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From Hawking Paradox to Anti-De Sitter: A Concept of Holographic World

Ajay Chetia

Amateur Researcher in Physics, Sivasagar, Assam, India.

Email: ajay.chetia@gmail.com

ABSTRACT

In 1976 Stephan Hawking said that each Black Hole radiates light, later called Hawking Radiation. That is the relationship of black hole, quantum mechanics and thermodynamics. This effect led scientists to a new topic named Hawking Paradox – a dilemma of black hole knowledge loss. In string theory, this paradox may also have a solution. The best way to tackle the issue of the loss of knowledge on black hole is by the Leonard Susskind and Gerard't Hooft holographic theory or through Juan Maldacena's linked AdS/CFT correspondence. We would review in this paper the paradox of black hole knowledge and quickly review several proposed resolutions with a view to the holographic theory and AdS/CFT.

Keywords: Space-time, Black Hole, AdS/CFT, Holographic principle

1. Introduction

1.1 Background

Einstein's 1915 principle of general relativity laid the foundations for scientific physics. Besides describing the fundamental notions of space and time and the astrophysical application of relativity, its resistance to the quantum mechanical treatment has given rise to great problems, observations and all other but original triggers of string theory. In a world of limitless mass, Black Hole is considered a super-dense entity. Einstein's general theory of relativity is uniform to clarify the properties of the Black Hole. In 1976 he launched a hypothesis that any Black Hole emanates light, later referred to as Hawking Radiation, which he defined as extraordinary. This is the first documented connection between the black hole, the quantum engineering and thermodynamics. Yet this observation significantly led physicists to a new issue in the Black Hole dubbed 'Hawking Paradox.' In string theory, this paradox may also have a solution.

The holographic theory of Leonard Susskind and Gerard't Hooft, or the associated AdS/CFT communication established by Juan Maldacena are another way of approaching the issue of blackholes knowledge loss. It could be that all the details found in the black hole is coded as such in the surface of the black hole when these rules extend to the black hole.

Another way is to look at the multiverse potential. The knowledge which enters a black hole can somehow be parallel from this universe

1.1.1 What is a Black Hole?

A black hole in principle is nothing but a solution to Einstein's gravity field equations in the absence of the material to explain the time-space conformity around a star that has collapsed gravitationally. Its gravity pull is so heavy that it cannot be escaped by even light. The biggest enigmatic and interesting phenomena in the cosmic cosmos most definitely originate from black holes. They live, and we have outstanding proofs now that they are found all over the world. The notion of black holes today makes it impossible to discern a "substantial fall" of a dying star, or a "black hole," which is the real very essence of a spacetime contour, from the initial scientific discontent amongst many leading physicists, including Einstein herself. The "severe problem" [Bena et al. (2016)], which is "likely to be the most significant question for fundamental physics today" [Mathur, (2009); Almheiri et al., (2013)], is the product of a contradiction between the foundations of general relativity and quantic mechanics..

2. Brief History of Black Holes

2.1 Early Theories

However, in a very tragic moment i.e. during World War II the documented evidence of the hunt for the mysterious bodies goes back to the 18th century. The theorists John Michell (1976) and then Pierre-Simon Laplace (1979) first introduced the notion in the 18th century that an object could consume light to become overshadowed by the rest of the universe. They used Newtonian gravitational principles to determine that the escape speed of light particles from any issue was so large that they were so huge and their power of gravity so strong that not even light could escape them [Romero and Vila, 2013]. They used the Newtonian gravitational principles. They were later named by Michell as "black stars." However, it was also unclear how much Newton's gravitational forces could affect it after the observations of 1801 that light particles dispersed in waves, thereby contributing to a denial of the idea of obscure stars.

It took about 115 years, though, to understand how light waves behave under gravity pulls. In 1915 the general philosophy of relativism was conceptualised again and Karl Schwarzschild presented the approach a year later. Schwarzschild also envisaged the existence of a diameter of a critical object over which light could not cross, defined as the Schwarzschild radius. The presumption was strongly connected with the "black star" of Michell, but was now deemed an inexpressible problem.

However, considering the theory, none, even close to the actual presence of a black hole, could be confirmed by any evidence. Therefore, everybody assumed that anything like dark stars might occur, as Michell hypothesised. However, barely one took the chance of its presence seriously before World War II..

2.1.1 Newtonian Gravity and Dark Stars

The documented evidence of the search for mysterious bodies dates from the 18th century in a very sad moments during the World War II. In the 18th century, theoreticians John Michell (1976) and then Pierre-Simon Laplace (1979) initiated the notion that an entity would absorb light to become shaded by the rest of the universe. They used Newtonian gravitational concepts to calculate that the escape speed of light particles from every problem was so massive, so big, and so heavy, that they could not even be escaped by light [Romero and Vila, 2013]. They utilised the Newtonian principles of gravity. Later on they were dubbed "black stars" by Michell. But how much Newton's gravitational forces could influence it after the observations of 1801, which contributed to a negation of the notion of obscure stars, through light particles scattered in waves. It was still uncertain.

It took nearly 115 years to realise how light waves are pulling under gravity. In 1915 relativism was again conceptualised in a general theory and a year later Karl Schwarzschild was applied to this method. Schwarzschild also considered the presence of the diameter of a vital object, known as a Schwarzschild radius, through which light could not cross. The theory was closely linked to Michell's "black star," but it was now considered a difficulty.

In spite of the hypothesis, though, none can be proven by some proof or near the physical existence of a Black Hole. So everyone believed, as Michell had speculated, that anything like dark stars might exist. Still barely one took his opportunity before World War II seriously.:

$$F_{2\to1} = -G\frac{m_1 m_2}{|r|^2}\frac{r}{|r|} \qquad (1)$$

Where G is the gravitational constant of Newton and where F is the attraction force which works between them.

If we now choose to quantify the attraction force that works between the super-massive body including black holes and light particles, we have equation (1).:

$$F = G\frac{Mm}{R_{bh}^2} \tag{2}$$

where, M and Rbhdenote the mass and radius of event horizon of black holes and m is the mass of light particle.

2.1.2 Einstein’s General Relativity

In 1915 Einstein's idea of "universal relativity" lay the basis for several principles in contemporary physics. Indeed, its resilience to quantum-mechanics is a crucial inspiration behind a string theory [Susskind, (2013)] not only to a basic conception of time and space but also to astrophysical applications, essential problems and viewpoints. The string theory is indeed a historic term, in which situations answer simple probabilistic formulas which can be resolved sequentially. Some of these traditional calculations are gravity formulas.

2.1.3 Black Holes: The Schwarzschild Singularity and Radius

In 1915 Einstein's idea of "universal relativity" lay the basis for several principles in contemporary physics. Indeed, its resilience to quantum-mechanics is a crucial inspiration behind a string theory [Susskind, (2013)] not only to a basic conception of time and space but also to astrophysical applications, essential problems and viewpoints. The string theory is indeed a historic term, in which situations answer simple probabilistic formulas which can be resolved sequentially. Some of these traditional calculations are gravity formulas:

$$r = Rs = 2G\frac{M}{c^2} \tag{3}$$

The Schwarzschil radius (Rs), which typically lies somewhere beyond an astronomical body's radius (r). For eg, Rs occurs at about 3 km, compared with 0.7 million km in the total radius..

3. Black Holes in General Relativity and Beyond

3.1 Fundamental Theories

Einstein's basic general theory of relativity (GR) involves the deformation of energy and momentum in space and time. It consists of objects that are just a waste of electricity. This total effect was described as the instantaneous gravitational force shown by vast interstellar objects including stars, planets and black holes in their immediate surroundings.

Eddington, one of the most influential astronomers at the period, declined Chandrasekhar's work at a conference on astronomy in Paris. His study of white dwarfs (stars after the explosion of their nuclear power), on the other hand, had led Chandrasekhar to believe that a large star could collapse [Wesemael, F. (2010). 'Unaffected by Fortune, Good and Poor,' the background and the reception for the white Dwarfs of Chandrasekhar's Radius Mass, 1935–65. The probability of the stellar collapse explained that a star in an area greater than its 'Schwarzschild radius' could no longer be compact and that the 'Schwarzschild singularity' could not go away as Einstein had wanted. Indeed, knowing the ultimate condition of the star was necessary.

3.1.1Event Horizon

'Schwarzschild singularity' according to Einstein is not at all physical singularity. It is rather a "coordinate singularity" owing to the "poor selection of alignment." The coordinates used by Schwarzschild for searching his solution are best fitted to an observer who wants to sit at a defined distance r from the centre. Far from it, the permanent r-surface is time-like, implying that the observer who wishes to be bound to the radius travels steadily relative to an observer who falls freely. However, the surface r = R near the Schwarzschild radius is light-like, regardless of the curvature of space time in Schwarzschild geometry. In other terms, an observer who wishes to stay connected to the radius must travel at light speed

The observer must enable his cocks with limitless acceleration to travel at light speed, which is physically unlikely. This ensures that the deceptive choices taken by coords contributes to the misleading inference of a 'singularity' which is not even an aspect of spatial geometry. The singularity of Polar Coordinates (r,q) in the plane around the origin r = 0 is another mathematical co-ordinate. An aeroplane at all stages is completely smooth. Its roots are no different and the geometry of the plane at the origin is perfectly non-singular.

We can transmit signals from the outside through the surface, but can never get signals from the surface. The 'Case horizon,' is such a one-way surface. More specifically than the space-time area, the black hole is confined by the event horizon [Herdeiro, C. A., &Lemos, J. P. (2018). Fifty years old, the dark hole: name Genesis. The preprinting of arXiv:1811.06587. arXiv preprint:1811.06587..

3.2 Entropy of a Black Hole

The mass of the black hole will be estimated from the outside of its gravity pull so the energy can stay conserved while we keep track of the energy level of a black hole in our space accounts. This implies that the second rule of thermodynamics will also be spared if, except with entropy, an entropy may be correlated with a black hole, even if the entropy of a black hole is held under our accounts of full entropy. Yet the previously stated "No-Hair" theorem shows that, other than its density, charges and spin, no other properties of the black hole were determined externally. This is merely the region of the event horizon which equals 4α-R^2 for the Schwarzschild black hole, where R is the Schwarzschild radius.

3.3 Black Holes Quantum Theory

As previously mentioned, black holes face critical scientific problems. Although it is still a scientific problem to contend with classic uniqueities, actual black holes puzzles emerge on a quantum basis. The black holes radiate radiation physically in the quantum. The thermodynamic temperature and entropy are both present.

In the early 1970s, James Bardeen, Brandon Carter and Stephen Hawking find that black hole mechanics rules are very much in line with thermodynamics laws. Null rule says that the surface gravity μ is unchanged at the horizon of a set black hole. The first theorem involves the mass m, the horizon region A, the angular momentum J, and the black hole charge Q accordingly.:

$$\mathrm{dm} = \frac{\kappa}{8\pi}\mathrm{dA} + \Omega\mathrm{dJ} + \phi\mathrm{dQ}, \qquad (4)$$

Where it is representedin D dimensions,

$$\Omega = \frac{2\pi^{(D+1)/2}}{\Gamma\frac{(D+1)}{2}} \qquad (5)$$

This rule is identical to the law on energy and entropy. The second black hole dynamics rule states that the event horizon region should not decline over time. This is calculated by writing:

$$\mathrm{dA} \geq 0. \qquad (6)$$

This is strongly related to the second law of thermodynamics, which states that the entropy of a closed system is a time constant that is not diminishing. As the consequence of (6) the following relation should be retained when black holes in A 1 and A 2 areas shape a new black hole with A 3 region:

$$\mathrm{A}_3 > \mathrm{A}_1 + \mathrm{A}_2. \qquad (7)$$

The third regulation notes that surface gravity¨ cannot be limited to 0. There is more than comparison in regard to the rules of black-hole physics and thermodynamics. We may also assume that the comparison is true and correct. This means the horizon A's field is the black hole's entropy S, and surface gravity · is commensurate with the black hole temperature. In terms of mass or area, we can express the black hole entropy. As long as density is concerned, black holes' entropy is equal to the mass of the squared black hole. The entropy is 1/4 of the horizon region in units of Planck duration in proportion to the area of the event horizon:

$$\mathrm{S} = \mathrm{A}/4\mathrm{l}_\mathrm{p}^2, \qquad (8)$$

or

$$S = A/4G, \tag{9}$$

where G is the Newton constant. Before moving to the discussion of black holes in string theory, let us compute the temperature of a Schwarzschild black hole. To begin we rotate the metric, t⟼iτ ,band write:

$$ds^2 = -\left(1 - \frac{2Gm}{r}\right) d\tau^2 + \left(1 - \frac{2Gm}{r}\right)^{-1} dr^2 + r^2 d\Omega_2^2. \tag{10}$$

Doing this gives us the following relations:

$$2\pi R = 2Gm^{-1/2}(r - 2gm)^{1/2}\beta, \tag{11}$$

$$R = 2(2Gm)^{1/2}(r - 2Gm)^{1/2} . \tag{12}$$

And so, dividing (2.13) by (2.14) we see that

$$\beta = 8\pi Gm. \tag{13}$$

Thus, we see that (since β∝T^(-1))

$$T = 1/8\pi Gm = 1/8\pi m, \tag{14}$$

Where in the last equality we switched back to the G = 1 units. Quantum mechanically speaking black holes radiate (Hawking Radiation) a thermal spectrum with temperature $T = 1/(8\pi m)$. Along with temperature, black holes have entropy and mass.

3.3.1 Hawking Radiation

If there is enterropy and energy in a black hole, so there must be temperature, since the concept of entropy can be identified. Any hot body now wants to glow and a black temperature void now needs to be radiated. This conclusions are ridiculous because a black hole was called after all since it was perfectly black and nothing could escape from it.

Hawking and others were originally able to compromise the second rule in the face of entropy. Rather soon however, in his classic paper he discovered that when you have quantum effects, a black hole would potentially have temperature. In a quantum theory, vacuum is continually forming and annihilating virtual particles and antiparticles. They are typically not split into actual particles without breaking energy efficiency, so it would lead to a particle-anti-particle pair being formed out of nowhere. But the anti-partum will collapse through the black hole near to the event's horizon and the sample as a true particle can evade to infinity. The black hole temperature T is given in a simple formulation, now known as the Hawking temperature.

$$T = \frac{\hbar\kappa}{2\pi} \tag{15}$$

where,κ is the surface gravity metpreviously. With this remarkable discovery, it becomes more than just an analogy:

$$S = \frac{Ac^3}{4\hbar G} = \frac{A}{4l^2} \tag{16}$$

The length l here is 10–33 cm long, the simple length developed from the constant trinity l^2=G⁄c^3 The length of the Planck is 3. The ultimate formula is true in all sizes and for all black holes with mass, load and spin. Remember that the temperature disappears as a black hole is typically black at the classic point of 0, paraphernalia. For two decades after Hawking's discovery this remained an open concern. There is still no thorough explanation of the entropy of general black holes, but notable progress has been made on this topic in the sense of string theory which we will explore later.

3.3.2 Hawking Paradox (The Information Paradox)

The central question first raised by Stephen Hawking [Hawking, S. W. (2005). Information loss in black holes. Physical Review D, 72(8), 084013.] is whether pure states evolve to mixed in the context of black hole formation and evaporation. This appears to be a meaningful question, which could in principle be tested by some future experimentalist; in the most optimistic of worlds black hole production could begin with the LHC. The corresponding out states can be labeled in occupation number basis as |├ n_i ⟩ where i denotes the mode in question. The information content is determined by carefully determining the elements of the density matrix,

$$\rho\{n\}\{n'\} = \langle h\{n\}|\rho|\{n'\}\rangle \tag{17}$$

in this series of experiments. The quantity that gives a precise measure of this information is the entropy.

$$S = -\mathrm{Tr}(\rho \log \rho)\,. \tag{18}$$

If any experimenter determines the elements of the density matrix by suitable projections onto outgoing states, in repeated experiments, she would conclude the state is pure if $S = 0$, or mixed if $S \neq 0$.

Note that a definite conclusion requires measurement of all the elements of the density matrix. For example, values of individual matrix elements can make the difference between pure and mixed states, as comparison of the mixed state:

$$\rho_1 = \frac{1}{2}(|0\rangle\langle 0| + |1\rangle\langle 1\rangle) \tag{19}$$

and pure state

$$= \frac{1}{2}(|0\rangle + \langle 1|)(|0\rangle + \langle 1\rangle), \tag{20}$$

illustrate.

Hawking has triggered our theoretical-practical dilemma, claiming that for a rather black hole collapse the mass matrix is complex. His aim was to research the design of a purely initial state|├ ψ_i ⟩┤ into a state on a spatial slice that spans both interior and exterior of the black hole, and thus intersects both the modes that have carried information into the black hole, and the outgoing modes ofHawking radiation. One assumes, in accord with local field theory, that the Hilbert space on such a slice can be decomposed into a tensor product

$$H = H_{\mathrm{inside}} \otimes H_{\mathrm{outside}}\,. \tag{21}$$

Denoting a general basis of inside and outside states by |├ α⟩┤ and |├ a⟩┤, Hawking's computation yields a definite state of the form

$$|\psi_i\rangle = \sum_{a\alpha} \psi_{i,a\alpha}|a\rangle|\alpha\rangle \tag{22}$$

on the spatial slice. Measurements made outside the black hole are summarized by the density matrix found by tracing over the inside states|├ α⟩┤ .

If the Hawking radiation does not contain information, the only alternative that could save unitary evolution is for the information to be preserved in some form of black hole remnant that is left behind when the semi-classical approximation apparently breaks down at black hole mass M ~ M_pl. This implies a new type of object, with mass M ~ M_pl, and with an infinite number of internal states to encode the infinite varieties of information that could be fed to a black hole.

The connection between information and energy ensures that such remnants would be very long-lived, given the small energy that would be available to carry away the large remnant information in its decay. This, too, is a disaster due to their infinite degeneracy, such remnants would be infinitely produced in generic physical processes. Thus, very general principles of local quantum physics and general relativity lead to a paradox

4.1 The Holographic Principle

The holographic principle is taken to be, in some senses, analogous to to a hologram, where a three dimensional image is perceived when a two dimensional surface is viewed. The idea of this principle seems to be that, in certain appropriate circumstances, the state of a string field theory defined on some spacetime M can be put into direct 1-1 correspondence with the state of another quantum field theory, where the QFT is defined on another spacetime E of lower dimension! often ℰ is is presented as though it were a boundary of M, the most familiar form of this ‘holographic principle is coming out from the work of Juan Maldacena in 1998 and is sometime referred to as Maldacen Conjencture, or elsr AdS/CFT Conjencture. Here M is to be a (1+9)-dimensional product AdS_(5)×S^5, where 〖AdS〗_5 is the (wrapped) (1+4)-dimensional anti-de Sitter space. The S^5 is a spacelike 5-sphere whose radius is of cosmological dimension, equal to 〖(-Λ′)〗^(1/2) , where Λ′ is the (negative) cosmological constant of 〖AdS〗_5. The smaller space E is to be the four-dimensional ‘scri’ (conformal infinity) of 〖AdS〗_5. We note that E, being four dimensional, is certainly not the boundary of M= 〖AdS〗_(5)×S^5 is ten-dimensional. Instead of boundary – i.e., - ‘scri’ – of M can be thought of as E×S^5. The Maldacena Conjencture proposes that string-theory on 〖AdS〗_(5)×S^5 is to be equivalent to a certain supersymmetric Yang-Mills theory on E.

Since the extra dimensions of ℳ are small- being cosmological scale- the rise of additional degrees of freedom, from the field dependence of on the *S*5, part of ℳ, decreases the chances of agreement between the two field theories. The same would apply to ordinary QFTs on ℳ and ℰ, since one particle states are themselves described simply by ordinary fields. The only chance of the holographic principle being actually true for these spaces is for the QFTs under consideration to be far from ordinary.

In the case of string theory M, it is certainly conceivable that there are very strong consistency conditions which drastically reduce the M namely ∞^ (〖M∞〗^9) functional freedom. But on the face of it, it seems very unlikely. Since the quantum state of a single particle in (1+n)-dimensional spacetime has the functional freedom ∞^ (〖P∞〗^n), where P is some positive integer describing the number of internal or rotational degrees of freedom of the particle. The quantum state of a single string would seem to have much greater functional freedom, since a classical string has infinitely many degrees of freedom. If the number ∞^(〖P∞〗^n)is somehow to be reduced, then there must be huge constraints, perhaps of the type that led to the restrictions on spacetime dimension and curvature

4.1.1 AdS/CFT Correspondence and String Theory

The AdS/CFT correspondence is related to two deep ideas in physics. The first of these is the idea that large N gauge theory is equivalent to a string theory [David et al., (2002)]. The perturbative expansion of a large N gauge theory in 1/N and g2 YMN has the form

$$Z = \Sigma_{g\geq0} N^{2-2g} f_g(\lambda) \qquad (5.7)$$

Where is the so-called't Hooft coupling. This is like the loop expansion in string theory

$$Z = \Sigma_{g\geq0} g_s^{2g-2} Z_g, \qquad (5.8)$$

With the string coupling equal to 1/N. Through some peculiar and not completely understood mechanism, Feynman diagrams of the gauge theory are turned into surfaces that represent interacting strings. Apparently, this is precisely what happens in the AdS/CFT correspondence.

4.1.2 The Holographic World

The second is the definition [Stoica, (2018)]. Holography. The theory derives from the study of black holes thermodynamics. It was shown that black holes could be regarded as thermodynamic structures with a temperature and entropy by Bekenstein and Hawking [Park, (2007)]. The temperature has a direct relation with the black body radiation of the black hole, while the entropy is shown by $S = A/4G$, the Newton is stable and the black hole is a part of the horizon.

Einstein's general relativity equations are compatible with the laws of thermodynamics of these descriptions. A clear image is reached if gravity is identical to a local field principle in d − 1 dimensions in a manner in d dimensions. They have the same entropy as the d dimensions, in d − 1 dimensions, as the volume. A name-holography was comparable to the hologram which saves all details of a 3d image in a 2d image. The AdS-CFT correspondence is holographic, since it claims that the five-dimensional quantum gravity is identical to a four-dimensional local field theory (forgetting the five compact sphere).

Susskind suggests, though, that seeing the whole world as a two-dimensional structure that just appears three-dimensional might address deeper theoretical physics issues. And in the analysis of a black hole, earth, or a whole world, mathematics relevant to this function. But Juan Maldacena's imaginary reality, which could be a holography – an anti-Sitter world – is just speculation. In the World of Friedman-Lemaitre-Robertson-Walker, the universe full of substance and radiation (FLRW universe). Holography is thus not an integral theory itself, but a modern universal theory..

5. Conclusion

In this post, we explored the idea of the holographical values, Ads/CFT solutions, a variety of introductory concepts concerning black hole, inventions, hawking radiation, paradox knowledge. It became established that the paradox of black hole data loss brings one to a modern realm of holography. Still in string theory there are few alternatives to the issue of knowledge loss, but holographic concept has shown a strong image of an antisitting-universe by modifying our dimension. Of course, the dilemma was not answered, but the paradox was re-framed. Many theorists still assume that unitary Black Holes are emerging. In the other hand, our current world composed of matter and irradiation has not balanced the imaginary anti-sitter system. Our environment brings one to a different idea from this point of view. Flate, homogeneous, isotropic, expanding universe, the universe of Fridman-Lemaitre-Robertson-Walker soon will be FLRW.

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