth. Notwithstanding, these solutions are plagued with the problem that gravity should cause deceleration as the previous models suggest [6].

In order to tackle this problem, cosmologists have attempted to formulate quantum gravity to adequately explain this phenomenon. A popular approach is the assumption in which the creation of the world has started from a no-boundaries condition to a de Sitter space [7]. This solution has also been recognized as problematic due to the contradiction of gravitational effectuality [8]. In other words, this model suggests that gravity should become greater in bigger vicinities. This assumption is, however, contradicting the concept in which

gravity cannot be ignored in the Planck scale [9].

Harmoniously, it is proposed to avoid these problematic scenarios by understanding the gravitational lensing. Previously, this effect was rigorously elucidated by inspecting the image distortions and also deriving the mass from the interferometric congruities [5,10]. Nonetheless, the accuracy of the derivations is questionable due to external redshift sources [5]. This problem was tackled in 2007 by proposing a source redshift distribution [11].

In spite of these findings, when supermassive relativistic systems such as black-holes are approached, the redshift as enumerated by LIGO [12] would get us the value $11_{-0.04}^{+0.03} nm$. Nevertheless, the uncertainty is against the source redshift distribution, making the acquired number ambiguous.

This ambiguousness has often been interpreted as a consequential result of cosmic censorship [13]. Even though the hypothesis proposed by Roger Penrose provides us with a better understanding, it is not inclusive to some exceptions. As an example, it has been

numerically proven that naked singularities in supermassive relativistic are possible [14], contradicting the initial cosmic censorship hypothesis by a theoretical counterexample.

In order to find a resolution for the distributed hypothetical problem, it is recommended to be taken by devising a thought experiment. In this thought experiment, a supposed photon is assumed to approach a black-hole. Correspondingly, the photon is thought to enter the Schwarzschild vicinity of a black-hole. Therefore, the photon is inspected in the event-horizon state, allowing for wave-particle duality and quantum behavior.

II. GRAVITATIONAL LENS EFFECT

Gravitational lensing is an effect in which particles that pass through strong gravitating fields will start to show deflective manner and hence, will exhibit two images. [15,16]. As illustrated in Fig.1, suppose that a particle passes the gravitational field of this massive body from an emitter at point E to a receiver at point R. Proportionately, an approximately curved distortion will cause the photons to be observed within two images, bending the light from the emitter to the receiver [16].

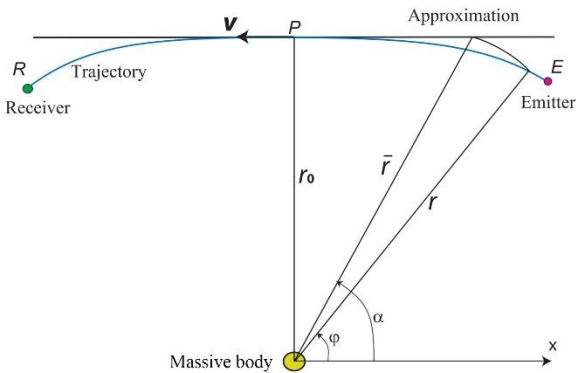


Figure 1: The trajectory bending exemplified by the diagram, where r_0 is the non-relativistic radius, \bar{r} is the straight-line approximation distance and r is the emissive distance from the gravitating field. α and ϕ are also the respective angles [16].

The angle of deflection [16] is enumerated by

$$\theta = \frac{4GM}{c^2 r} \quad (1)$$

where G is the gravitational constant ($6.67408 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$), M is the mass,

c is the speed of light in vacuum, and r is the gravitating radius, being equivalent to the Schwarzschild radius in black-holes, noted as r_s . The Schwarzschild radius is similarly acquired by

$$r_s = \frac{2GM}{c^2} \quad (2)$$

In correspondence with the thought experiment devised in Sec.1., if the approaching photon gets in the event-horizon of a black hole, then $r_s = r$ and hence

$$\theta_{BH} = \frac{4GM}{c^2 \frac{2GM}{c^2}} = 2 \text{ rad} \quad (3)$$

which means the photon immediately reaches itself with the initial spin. Conceptually, this could be interpreted as a quantum wave-particle duality.

III. WAVE-PARTICLE DUALITY

As elucidated above, wave-particle duality as conceptually verifiable. Wave-particle duality is a photoelectric phenomenon in which particles, especially photons, exhibit both wave and particle behavior simultaneously. Conversely, the seemingly contradictory characteristics of wave and particle expressions are complementary. To put simply, a photon, as an instance, is believed to be a wave of particles when propagated and a particle when detected [17].

Experimentally, this congruity is reported in a paper by T. L. Dimitrova and A. Weis [17]. The experiment included an apparatus setup (Fig.2) in which interferometry was used. The results are visible in Fig.3.

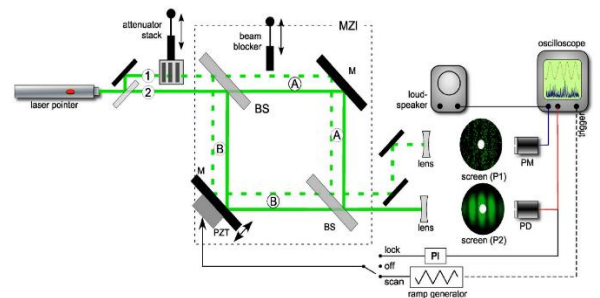


Figure 2: Experimental apparatus for the simultaneous demonstration of the wave and particle nature of light. Both

the strong and the attenuated beams are shown here to lie in the plane of the interferometer.

BS: beam splitter, M: mirror, PM: photomultiplier, PD: photodiode, and PI: feedback amplifier. [17]

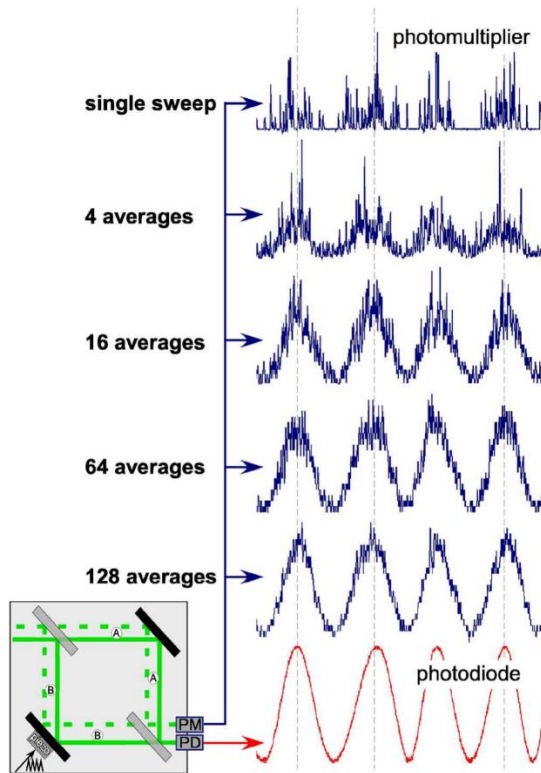


Figure 3: Simultaneous demonstration of the particle and wave aspects of light. The bottom trace shows the intensity distribution measured by the photodiode (wave aspect). The top trace shows the pulsations registered by the photomultiplier. By averaging many traces, the signal from the photomultiplier becomes smoother; the average time increases from top to bottom, and approaches the signal shape from the photodiode. [17]

Observably, as shown in Fig.3, the wave behavior becomes more dominant as the average time intervals are congruously increased. This suggests a relationship between the observation repetition and the duality, resulting in higher deviations in shorter intervals. In other words, the more repeated the observation is, the more wave-like the supposed photon becomes.

Moreover, wave-like particles tend to have more conjoined interferometric fringes [17]. As a result, the photon in the thought experiment could be explicated using photoelectric equations.

Proportionately, the photon energy [18] is calculated by

$$E = \frac{hc}{\lambda} = hf \quad (3)$$

where E is photon energy, h is the Planck constant ($6.62607014 \times 10^{-34} \text{ Js}$), and λ is the wavelength. The wavelength [19] is acquired by

$$\lambda = \frac{h}{p} = \frac{c}{f} \quad (4)$$

where p is the momentum of the photon.

Accordingly, if we assume that the photon is in the VLF radiation spectra with the frequency of 3 kHz , we can use Eq.3-4 to get the photon energy value that is illustrated in Tbl.1.

Calculated energy	$1.986445854151 \times 10^{-30} \text{ J}$
Radiated energy received by LIGO observatories [12]	$1.7914293227483 \times 10^{22} \text{ J}$
Difference	$\approx 1.7914293227483 \times 10^{22} \text{ J}$

Table 1

Visibly, there is a huge variation between the received and the calculated value. However, due to the matter of the fact that wave behavior is interpreted as being present in multiple locations, we could assume that the photon is present everywhere around the event-horizon of a black-hole. Notwithstanding, it was derived in Sec.2. that the photon would take a spin with the angular value of 2 rad . Hence, this promptly suggests that there possibly could be a deviation within the propagation, ruling uncertainty for the derived spin value.

IV. THE UNCERTAINTY PRINCIPLE

The quantum standard deviation, also known as the Heisenberg uncertainty principle [20], states that the accuracy with which two such variables can be measured simultaneously is subject to the restriction that the product of the uncertainties in the two measurements is at least of order h (the Planck constant) [21]. Subsequently, the conjugate parameters of position Δz and momentum Δp couldn't be simultaneously measured in a complementary

behavior. This is shown in the inequality below [22].

$$\Delta z \times \Delta p \gtrsim h \quad (5)$$

As mentioned in Sec.2., the photon would spin to its immediate previous position. Thus, Δz would be 0 and hence, $\Delta z \times \Delta p = 0$, thereby violating the uncertainty principle. Furthermore, due to the angular movement of the photon, we couldn't assume that the particle has complete vertical movement, resulting in a one-dimensional space [22]. As a result, the photon would exhibit no image, being cosmically censored (this is true for a proportion of photons which will be explained in detail in further sections). This is, however, against the data on the received radiation [12] from marginal relativistic areas such as Schwarzschild vicinities.

As a resolution, it should be noted the uncertainty principle is governed by time. Nevertheless, if we suppose that our deviation is in stationary state, we could partially ignore time. Therefore, this could explain the reason of electromagnetic reception.

V. THE STATIONARY STATE

The stationary state is a behavioral approach to quantum systems that express simultaneity. In other words, the parameters are independent of time [23]. Subsequently, particles are equally distributive for parameters such as position, velocity, and so forth [24].

In order to verify that the supposed photon reaches independency of time in the event-horizon of a black-hole, it is required to verify the non-existence of time dilation in the mentioned vicinity. The gravitational time dilation [25] between two photon states can be acquired by

$$t_0 = t_f \sqrt{1 - \frac{r_s}{r}} \quad (6)$$

where t_f is the co-ordinate time between the events. Due to the matter of the fact that in our thought experiment $r = r_s$, the result will be equal to 0. Hence, it could be understood that

the photon is independent of time, allowing for the possibility of the stationary state.

The stationary state [24] could be elucidated as

$$\hat{H}|\psi\rangle = E_\psi|\Psi\rangle \quad (7)$$

where \hat{H} is a Hamiltonian operator, $|\Psi\rangle$ is the accordant quantum state, and E_ψ is the representative of the eigenvalue of the photon energy level. In this case, due to the proportionating relevance of photoelectric energy to the electromagnetic frequency of the supposed photon [18], we are able to substitute E_ψ with Eq.3. Moreover, as a result of Eq.2, the photon has singularly taken two positions. Hence, the boson nature of photon is ignored, which could have otherwise been problematic [26]. For that reason, merely the multitude of the singular photon is taken into account, allowing us to have $|\psi\rangle = \langle\psi|\psi\rangle = 1$. Thus, the stationary state will be equal to the calculated energy in Tbl.1.

Consequently, the existence of global states of a composite system which cannot be properly elucidated using sub-states is implied, resulting in quantum entanglement [27].

VI. QUANTUM ENTANGLEMENT

In correspondence with the contemplation above, quantum entanglement could be occurring. Entangled states of quantum particles highlight the nonseparability and nonlocality of quantum mechanics most vividly [28]. As illustrated in Fig.3, a binary set of photons would exhibit entangled-state emissions.

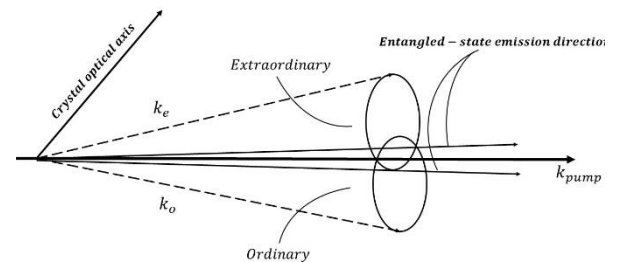


Figure 4: Spontaneous down-conversion cones present with type-II phase matching. Correlated photons lie on opposite sides of the pump beam. [28]

This instance, which is expressive of a type-II matching [28], experimentally validates quantum entanglement. Type-II matching is a type of entanglement in which the down-converted photons are emitted in two cones [29], one ordinary polarized, and one extraordinary polarized. This pattern is similar to the way the supposed photon behaves in Sec.5.

Theoretically, the quantum state [28] is explained by

$$|\psi\rangle = \frac{|H_1, V_2\rangle + e^{i\alpha}|V_1, H_2\rangle}{\sqrt{2}} \quad (8)$$

Where H and V indicate horizontal (extraordinary) and vertical (ordinary) polarization, respectively. α arises from the birefringence [28]. In the devised thought experiment, the photon takes a 2 *rad* rotation around the gravitating field. Therefore, $e^{i\alpha}$ can be substituted with $\cos 2\pi + \sin 2i\pi = 1$, giving us [27,28]

$$\begin{aligned} |\psi\rangle &\otimes |\phi\rangle \\ |\psi\rangle &= \frac{|H_1, V_2\rangle + |V_1, H_2\rangle}{\sqrt{2}} \\ |\phi\rangle &= \frac{|H_1, H_2\rangle + |V_1, V_2\rangle}{\sqrt{2}} \end{aligned} \quad (9)$$

where $|\psi\rangle$ and $|\phi\rangle$ are the non-interacting states. Because of the immediate rotation, it could be implied that the horizontal and vertical polarizations equal $|\psi\rangle$. Hence, we have

$$\begin{aligned} |\psi\rangle &= \frac{|\psi\rangle}{\sqrt{2}} \\ |\phi\rangle &= \frac{|\psi\rangle}{\sqrt{2}} \end{aligned} \quad (10)$$

This is strongly suggestive of a binary collapse. Subsequently, the entangled particles will act as fluctuated matter, with one collapsing, while the other escapes the gravitational vicinity [30].

Descriptively, this elucidates the reception of radiation [12]. In order to verify this, we should

use the formula of Hawking radiation [31] as below

$$T_H = \frac{c^3 \hbar}{8\pi G M k_B} \quad (11)$$

where \hbar is the reduced Planck constant ($\frac{h}{2\pi}$), and k_B is the Boltzmann constant ($1.38064852 \times 10^{-23} \text{ J.K}^{-1}$). If we use the subjective black-holes on the event GW170814 [12] in order to calculate the radiation, we have

Calculated energy in case of Hawking radiation	$1.0945959061111 \times 10^{-9} \text{ J}$
Radiated energy received by LIGO observatories [12]	$1.7914293227483 \times 10^{22} \text{ J}$
Difference	$\approx 1.7914293227483 \times 10^{22} \text{ J}$

Table 2

When we inspect the values and also the difference, it is fair to say the value highly differentiates from the reception by LIGO observatories [12]. Accordingly, it could be denoted that the photons might reach superluminality, causing such huge variation in Tbl.2.

VII. SUPERLUMINALITY

Astronomers observe a large number of radio sources that move with apparent superluminal speed. In other words, they travel faster than light. This [32] is shown by

$$v_{observed} = D \times \frac{d\alpha}{dt} \quad (12)$$

where D is the distance to the radio source ($1.702931485064544 \times 10^{25} \text{ m}$ in case of the binary black-holes of event GW170814 [12]), and $d\alpha/dt$ is rate of change of angular separation between gravitational components. If the binary system of black-holes (BBH) on event GW170814 is scrutinized, the gravitational components would be the BBH. This is illustrated in Fig.5.

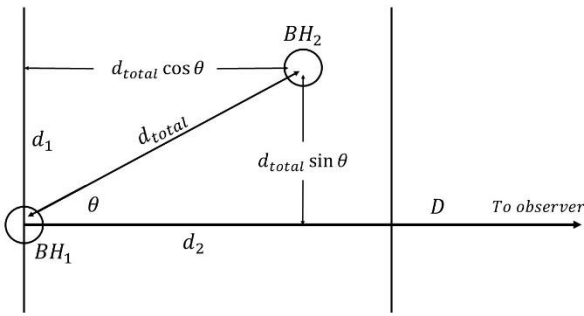


Figure 5: Due to the high value of mass of the BBH, being $m_1 = 30.5^{+5.7}_{-3.0} M_\odot$ and $m_2 = 25.3^{+2.8}_{-4.2} M_\odot$ [12], the components are considered to be the black-holes. d_{total} : distance between the black-holes D: the distance between the inspiral stage and the observer [32].

Accordingly, we would have to find the merger acceleration rate of the BBH to use Eq.2 Conversely, it is derived that this value may vary from 175 km/h for the types of BBH with the mass ratio of 5:1, to 5000 km/h in the merger stage of two identical black-holes [33].

In order to correctly identify the acceleration, a diagram is used to find the range. The graph is shown in Fig.6.

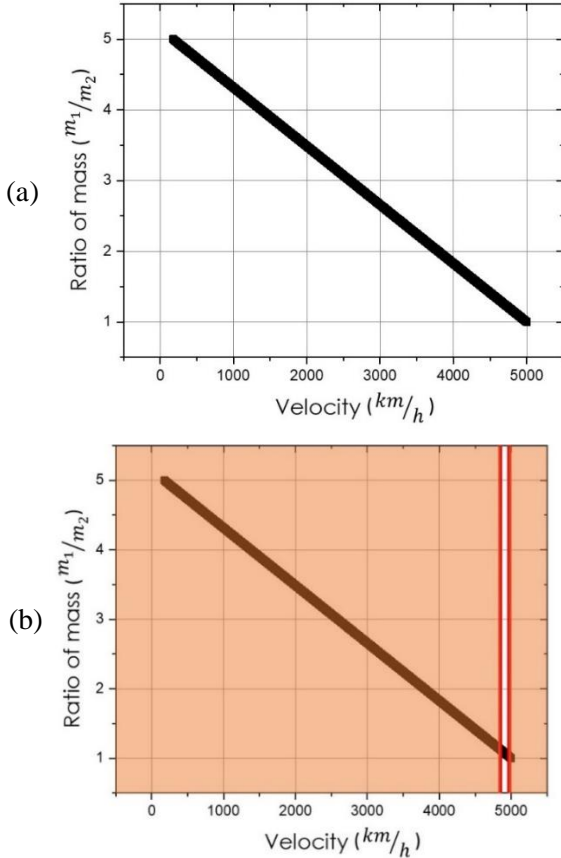


Figure 6: (a) The factual identification is done by making a graphical illustration of the amplitude of mass and also velocity. In this illustration, 175 km/h was given the value of 5, and 5000 km/h was given the value of 1. Subsequently, the variation between these value was divided by 4825 steps, each valued as $+1 \text{ km/h}$. (b) The correct velocity is found to be the ratio of $m_1:m_2$, which is ≈ 1.20553 . Proportionately, the values approximately greater or less than the value above is highlighted, indicating falseness. Consequently, the correct value is found to be in the white region, being 4752 km/h .

In correspondence with the value enumerated from Fig.6., we could use Eq.12 to acquire the velocity of the proposed superluminal motion. The result is shown in Tbl.3.

Calculated superluminal speed	$1.702931485064544 \times 10^{25} \text{ m/s}$
Speed of light in vacuum	299792458 m/s
Difference	$\approx 1.7029314850645 \times 10^{25} \text{ m/s}$

Table 3

In accordance with Tbl.3, there is a tremendous variation. This could possibly mean that superluminality is reached with correspondence with relativistic velocity, causing such huge gap that could be a result of observational velocity [32], not the initial velocity. Therefore, the relativity should be taken into account in order to properly explicate this difference that could appear as impossible.

To justify the observational variation [32], we should inspect both collapsing and escaping photons [30].

1. The collapsing photon

The itemized photon is a particle that fails to escape the event horizon of the black-hole [34]. Subsequently, a particle-antiparticle would be occurring that could be possibly responsible for the received radiation by LIGO observatories [12].

In order to inspect the velocity of this particle, we have the expression below:

$$v = \frac{d}{t} \quad (13)$$

where d is the distance ($2\pi r_s$ in black-holes), and t is time. Because of the presence of a relativistic system as an instance, t has to be defined by time dilation ($\Delta t'$). This [35] is given by this expression

$$\Delta t' = \gamma \Delta t \quad (14)$$

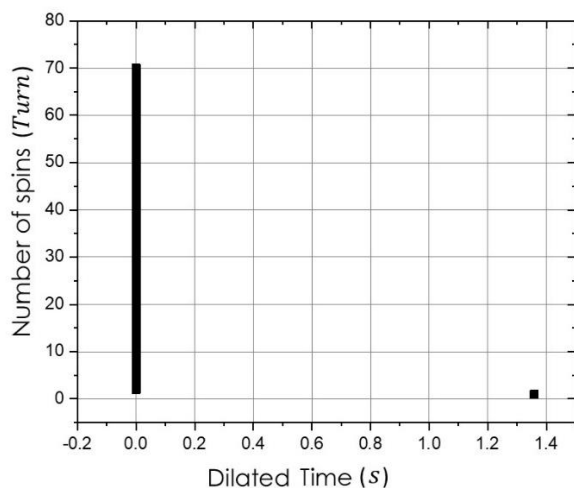
where γ is the Lorentz factor [36], being given by the expression

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (15)$$

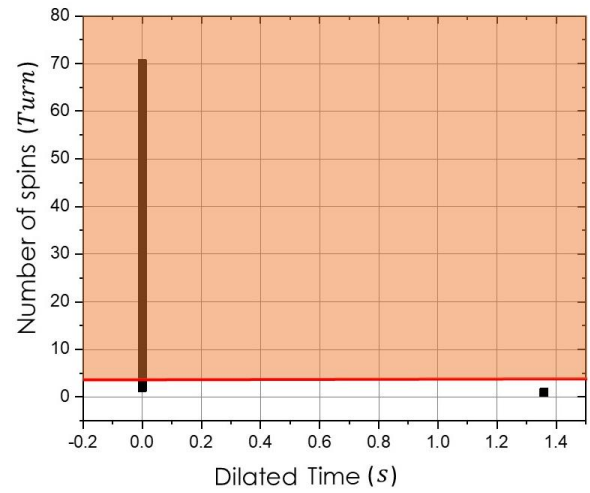
Accordingly, we can use Eq.13-15 to define the velocity of the collapsing particle. Notwithstanding, if we assume that the supposed photon travels at the speed of light [37], we would have $\gamma = \frac{1}{0}$ which is undefined. Therefore, we have to assume that the speed at which the collapsing photon travels might reach an upper bound of c [38], not necessarily c . Proportionately, we have

$$v_{\text{photon}} = \lim_{v \rightarrow c} \gamma(v) \quad (16)$$

In accordance with Eq.13-16, we could graphically explain what that would happen to the collapsing photon by dilation. This is done in Fig.7.



(a)



(b)

Figure 7: (a) Eq.13-16 were used to calculate the dilated time in the close proximity of c . Visibly, the photons reach the point of approximately no-movement. The seventieth point roughly reached 10^{-301} seconds. (b) The photons in relative motion are in the white area, while the ones with the dilated value of about 10^{-19} s (which is the accuracy of IT-CsF2 atomic clock, being 1.7×10^{-16} s [39]) are highlighted in red.

When we inspect Fig.7, we see that the dilated time gets higher, resulting in lower values of time ($t \propto \Delta t'^{-1}$). Subsequently, we observe motionlessness as a result of $v \propto t^{-1}$. This could be interpreted as the collapsing photon would stop moving.

2. The escaping photon

According to Hawking radiation [30], the other particle will escape the gravitational field. These escaping particles could be the main source of the radiation reception [12].

In order to find the velocity of escape, it is assumed that the photon escapes the relativistic field at the speed of light. Hence, d in Eq.13 would be defined as

$$d_{\text{travelled}} = 2\pi(r_s + t(c)) \quad (17)$$

Because of the relativistic effects, the travelled distance will be contracted [40]. The contracted length [41] is given by

$$L = L_0 \gamma^{-1} = L_0 \sqrt{1 - \frac{v^2}{c^2}} \quad (18)$$

The elapsed time would be

$$t_{elapsed} = \sum_{i=1}^n i \quad (19)$$

Moreover, the velocity at which the photon travels at would be calculated by Eq.3.

In correspondence with Eq.17-19, we could draw a graph to illustrate the plausible values. The graph is shown in Fig.8.

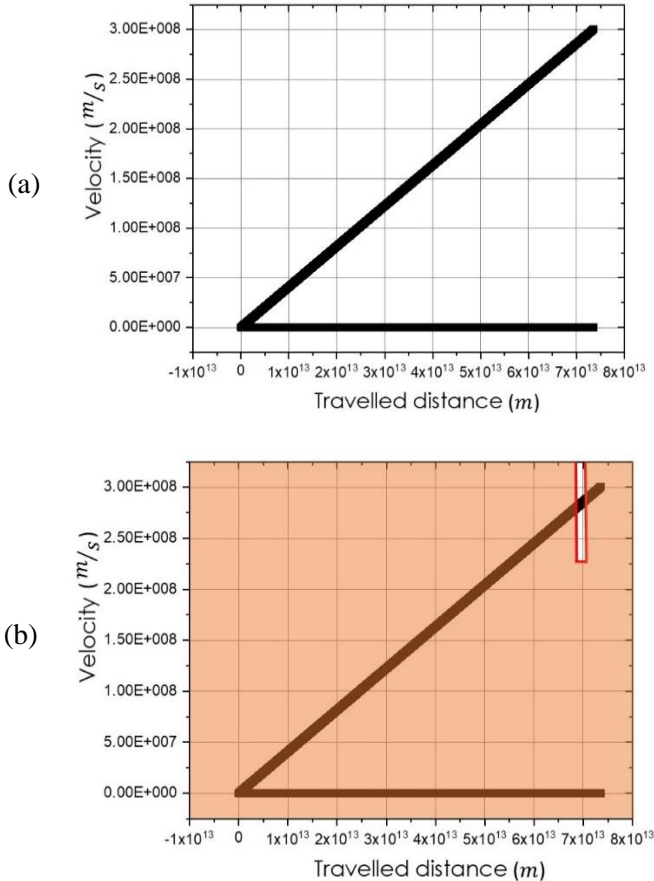


Figure 8: (a) An accordant graph is drawn in which the speed reaches the upper bound of c within its approximate peak. (Inflation of values has happened because of the extent of distance.) (b) The closest numbers to c were $299789589.890841 \text{ m/s}$, and also $299797282.523346 \text{ m/s}$. The average is $299793436.207094 \text{ m/s}$, which is 978.207094 m/s different from the value of c . (The verifiable values are in the white region.)

Observably, photons travel faster than light. This result is also verified by K. Scharnhorst [42] by electromagnetism.

As seen in Sec.7., the photon takes on two circumstances simultaneously. This could be interpreted as superposition. Moreover, as elucidated in Sec.7.1-2., the photons will diverge from each other [30]. We also know

from Eq.9 and Eq.10 that both will have the same quantum state. Furthermore, they will have the same quantum state regardless of time [43]. This, however, contradicts the notion of singularity and also the information paradox because of the collapse of the photon [44,45]. Therefore, it could be implied that decoherence is happening.

VIII. DECOHERENCE

‘One of the most striking features of quantum theory is the quantum superposition principle. [46] It has been demonstrated in numerous experiments with diverse systems, such as neutrons [46,47], atoms [46,48] and even large molecules [46,49]. However, quantum superpositions are not observed on everyday, macroscopic scales. The origin of the quantum-to-classical transition is still an active field of research. A prominent role in this transition is commonly attributed to decoherence [46,50,51]: due to interaction with an external environment, a particle gets entangled with its environment and loses its quantum coherence.’

Accordingly, when we approach the escaping photon, we incline that it has reached superluminality (as explained in Sec.7.). Thus, it is plausible that the initial photon gets entangled with its superluminal image. This could be explicated by Eq.9 and Eq.10., which could be defined as a consistent state ($|\psi\rangle = |\phi\rangle = \frac{|\psi\rangle}{\sqrt{2}}$).

Because of the consistency of the superluminality, which could be as a result of constant entanglement, time could be ignored and therefore, the system is stationary, allowing us to use Eq.7. In Eq.7, the Hamiltonian operator could be represented by

$$\hat{H} = \hat{H}_S \otimes \hat{I}_B + \hat{I}_S \otimes \hat{H}_B + \hat{H}_I \quad (20)$$

where \hat{H}_S is the Hamiltonian of the system, \hat{H}_B is the Hamiltonian of the environment, \hat{I}_S and \hat{I}_B are the identity operators, and \hat{H}_I is the interaction Hamiltonian. In order to find the Hamiltonian operators, we have to find the total energy which is given by [52]

$$E = mc^2 \quad (21)$$

Due to assumption that photon is massless [53], the effective mass [54] is acquired by

$$m = \gamma m_0 \quad (22)$$

Thus, Eq.20 can be written as

$$\hat{H} = \frac{\gamma_s c^4 h f}{\sqrt{2}} + \gamma_l c^4 h f \quad (23)$$

where γ_s is the Lorentz factor of the system, and γ_l is the Lorentz factor of the interaction between the system and its environment. Please note that $\hat{H}_S \otimes \hat{I}_B \approx \hat{I}_S \otimes \hat{H}_B$ on the account of the duplication of the photon.

Because of the duplication, it could be implied that in Eq.7., $|\psi\rangle = \langle\psi|\psi\rangle = 1$ and hence, Eq.7 equals Eq.23. If we use Eq.23 to calculate the energy in the stationary state, we have

Calculated energy of decoherence	$1.46890177365638 \times 10^7 J$
Radiated energy received by LIGO observatories [12]	$1.7914293227483 \times 10^{22} J$
Difference	$\approx 1.7914293227483 \times 10^{22} J$

Table 4

Tbl.4 adequately explains why we receive radiation. Proportionately, the photons would reach decoherence, releasing a low amount of energy compared to the radiated energy, and also lose the information because of decoherence [55], allowing for the nakedness of the singularities of black-holes if not lost.

Even though this explains why we don't receive any information about the black-holes from the escaping photons, it doesn't provide us with the understanding of the collapsing photons, which also emit radiation because of the particle-antiparticle radiation [30].

VIII. COSMIC CENSORSHIP

'In the classical theory black holes can only absorb and not emit particles. However it is shown that quantum mechanical effects cause black-holes to create and emit particles as if

they were hot bodies with temperature $\frac{\hbar k}{2\pi k} \approx 10^{-6} \left(\frac{M_\odot}{M}\right)^\circ K$ where k is the surface gravity of the black black-hole' [56,57].

This principle instantaneously suggests that even though the collapsing photons in Sec.7.1. reach motionlessness, they emit radiation because of the particle-antiparticle phenomenon [56]. If this is true, the event-horizon of black-holes could be naked regardless of the decoherence of the escaping photons.

The possibility of event-horizon nakedness is defined by [58]

$$r_\pm = \mu \pm (\mu^2 - a^2)^{\frac{1}{2}}, \quad \mu = \frac{GM}{c^2}, a = \frac{J}{Mc} \quad (24)$$

where r_\pm is the coordinate of the event-horizon, and J is the impulse of the field ($=m(v_2 - v_1)$).

The event-horizon disappears when $\mu^2 < a^2$ [58]. If we use this equation for the BBH in the event GW170814, we have

μ^2	83170.253444390939 m
a^2	$2.9133461091654 \times 10^{-38}$
$\mu^2 > a^2$	83170.253444390939
$\mu^2 \nless a^2$	$> 2.9133461091654 \times 10^{-38}$

Table 5

Tbl.5 implies that there is a high chance that the singularity is naked, contradicting the cosmic censorship hypothesis [13].

According to this hypothesis, physical singularities are typically hidden with black-hole event horizon, and located at the radius equal zero ($r = 0$) centers of the electrostatic field or gravitational field; and according to assumption, therefore cannot be seen from the rest of space-time [59].

Nevertheless, we haven't received any images from the event-horizon of black-holes, implying that our system might be governed by Bohmian mechanics.

Bohmian mechanics postulates the existence of both a quantum wave, which corresponds to the usual quantum wave function, and of particles whose motion is guided by the wave [60,61].

In accordance with Bohmian mechanics, we have to initially define the Schrödinger's equation [62], being

$$i\hbar \frac{\partial}{\partial t} |\psi(t)\rangle = \hat{H} |\psi(t)\rangle \quad (25)$$

where i is the imaginary unit. $i\hbar \frac{\partial}{\partial t} |\psi(t)\rangle$ in spinning particles (e.g. photons have the spin of $S=1$) is acquired by

$$\begin{aligned} & i\hbar \frac{\partial}{\partial t} |\psi(t)\rangle \\ &= \left(- \sum_{k=1}^N \frac{\hbar}{2m_k} (\nabla_k - \frac{ie_k}{\hbar} A(q_k))^2 + V \right. \\ & \left. - \sum_{k=-1}^N \mu_k \frac{S_k}{\hbar S_k} \cdot B(q_k) \right) |\psi(t)\rangle \quad (26) \end{aligned}$$

where m_k is the mass of the particle ($m_{photon} = 0$), e_k is the charge ($e_{photon} = 0$), ∇_k is the square root of the Laplace operator ($=\sqrt{\Delta}$), A is the vector potential ($=\vec{v}$), q_k is the position operator ($q_{photon} = \langle \psi | \psi \rangle = 1$), V is the potential energy function ($V_{photon} = 0$), μ_k is the magnetic moment of the particle ($\mu_{photon} = \pm(ec/\omega)$) [63], S_k is the spin ($S_{photon} = 1$ [64]), and B is equivalent to $\nabla \times A$. Eq.26 can be simplified for the supposed photon. Accordingly, we have

$$i\hbar \frac{\partial}{\partial t} |\psi(t)\rangle = -\left(\frac{2\pi-r_s}{\sqrt{2\pi}}\right) \mp (ec/2) \frac{1}{\hbar} \cdot \frac{r_s^2}{\sqrt{2\pi}} \quad (27)$$

Furthermore, it was mentioned in Sec.5. that the system becomes stationary. Therefore, we can omit (t) from Eq.27 and combine Eq.26-27 and Eq.7 to have

$$\hat{H} |\psi\rangle = -\left(\frac{2\pi-r_s}{\sqrt{2\pi}}\right) \mp (ec/2) \frac{1}{\hbar} \cdot \frac{r_s^2}{\sqrt{2\pi}} \quad (28)$$

Thus, we can use Eq.28 to calculate the radiated energy. The results are shown in Tbl.6.

Calculated energy in Bohmian mechanics (positive charge)	66357.7545130666247 J
Radiated energy received by LIGO observatories [12]	$1.7914293227483 \times 10^{22}$ J
Difference	$\approx 1.7914293227483 \times 10^{22}$ J

Table 6

The negative charge will be dismissed because it requires a change to the gravitational field, resulting in negative energy [64].

Proportionately, we could use the information acquired by Eq.27 and use Eq.21 to calculate the effective mass by

$$\frac{E}{c^2} = m \quad (28)$$

Consequently, we can use Eq.28 to calculate μ in Eq.24 Thus, we would have

$$\mu = \frac{-G\left(\left(\frac{2\pi-r_s}{\sqrt{2\pi}}\right) \mp (ec/2) \frac{1}{\hbar} \cdot \frac{r_s^2}{\sqrt{2\pi}}\right)}{c^4} \quad (29)$$

Because the photon reaches motionlessness (as discussed in Sec.7.1) Eq.21 is only used for the photons not the BBH. Hence, we could evaluate the possibility of nakedness by Eq.21 The result is shown in Tbl.7.

μ^2	$1.9614000368344 \times 10^{-11}$
a^2	$6.4911626206591919 \times 10^9$
$\mu^2 < a^2$	$1.9614000368344 \times 10^{-11} < 6.4911626206591919 \times 10^9$

Table 7

As illustrated in Tbl.7, $\mu^2 < a^2$ is verifiable. Therefore, the singularity is cosmically censored. In other words, it is shown that the collapsing particles are censored, too, revealing the reason why we don't receive an image of the event-horizon of a black-hole.

Conceptually, this could be elucidated as a phenomenon in which the photons would reach motionlessness and as a result, do not transmit any information. Besides, because of the angular difference at which the photons are located at, only a proportion of the image will

be sent in one direction, whereas the other one will be sent to another receiver. This is like delivering a piece of a 1000-pieces-puzzle to one thousand people. Normally, if they don't communicate with each other, they might have no idea what the general image of the complete puzzle is.

Proportionately, we only receive a proportion of the black-hole. That's why we have been able to capture the shadow of a black-hole [65], not its complete image. This concept is illustrated in Fig.9.

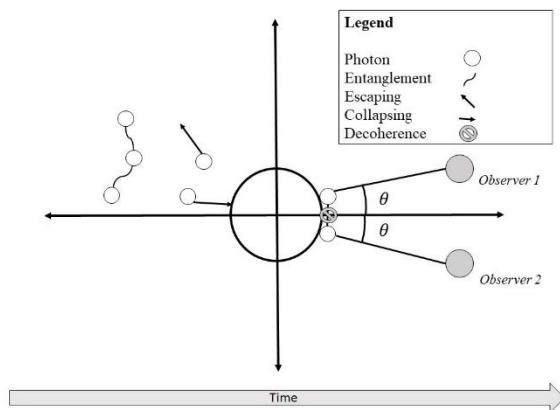


Figure 9: (1) The photons are entangled. (2) One photon escapes while the other collapses. (3) The photons get decoherent because of the relativistic dilation. (4) Only a fragment of an image of a black-hole is received by each individual observer.

Notwithstanding, we have to verify these findings with the gravitational waves received by LIGO observatories.

X. OBSERVATIONAL VALIDATION

1. Detection of gravitational wave

In order to experimentally validate the phenomenon in Sec.9., we have to inspect gravitational waves. A GW (gravitational wave) is distortion that propagates through the universe at the speed of light, being caused by the warps of the space-time fabric due to concentrations of mass or energy [66]. In other words, GWs can be interpreted transverse waves of spatial strain that travel at the speed of light, generated by time variations of the mass quadrupole moment of the source [12,67,68].

Proportionately, the Laser Interferometer Gravitational-wave Observatory (LIGO) was constructed by a Caltech-MIT collaboration.

The mechanism by which the observatory detects gravitational waves is interferometry. Advanced LIGO will consist of three interferometers [69]. The interferometers merge two or more sources of light in order to create an interference pattern. Such patterns result from overlapping waves of light. When the peaks of two waves of light overlap, they combine to form a larger peak (constructive interference). In contrast, when the valley of one light wave overlaps with the peak of another light wave, the two waves cancel each other out (destructive interference) [70]. The basic layout is shown in Fig.10.

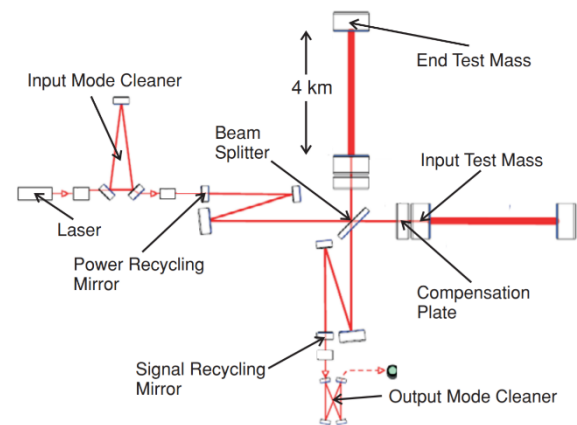


Figure 10: Advanced LIGO optical layout. Light travels from the laser through the input mode cleaner into the power recycling cavity. The light is split at the beam splitter, then enters the two 4 km long arm cavities formed by the input and end test masses. Any signal exits through the signal recycling mirror and output mode cleaner. Also shown are the compensation plates used to control thermal lensing [69].

2. GW170814

On August 14, 2017 at 10:30:43 UTC, the Advanced Virgo detector and the two Advanced LIGO detectors coherently observed a transient gravitational-wave signal produced by the coalescence of two stellar mass black holes [12]. This event was later called GW170814, in which a system of a binary black-holes (BBH) was subjectively the source of the waves.

In correspondence with the detection, a bulk data set with the frequency of 16384 Hz in ± 32

seconds [71] is used to provide us with an insight into the overlap of the theoretical discussions in this paper and also the observational data. The bulk information is drawn in Fig.11.

In order to include the theoretical background, Eq.28, which was the main output of the theoretical discussion, is graphically drawn. Subsequently, the graphical data will be compared with Fig.11, providing us with a better understanding of how the theoretical and observational data might validate each other. This is done in Fig.12.

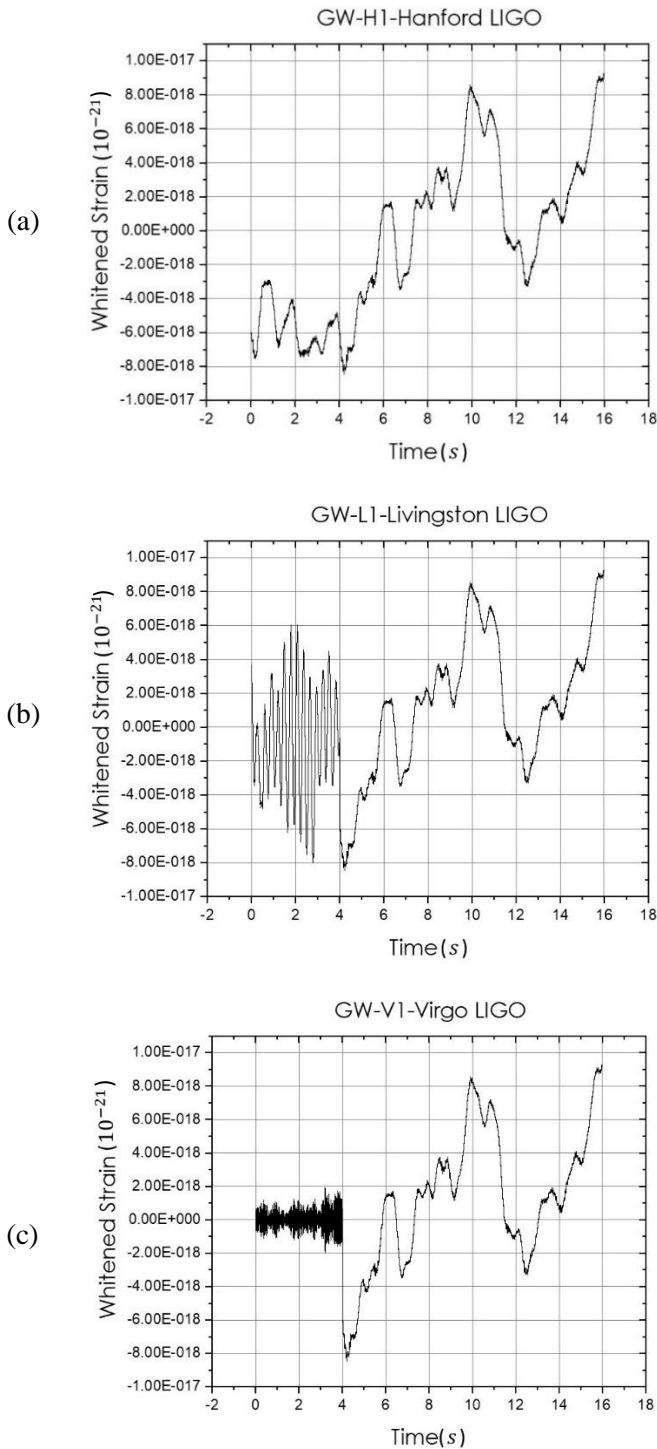


Figure 11: The interferometric signals received by all arms (Hanford, Livingston, and Virgo) are graphically illustrated. (b,c) Please note that because of the interferometric procedures, the data set of Livingston and Virgo show the initial time. Therefore, after approximately 4 seconds, the data set of (b) and (c) are filled with the signals received by the Hanford arm.

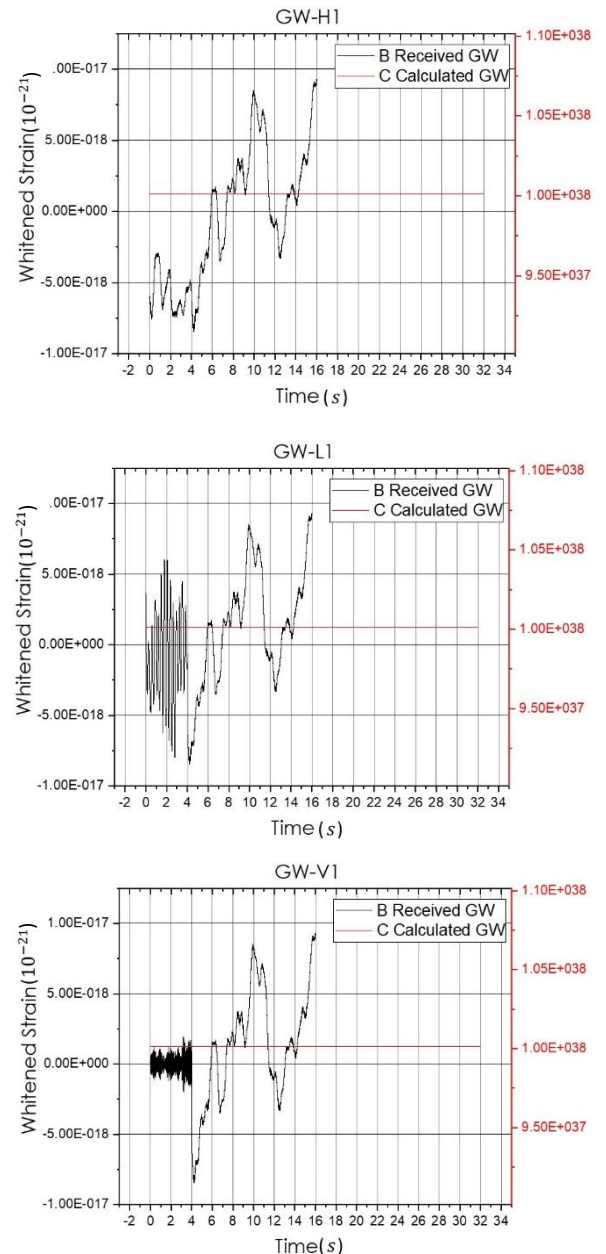


Figure 12: The result of Eq.28 is scrutinized by the Planck constant and drawn on the graphical illustration of Fig.1. The black line represents the received gravitational waves, while the other is suggestive of the calculated value of supposed gravitational waves. Besides, it is shown that they have no overlapping areas, thereby verifying Eq.28 because the energy has no disturbance on the received GW.

As elucidated in Fig.12, the calculations and the receptions show no sign of overlapping

each other. This could be interpreted that the energy that is transmitted by the collapsing photons (as discussed in Sec.9.) has no influence on what we receive, validating the hypothetical idea that Eq.28 was suggesting.

XI. CONCLUSION

In this paper, the reason why we don't receive any coherent images of black-holes was explained.

The method by which the congruity above was explained was the usage of a thought experiment. In this thought experiment, which is close to what really happens, a photon was thought to be in the vicinity of a gravitational field, e.g. black-hole.

Proportionately, the thought experiment was explained by series of theories. The initial theory was the gravitational lensing effect. Using accordant equations, it was proven that the photon instantaneously takes a turn around a black-hole, suggesting the presence of a photon all around the gravitating field. Subsequently, because of the implication above, it was proposed that wave-particle duality could explicate the behavior of the photon. Notwithstanding, the calculations indicated that the behavior cannot be certain. As a result, uncertainty was applied to the behavior of the photon. Paradoxically, due to the matter of fact that the photon was initially governed by time, it was suggested that we approach the uncertainty in the stationary state, where we could ignore time. This approach was, however, showed that the photons create a system in which subsystems cannot explain what that happens in the system. This explanation illustrated instantaneous entanglement. It was then mathematically proven that the entangled particles will have the same quantum state, sparking the idea that particle-antiparticle radiation might be occurring. Consequently, the Hawking radiation equation was used to prove this. Nevertheless, the output energy was too low to adequately explain the received radiation by LIGO. Therefore, the only plausible solution

seemed to be superluminality. In other words, it was implied that the photons reach superluminality. The superluminal motion was explained for two types of photons.

The first type were the escaping photons. Accordingly, it was proven that the photons reach superluminality. This causes them to become decoherent and lose information, losing the image of a black-hole.

On the other hand, the second type which were collapsing photons were inspected. Proportionately, it was proven that time dilation causes the escaping photons to get motionless. Then, Bohmian mechanics was used to prove that the photons diverge from each other, sending merely one fragment of the image of a black-hole.

As a result, it was theoretically shown that we don't receive complete images of black-holes. Subsequently, this was validated by observational data from LIGO, which successfully suggested the acceptability of the hypothetical assumption.

XII. OUTLOOK

The theoretical assumptions of this paper can be expanded upon by inspecting the small proportion of data that Eq.28 was suggesting could be emitted. Moreover, it is recommended to scrutinize quantum fluctuations of the vacuum space to explain the possibility of receiving an image from a black-hole.

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