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On the Change in Entropy Due to Accretion and Collision of Black Holes

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Abstract* — Inside of any event horizon of a Black Hole is totally a mysterious wonderful world. The singularity inside the event horizon is of infinite density and creates tremendously huge gravity. The gravity is so horribly huge that even light cannot come out from inside the event horizon to the outer world. So no information about the happenings inside the event horizon is available to the outer world. Although it is quite impossible to get information from inside the event horizon of any black hole, it is possible to predict and estimate a lot regarding the mysterious world inside the event horizon including the singularity at the center, with the help of general and special theory of relativity. In the present paper we discuss several issues. First of all we introduced the concept of computation of gravity at the juncture of Newtonian Gravitation and General Theory of Relativity. Secondly we discussed the different definitions of time and the definition of time inside the event horizon. Finally from the First Law of Black Hole Thermodynamics we showed how the accreted mass is absorbed in the form of decrease in entropy, increase in electrical charge, and increase in angular momentum and finally increase in effective mass of the black hole. This apparently indicates the fall of entropy and thereby a violation of Second Law of Black Hole Thermodynamics. We justified no violation of the law – not from the angle of Hawking Radiation or thermal evaporation of the Black Hole (which has to assume and impure system of central Black Hole and the surrounding thermal radiating particles) but from a complete different new logical concept of Entropy inside the event horizon of any Black Hole.

***Keywords* — space time, world line, space time curvature, black hole, Schwarzschild Black Hole, Kerr Black Hole, event horizon, singularity, entropy, laws of black hole thermodynamics, Hawking Radiation**

I. INTRODUCTION

(i) Three different steps namely (a) 'Pre Main Sequence' (b) 'Main Sequence' (c) 'Post Main Sequence' broadly comprise the 'Life Cycle' of any star.

(ii) Pre Main Sequence of a star is the formation of the star from a nebula, through gravitational collapse of gaseous materials of the nebula. Due to huge gravitational force, parts of a Nebula are heavily concentrated. A huge energy in the form of heat is liberated due to compaction or compression, which primarily initiates the process of fusion of hydrogen into helium in the central part or core of the star.

(iii) The fusion process converts more and more hydrogen atom into helium atom liberating more heat in a chain reaction process. With this the star enters into Main Sequence and is called Main Sequence Star.

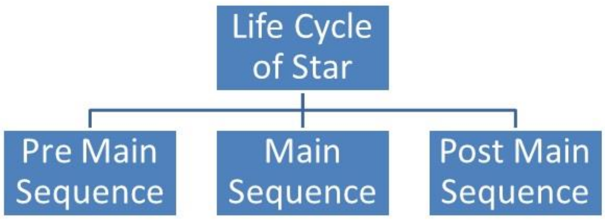


Fig 1 Pre Main and Post Main Sequence of Star

(iv) Now a time comes when all the hydrogen atoms at the core of the star have been converted into helium, and the fusion process is bound to terminate and thereby no further heat is generated by the star. Eventually the star gradually cools down. The volume balance in between gravitational force and heat is now disrupted. Due to only huge gravitational force the volume decrease and density increases. Now it is the time for the star to enter into Post Main Sequence.

(v) The fate attained at Post Main Sequence by a star is not a unique one and interestingly a star may attain different situations in Post Main Sequence. In the case, the mass of the star is less than or equal to 'Chandrasekhar Limit' i.e. 1.44M (where M is the Astronomical Mass i.e. the mass of the sun) the star is converted to "Red Giant" which still radiates some energy due to compaction and ultimately cools down to become a "White Dwarf".

(vi) If the mass of the star exceeds the 'Chandrasekhar Limit', then huge gravitational force creates sudden huge gravitational collapse and thus excessive heat is generated in the core of the star. At this time, the outer shell of the star becomes so hot that the heat energy cannot be radiated away as fast as is required to maintain the structure of the star. As a result, the star is bound to undergo a violent explosion, formally called 'Supernova Explosion'. 'Supernovae' are usually extremely bright such that some of them may even be visible in broad day light. But the visualization of this 'Supernova' is not very frequent for us – rather it is very rare incidence.

After supernova repulsion (between electrons even if the mass of the star exceeds 1.44M, due to Pauli Exclusion Principle the star would not be able to balance the gravity of the star and thereby the star would completely fail to support its size and structure against its own gravity. The star eventually rapidly reduces its size and becomes either a **Neutron Star or a Black Hole.**

II. NEUTRON STAR

(i) In the case the mass of the star exceed the Chandrasekhar Limit i.e. 1.44M, all the hydrogen is converted to helium, thus no heat is developed through fusion. Eventually only force acting on the star is gravitational force which collapses the star.

(ii) This gravitational energy is converted into huge amount of heat. But the star is unable to make all on a sudden change in structure due to huge heat evolved. Thus the outer shell of the star bursts into pieces creating "Supernova".

(iii) The inner core part is now cooled down because of the fact that there is no hydrogen fuel. If the mass is still above Chandrasekhar Limit, it would not be converted to 'Red Giant' and "White Dwarf". Rather through huge gravity all the electrons will collapse with central protons in an atom and the nucleus would be only charge less neutrons. Thereby the whole post main star in this case would be the combination of neutron particle combination with huge density. It may so happen that the post main star having mass two times that of the sun may have diameter of only 25 km.

(iv) The neutron particles now will apply opposite pressure to resist the further collapse.

III. FORMATION OF BLACK HOLES

If the mass of the neutron star is within 3M, then the neutron star would succeed in retaining its size and structure – this again by Pauli Exclusion Principle. But unlike the previous case (whether it would be reduce to a white dwarf or a neutron star), this time the repulsion is between (neutron and neutron, proton and proton, proton and neutron). In the case the repulsion is able to balance the gravity of the star; the neutron star would retain its structure and size and would remain and continue as neutron star.

What would happen if the mass the star is more than 3M? In such a case the intermediate neutron star finally reduces to a Black Hole. This is because of the fact that in such a case the repulsion between proton and neutron etc. due to Pauli Exclusion Principle is unable to support the structure and size of the intermediate neutron star and the neutron star continuously further collapses to finally reduce to settle down to Black Hole.

IV. TYPES OF BLACK HOLE

The escape velocity of Black Hole exceeds the velocity of Light. A collapsing post main sequence star becomes a Black Hole when its radius shrinks to a critical one called "Schwarzschild Radius". We know, the surface with this critical radius is called "Event Horizon" and is the boundary beyond (inside) which all information is trapped. This is because of the fact that no event within the black hole can be observed from outside the black hole in any way. Space Time is heavily distorted, random and irregular inside the event horizon. Any object collapses to a single point object, called 'singularity' at the centre of a black hole.

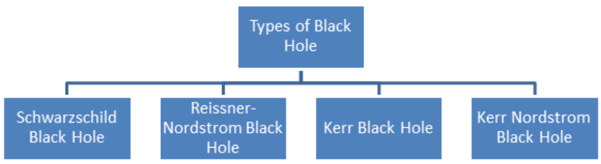


Fig. 2 Different Types of Black Hole

Types of Black Hole:

A. Schwarzschild Black Hole: Non Rotating Black Hole without electrical charge. Shape is spherical.

There are only two parameters in the metric of Schwarzschild Black Hole. These are mass and entropy of the black hole

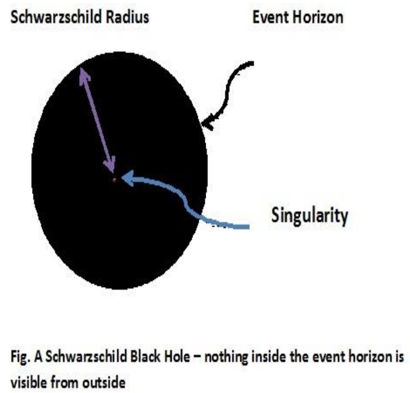


Fig. 3 One Schwarzschild Black Hole

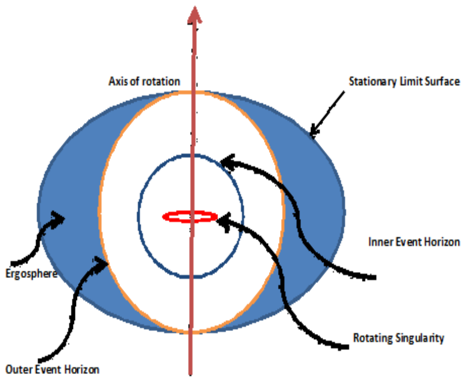


Fig. 4 One Kerr Black Hole

B. Reissner -Nordstrom Black Hole: Non Rotating Black Hole with electrical charge. Shape is spherical.

There are three parameters in the metric of this black hole. These are mass, entropy and electric charge.

C. Kerr Black Hole: Rotating and Uncharged Black Hole. Elliptical in Shape

There are three different parameters in the metric of the black hole. These are mass, entropy, angular momentum.

***D. Kerr-Nordstrom Black Hole*:** Rotating and Charged Black Hole. They are also Elliptical in Shape.

There are four different parameters in the metric of this type of black hole. These are mass, entropy, angular momentum and electrical charge.

Schwarzschild Radius: Schwarzschild radius 'R' is the upper limit of radius of any mass 'M' so that the mass M is the mass of a black hole. The lower limit is theoretically zero.

Calculation of Schwarzschild Radius of a Schwarzschild Black Hole

a) Escape Velocity
If the kinetic energy of an object is equal to its potential energy then the object will escape from earth. So earth and every planet and every cosmic body has its own escape velocity.

b) Expression for Escape Velocity
Let the mass of the object is ‘m’, the mass of the earth is ‘M’, the constant of Gravitation is ‘G’ and the radius of earth (assumed spherical) is ‘R’. Now the object will only escape when its Kinetic Energy equals its Potential Energy. Thus

$$\frac{1}{2}mv^2 = \frac{GMm}{R} \ldots\ldots\ldots\ldots (1)$$

Giving the escape velocity ‘v’ as:

$$v = \sqrt{2GM/R} \ldots\ldots\ldots (2)$$

Thus the escape velocity of any terrestrial object is dependent on the mass as well as the radius of the object.

c) Expression for Schwarzschild Radius:
For a Schwarzschild Black Hole (Non Rotating Black Hole), the light cannot come out of the black hole (like all other types of black hole). If in equation number 2 we replace ‘v’ by the velocity of light ‘c’ (since the escape velocity of the black hole is just slightly above the velocity of light), we get the radius of the Schwarzschild Black Hole (formally called Schwarzschild Radius) as below:

$$c = \sqrt{2GM/R} \ldots\ldots\ldots\ldots (3)$$

$$R = \frac{2GM}{c^2} \ldots\ldots\ldots\ldots (4)$$

This is the upper limit of the radius of the mass ‘M’ such that the mass is the mass of a Black Hole. Alternatively it is a Black Hole of mass “M” having the radius “R”.

Now a Schwarzschild Black Hole is a stationary or a non rotating black hole. Now for a rotating black hole, like Kerr or Kerr Nordstrom Black Hole, as shown in Fig there is an ergo sphere surrounding the outer event horizon. Also inside the outer event horizon, there lies an inner event horizon. Inside this event horizon the rotating singularity exists.

As we know, the Kerr Black Hole is governed by three parameters, namely mass, entropy and angular momentum, while Kerr Nordstrom Black Hole is governed by four parameters – mass entropy, angular momentum and electrical charge.
Both Kerr and Kerr Nordstrom Black Hole has ergo sphere from where Hawking Radiation occurs and that region is visible from outside. Due to rotation of either Kerr or Kerr Nordstrom Black Hole, they have angular momentum and with this two event horizons are formed – one outer and the other inner. In between outer and inner event horizon, light wave can neither come out of the outer event horizon nor cross the inner event horizon and dragged towards the rotating singularity. The huge gravitational force is used up to create angular momentum and rotation or light particles there and they rotate in between outer and inner event horizon. But inside the inner event horizon naturally the gravitating force is comparably much larger so that light particles are only dragged towards the singularity.

While the radius of outer event horizon is dependent on mass, the radius of inner event horizon depends on angular momentum (Kerr Black Hole) angular momentum and electrical charge (Kerr Nordstrom Black Hole).

Outer and inner event horizon is merged:

a) This happens in case of Schorzschild Black Hole. In this case since the black hole is stationary, there is only one evnet horizon.

b) Also in case of Kerr Black Hole this may happen. In such a case they black hole should be of huge mass and comparably smaller angular momentum. For the same huge mass, as the angular momentum becomes smaller, the inner envet horizo comes closer to the outer one and untimately the two are merged together.

c) Also in case of Keer Nordstorm Black Hole, even with comparably lighter mass and smaller angular momentum with respect to (b) due to the presence of electrical charge, the innner event horizon comes closer to the outer one based on the amount of elecrical charge and with a particular electrical charge these two are merged together.

V. CONNTRIBUTION OF THIS PAPER

In the present paper we discuss several issues namely the comparison of Newtonian Gravitation and General Relativity and the computation of gravity at the juncture of the above two. We have thrown light on the variation of Space Time of an object when the velocity changed from zero to infinity. Also we propose that the gravitation on the surface of any black hole is a huge constant and is related to the velocity of light in vacuum. Also we gave the concept and different definitions of time. Then we relate time with entropy and universe expansion.

The main contribution in this paper is to justify that when surrounding matter is accreted inside a black hole or two black hole merges together, it does not violate the Second Law of Thermodynamics in its unrevised form – the entropy is still non decreasing. If we see the change in entropy form outside the black hole event horizon, there is a decrease in entropy, while if it is visualized from inside the event horizon, there is definitely an increase in entropy. We need not take the help of surrounding space radiation of the black hole and formulate a revised version of Second Law of Black Hole Thermodynamics.

VI. NEWTONIAN GRAVITATION VS. EINSTEIN'S GENERAL RELATIVITY

There is no basic difference between Newtonian Gravitation and General Relativity until and unless:

1) *The object of mass m (either an ordinary star or a black hoke) is within the gravitational radius Rs o f any black hole of M where Rs is given by*

$$Rs = \frac{2GM}{c^2} \quad \dots\dots\dots\dots\dots (5)$$

2) *The object M is roatting creating a gravitational wave in space time*

3) *The object of mass m and size (radius) b is closer than the distance R to the object (eithe a star or a black hole) of mass M wher R is given by*

$$R = (M/m)^{1/3} * b \dots\dots\dots\dots (6)$$

The value of R is obtained by equating the tidal force created by the star to the self-gravity of the nearby object.

Thus if there are two gravitating black holes of equal mass M, they will simply act as ordinary star governed by Newtonian Gravitation until and unless one of them enter inside the event horizon of the other.

VII. EFFECT OF VARIATION OF VELOCITY ON SPACE TIME

Space time is a 4D fabric having 3D space (x,y,z) and 1D time. The space time of an object represents all possible trajectories of the object while stationary or in motion. Each of those trajectories represents one 'World Line' of the object. Thus an object is only allowed to traverse on a particular trajectory or world line in space time of the object.

Let us simplify the situation by assuming 2D space (x,y coordinate) and 1D time (z axis). Thus the space time of any object is 3D. With this assumption we will be able to plot all the events in the trajectory of the object in the x,y,z space time coordinate system. An event is a particular position of the object in the world line of space time.

Case – 1 Object is Stationary: The world line of the object is along the time axis (z axis). The space of the object freezes. The space time of the object is comprised of that single world line. The stationary object only moves along the world line of space time which is the time axis. The span of the closed interval of time of the object is infinite.

Case – 2 Object is Moving with Infinite Velocity: A single world line (which itself is its space time) of the object is only on the space plane i.e. x,y plane. The time of the object "freezes". Thus the world line or space time of the object is along the x,y plane. The span of the closed interval of time of the object is zero.

This infinite velocity of the object is actually realized inside the event horizon of any black hole. There, the behaviour and role of "space" and "time" is interchanged. There the space is 1D while the time is 3D. While the time is unidirectional (1D) in space (outside any event horizon), inside the event horizon the space is unidirectional (1D), due to infinite and unidirectional velocity of the object towards the singularity of the black hole. This is because of the fact that the object only moves along the world line in x,y space in unidirectional manner. (This may be treated as new time axis, because its flow is unidirectional space like unidirectional time outside the event horizon). The flow of space (which is now treated as 'time') is unidirectional because of the fact that the only destiny of the moving object is the singularity of the black hole.

Conclusively, if the object is stationary, then the object moves along the time (y) axis. The world line of the object is along the time axis.

Also if the object moves with infinite velocity then the object moves along the **modified / new** time axis. The world line of the object is the modified / new time axis.

Case – 3 Object is moving with a finite velocity: The space time of the object makes an angle with the x,y plane. This angle is in the open interval of zero and infinity. The world line of the object is a straight line lying on its space time and this also makes an angle with the x,y plane, with the same open interval.

Case – 4 Object is moving with finite velocity and is under the influence of external gravitation: As in Case - 3, the space time of the object makes an angle with x,y plane with the same open interval of zero and infinity. But this time there is a hole in space time of the object near the gravitating matter. This creates **Space Time Curvature** in the space time of the first object due to the presence of gravitation.

The size and shape of the hole or curvature in the space time of the first object depends on several factors: (1) mass of the gravitating matter. (2) distance of the gravitating matter (3) velocity of the gravitating matter.

VIII. THE GRAVITY ON THE EVENT HORIZON SURFACE OF ANY BLACK HOLE IS CONSTANT

We equate the kinetic energy with potential energy to get the escape velocity on the surface of the event horizon of a black hole. The escape velocity is the velocity of light. In this derivation we assume the applicability of Newtonian Gravitation on the surface of the event horizon of any Black Hole. With this we find the gravitational radius of any Black Hole.

With the same logic, there is no difficulty to assume that the gravity on the event horizon surface is given by:

$$g = \frac{GM}{R_s^2} \dots\dots\dots\dots\dots (7)$$

where Rs is the event horizon radius.

Also we know equation (5)

Putting the value of Rs from (5) to (7) we get

$$g = \frac{c^4}{GM} \dots\dots\dots\dots\dots\dots (8)$$

which is only dependent on the velocity of light and G and the mass of the black hole and is constant all throughout the surface of the event horizon of the black

This clearly shows that the huge gravity on the surface of the event horizon of any black hole is constant and is quite independent of the mass of the black hole.

IX. ENTROPY

The entropy of a dataset D is the way to measure the total amount of disorder or variation in terms of the number of different classes or categories in that dataset.
Thus if all the records in a given dataset belongs to the same class or category, then the entropy of that dataset will be zero.

On the contrary, if all the records are uniformly distributed among the different classes and the number of classes is very large in number, then the entropy would be maximized.

Here we are presenting the mathematical formulation of entropy:

Entropy: Suppose there is a dataset D. It has 'm' different class of records. Also it has n different records altogether. The probabilities pi's are proportional to the number of records in that class. Thus if the 'i' th class is having 'i' number of records in it, then the probability of the 'i' th class is:

pi = i/n

Now suppose these records are having the probabilities of occurrence p1, p2, p3 ……………pm

Then the entropy of the dataset D, symbolized as H(D) is defined as:

$$H(D) = -\sum_{i=1,2,\dots\dots\dots m} pi * logpi \dots\dots\dots\dots (9)$$

Here we assume

0log0 = 0

Thus during the origin of universe i.e. during 'Big Bang' there was only one class and the entropy of the universe was zero.

As the time advances, the original universe is continuously split up into number of different classes or variations. Thus the entropy of the universe is continuously ever increasing.

X. TIME

It is difficult to define time because time is not a physical concept for realization like mass, volume, density etc. So it is also difficult to specify the direction of flow of time, until and unless we correlate time with another physical concept.

There are broadly there different definitions of time in each of which we correlate time with another physical concept. These are

4) *Thermodynamic Definiton ot Time*
5) *Cosmological Definition of Time*
6) *Psychylogical Defination of Time.*

In Thermodynamic definition of time, time is proportional to entropy of a known system (say our universe) and is flowing in the direction of increasing flow of entropy. During the Big Bang , the time as well as the entropy of the universe was zero and constantly it is increasing and ultimately it will end up the increase in entropy and start the process of decreasing the entropy, through which the direction of flow of time would be reversed.

In Cosmological Definition of Time, the time is proportional to the amount of expansion of our universe and the direction of flow of time is in the direction of expansion of our universe. During Big Bang the time measured was zero as the expansion was zero, while when the universe would stop expansion and start contraction the direction of flow of time would get reversed.

In Psychological Definition of Time, time is flowing from past to future via present. The past is what we can remember. The future is what we cannot remember but imagine only. The present is what we can neither remember nor imagine. So in this concept of time, time is flowing in the direction from what things we can remember to what things we can imagine via what things we can neither remember nor imagine.
We know that the arrow of time (i.e. the direction of time flow) in time like interval outside the event horizon of any black hole is dependent on the direction of increase of entropy. But the arrow or direction of time is just the reverse inside the event horizon of any black hole due to the nature of space time there. Thus while the time is flowing in the direction of increasing of entropy outside the event horizon, it is flowing in the direction of decreasing of entropy inside the event horizon of any black hole. So the situation is just the reverse inside a black hole event horizon. Thus the property of entropy is also reversed inside the event horizon of any black hole. This is discussed subsequently in section V and VIII.

XI. IT IS POSSIBLE TO MOVE TO THE PAST

We understood that the direction of flow of time is (arrow of time) is the direction of expansion of our universe, which is conceptually equivalent to the direction of increase of entropy of the universe. Now is it possible to see the past?
Formally speaking can your past come again as your future? The answer is yes.

To understand how it is possible, let us imagine that you have boarded on a train at the station A and the train is moving from station A to station Z via the intermediate stations B,C,D etc. Further suppose that the direction of flow of time is analogous to the direction of movement of your train. Suppose presently you are at station D. In such a situation, the future incidents are analogous to the stations ahead of your i.e. E,F,G,H etc. Similarly the past incidents are analogous to the stations which you have already crossed away before i.e. A,B,C. And the present is analogous to the station A, which you are now just crossing.

Now suppose a time comes when you reached your destination station Z and the same train (or any other train) is moving backward from station Z to station A. This is simply analogous to the reversal of the direction of time. Thus you will be able to see the stations again in in reverse sequence. Now suppose you are at the same station D in your reverse journey. With respect to D and with the new direction of movement, the stations which are now ahead of you is analogous to future (stations C, B, A). But these were analogous to past with the previous direction of your movement. New past (i.e. E,F,G, … Z) were the previous future of your previous direction of movement. With this it is analogous to say that you are able to see the past once you perform the reversal of the direction of movement.

We told previously that when your journey is forward (i.e. A to Z), at station D, the past is analogous to stations C,B,A but the stations are not exactly the past. Similarly the future is analogous to E,F,G,…. Z but the future is not exactly E,F,G, …Z

Similarly the analogy with past and present also changes with the reversal of your direction of movement i.e. Z to A.

This is because of the fact that the forward flow of time (i.e. the direction of expansion of universe or the direction of increase of entropy) is analogous to movement from station A to station Z. Similarly the backward flow of time (i.e. the direction of contraction of universe or the direction of decrease of entropy) is analogous to movement from station Z to station A.

From the above, it is clear that to see the past you have to reverse the direction of flow of time. We can realize this either by reversing the direction of expansion of our universe (or by making the universe contract) or by reversing the direction of increase of entropy (or by allowing entropy decrease). We told that these two are conceptually equivalent. This means if after the maximum expansion of the universe up to a limit, if the universe starts contraction, then instead of increase of entropy the entropy will ever decrease from time to time. This is because of the fact, that these two are conceptually equivalent and are the direction of flow of time.

So when the universe after expansion to its maximum limit starts contraction, the direction of the time flow is reversed and we will be able to see the past incidents (of the previous direction of time flow) as the future incidents (of the present direction of time flow).

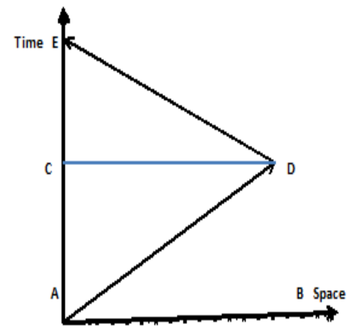
But this is not possible for us to be present at the oldest age of our universe. But it is possible to see the past. Can you imagine yourself inside the event horizon of a black hole? In the realm of event horizon, everything is just the reverse. Not only the space time is too much random and irregular but also space is one dimensional towards the singularity while the time is three dimensional, so that you can steer the time in any direction according to you choice. In that territory time is flowing in the direction in which the entropy is decreasing – time is flowing in the direction in which the universe inside the event horizon is contracting or shrinks toward the singularity due to huge gravity. It is quite possible to see the past we have already came across outside the event horizon, once we cross the event horizon and enter inside it – if from there we look at the outer world outside the event horizon.

Thus when two black holes merge together, the mass of the resulting black hole will get increased along with the increase of charge and angular momentum and decrease in entropy. This apparent decrease in entropy is only from outside the event horizon. If we move inside the event horizon of the black hole we will realize that the direction of flow of time is the direction of decrease of entropy. Thus the law of non-decreasing entropy of Second Law of Black Hole thermodynamics still holds well in the case we visualize it from inside the event horizon of the black hole.

XII. MOVEMENT TO THE PAST – A REVISIT

At lower velocity the flow of time is unidirectional (time like interval) and thus we can steer the direction of movement in space, i.e. we can move forward and backward in space. But if the flow of space is unidirectional (space like interval) which happens at infinite velocity of an object rushing towards the singularity inside the event horizon of any black hole, the object can similarly steer the direction of time. In this way the object can move to past as well as future from any present time.

Suppose we move from home to our institute and come back home after some time. Different space times are indicated in Fig. 5. Here we can move front, back, left or right in space.



Space is along the x axis

Time is along the y axis

A = Our home space time when we start; B = Space time of institute when we start.

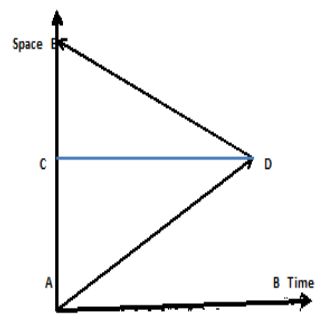
C = Our house space time when we reach institute; D = Our institute space time when we reach.

E = Our house space time when we come back home.

As we are in time like interval, the angle DAE is too small.

Fig. 5 Different Space Time during to and fro movement in space

Now if possible, suppose we move with infinite velocity from our home to our institute and come back home after some time. Our different space times are indicated in Fig. 6. Here we can move front (future), back (past), left and right.



Space is along the y axis

Time is along the x axis

A = Our home space time when we start; B = Space time of institute when we start.

C = Our house space time when we reach institute; D = Our institute space time when we reach.

E = Our house space time when we come back home.

As we are in space like interval, the angle DAE is too small.

Fig. 6 Different Space time during to and fro movement in time

XIII. DIFFERENT TIMES OF AN OBJECT

An object may have two different types of time – namely

(1) Proper Time
(2) Reference Time

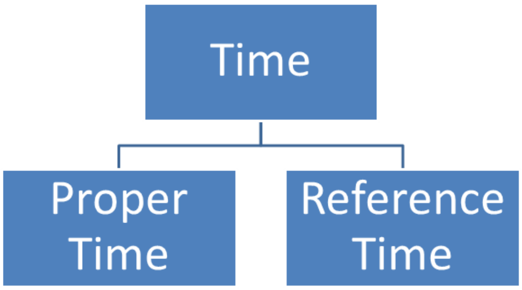


Fig. 7 Two Different Types of Time of a Object.

Suppose there are two persons are sitting in chairs in the same room. They start measuring the space time of one object say a cupboard in the room. They will measure exactly the same space time of the cupboard.

Now suppose one person starts moving, while the other one is still sitting. Now they will measure different space time of the same cupboard and will disagree on both space and time of the concerned object. There is a significant difference between one, say time measured by the two persons.

Why this thing happens? This is because of the fact that both space and time has to be measured in a relativistic manner. Both are dependent on the velocity of the object.

Proper Time: The proper time of an object is the time measured by one observer, when the observer is at rest.

In that case the 'space time' coordinate system used by the observer is absolute.

Reference Time: The reference time of an object is the time measured by one observer, when the observer is in motion.

In such a case the observer uses his own reference 'space time' coordinate system. Needless to say, this reference 'space time' coordinate system of the observer is related to his velocity.

Suppose point A is emitting LASER beam of light. An observer at B at rest receive the light after the elapse of 't' unit of time. When A starts sending the light, another observer from the same location of B starts moving in the direction making an angle of 90 deg. with AB. Suppose the second observer receives the light at point C and measure the time as 'T'.

If the velocity of light is assumed as 'c', then the three different distances are as below:

AB = ct
AC = cT
BC = VT

Thus

$$AC^2 = AB^2 = BC^2$$

$$(cT)^2 = (ct)^2 + (vT)^2$$

$$T = \frac{t}{\sqrt{1-\left(\frac{V}{c}\right)^2}} \quad \ldots\ldots\ldots\ldots\ldots (10)$$

In this case 't' is the proper time measured by first observer ,as this is measured by the observer at rest. But 'T' is the reference measured by the second observer since he is in motion with a velocity 'V'.

Note that for first observer, the proper time and measured reference time is same. (If we put V=0 in equation (5) we get T = t

For the second observer the proper time 't' and measured reference time 'T' differs because of his velocity 'V'.

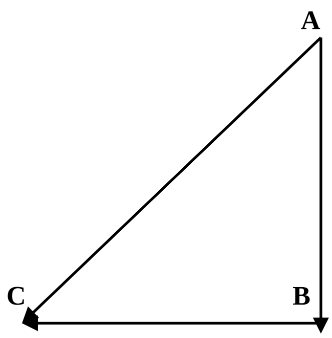


Fig. 8 Measurement of Proper and Reference time

XIV. MISUNDERSTANDING ABOUT A BLACK HOLE

A black hole is only dangerous and can absorb matter within its own domain or territory.

Suppose there is a gravitating black hole of mass M and a star of mass m and size b is passing away at a distance R.

The tidal force or force difference acting on the mass m of size b in the gravitational field of M is

$$\frac{GM}{R^2} * \frac{b}{R} = \frac{GMb}{R^3} \quad \ldots\ldots\ldots\ldots(11)$$

The self-gravity on the surface of the star produced by its own mass m is

$$\frac{Gm}{b^2}$$

The moment tidal force created by M exceeds self-gravity produced by m, the mass m will suffer tidal disruption, i.e. when

$$\frac{GMb}{R^3} > \frac{Gm}{b^2} \ldots\ldots\ldots\ldots(12)$$

$$R = \sqrt[3]{\frac{M}{m}} * b \quad \ldots\ldots\ldots\ldots(13)$$

Thus, if the star of mass m and size b comes closer to the black hole of mass M than the distance R it will be disrupted by tidal force.

So the gravity produced by a black hole only would have tremendous effect at some close distance from the black hole.

From that distance onwards (i.e. towards the black hole), the General Relativity of Einstein and not Newtonian Gravitation is applicable.

As for example, suppose a black hole is 1000 time more massive than a nearby star of size 500 km. Thus M/m =1000 and b = 500 km

$R = (1000)^{1/3} * 500 = 5000$km

So beyond the distance of 5000km. to the nearby star, the gravitating black hole is an ordinary mass (i.e. Newtonian Gravitation is applicable)

XV. ACCRETION AND COLLISION OF BLACK HOLES – APARENT VIOLATION OF SECOND LAW OF THERMODYNAMCIS

Classical law of gravitation contradicts 'non decreasing entropy'. Thus when two black holes are merged through collision or matter from nearby star is injected into the black hole, and then an outside observer determines the amount of entropy absorbed by the black hole is to increase according to classical theory. But in reality it is found to decrease, in the part of the world accessible to him, when the system is stable quite soon after the absorption. This means that the black hole as if has forgotten such 'details' as a result of merging or collision in the form of structure of the ingested body and its entropy.

If we still accept that the law of non-decreasing entropy for a black hole also, we also have to accept that that black hole itself possesses some entropy and the hot bold through accretion or colliding other black hole transfers its entropy S along with its mass, angular momentum and electrical charge as well. With this idea, the entropy of the entire system increases at least by 'S'.

When the black hole reaches an equilibrium or stationary state after completion of relaxation process, it is only described by 3 parameters – Mass 'M', Angular Momentum 'J' and finally Electrical Charge 'Q'.

Now we are finding the scope to describe Four Black Hole Thermodynamic Laws.

A. Zeroth Law:

The surface gravity k of a stationary black hole is constant everywhere on the surface of the event horizon.

This has the implication that thermodynamics will not allow the black hole to equilibrium state when different parts are at different temperatures.

Thus also, the surface gravity κ, the angular velocity Ω and the electric potential φ are always constant on the surface of the event horizon of a stationary or equilibrium black hole.

B. First Law:

When a black hole system switches from one stationary state to another, its mass change is given by:

$$dM = \Theta\, dS_H + \Omega\, dJ + \varphi\, dQ + \delta q \ldots\ldots\ldots\ldots(14)$$

dM = Change in mass M of the black hole

dS_H = Change in entropy S of the black hole

dJ = Change in angular momentum J of the black hole

dQ = Change in electrical charge Q of the black hole

δq = Contribution to the change in total mass due to change in stationary matter distribution outside the black hoe

According to the thermodynamic analogy, in black hole physics, the quantity

ϴ play the role of temperature and Ω, and φ are the angular velocity, and electric potential of the black hole.

C. Second Law:

In any classical process, the area of a black hole A and its entropy do not decrease in any way. i.e.

$$\Delta S_H \geq 0 \ldots\ldots\ldots\ldots(15)$$

From the above non decreasing nature of S_H, one can conclude that it is impossible to extract any information about the structure of the black hole.

Generalized Second Law:

Entropy SH is proportional to surface area A of the black hole:

$$S_H \propto A \ldots\ldots\ldots\ldots(16)$$

Now Hawking Radiation or quantum evaporation of the black hole reduces the area of the event horizon of the black hole. Thus, SH also decrease. But this is violating non-decreasing SH given by equation (2).

Now Hawking Radiation in black hole is thermal in nature. As the black hole evaporates due to radiation, there is an accompanying increase in entropy, **if we visualize the black hole globally along with its surrounding space.** Thus the total entropy of the entire system

$$S = S_H + S_M \ldots\ldots\ldots\ldots(17)$$

do not decrease.

This implies

$$S = S_H + S_M \ldots\ldots\ldots\ldots(18)$$

Thus as S_H decrease with the decrease of area A of the black hole due to thermal evaporation, there is a corresponding rise of Sm, thereby making the total S non decreasing.

D. Third Law:

There are different versions of third law. They are although conceptually identical. One most popular version is stated below:

As $\Theta \rightarrow 0$, the entropy of a system tends to an absolute constant zero (0).

A corollary of the above third law was formulated by Bardeen et. al (1973). It is as stated below:

It is impossible by any procedure, no matter how much idealized, to decrease the black hole temperature to zero, by any finite sequence of different operations.

XVI. ENTROPY OF A BLACK HOLE IS NON DECREASING DUE TO ACCRETION OR COLLIIONS WITH ANOTHER OBJECT

Now the first law of black hole thermodynamics tells that if nearby stars are accreting matter and is finally absorbed by the black hole or two black holes are colliding, the black hole switches from one stationary state (before accretion or collision) to another stationary state (after accretion or collision). The corresponding change in mass of the black hole is given by equation (1). The different components which contribute to change the mass dM is dS_H, dJ, dQ and δq. As mass is accreted or a second black hole collides or merges the mass of accreting star or black hole is absorbed in the form of increase in angular momentum J, electrical charge Q and the effective change in total mass q due to change in stationary matter distribution outside the black hole.

When matter from nearby star accretes into the black hole or one black hole merges with other,

1. Before Merging and Thermal Evaporation

$$S_H > 0 \text{ and } S_m = 0$$

2. After Merging and Before Thermal Evaporation

$$S_H < 0 \text{ and } S_m = 0$$

3. After Merging and Thermal Evaporation

$$S_H < 0 \text{ and } S_m > 0$$

Initially after merging and before thermal evaporation

$$S = S_H + S_m$$

is decreased, because Sm = 0;

This makes

$$S = S_H \leq 0$$

due to merging and before thermal equilibrium.

As during that time there is no thermal equilibrium, there is no contribution of radiation to the entropy – thereby there is no decrease of area of the black hole due to thermal evaporation.

So the question is after merging, why the entropy S_H is still decreased before and after equilibrium. (Note that the total entropy S increase after equilibrium but the entropy S_H, which is due to the geometry of space time of the black hole decreases and remains same before and after equilibrium).

S_H is not governed by thermal radiation and it remains decreased and constant before and after equilibrium of the black hole. It follows the general rule of entropy, that when two objects are merged the entropy is decreased. Whatever increase in entropy we see is the increase in S and is due to Sm and not due to S_H.

Now the question is what would happen to entropy **if we do not visualize the black hole globally along with its surrounding space.** Always the SH part of the entropy S of equation (4) decrease due to accretion or collision. We are justifying the non-violation of Second Law only by visualizing the black hole globally. But then we are making system having two different parts one the core black hole and other the surrounding radiating space – the system becomes impure.

It is possible to justify the non-violation of Second Law even if we consider the Black Hole excluding the surrounding radiating particles and space. The apparent decrease in S_H is actually an increase if we visualize the entropy from its actual position i.e. inside the event horizon of the black hole.

We have already discussed in previous sections, that the direction of flow of time is the direction of increase of entropy. It is conceptually equivalent to saying that the direction of flow of time is the direction of expansion of universe. But if the universe starts contracting after maximum expansion, the direction of flow of time is the direction of contraction of universe as well as in the direction of decrease of entropy.

Is it possible to actuate the contraction of universe? Yes, it is inside the event horizon of any black hole.

Inside the event horizon, every phenomenon is just the opposite in comparison to that outside. The space time is random, too much irregular and distorted. There the role of space and time is reversed. The space is unidirectional (1D) only targeting towards the singularity, while the time is 3D so that you can move back to past. The direction of flow of time is in the direction of contraction as well as in the direction of decrease of entropy.

Thus when we tell that there is a decrease of entropy $\mathbf{S_H}$ in equation (4), we are telling this from outside the event horizon of the black hole.

Thus when two black holes are merging or any nearby object accretes inside a black hole, from outside the event horizon of the resulting black hole we see that definitely the entropy $\mathbf{S_H}$ decrease.

We need not have to forcefully justify non decreasing entropy by considering the surrounding radiating space outside the black hole together with the black hole.

Simply visualize the change of entropy from inside the black hole event horizon. In that region time flows in the direction of decreasing entropy – unlike that outside the event horizon.

So if we visualize the change in entropy from inside the event horizon, the apparent decrease of entropy (from outside the event horizon) is actually an increase in entropy. So we can smoothly say that the Second Law of Black Hole Thermodynamics is still holds good justifying non decreasing entropy – while we need not have to consider the surrounding space radiation together with the black hole.

XVII. CONCLUSTION

The present paper discusses the concept and different definitions of time and relates time with entropy. Also it compares Newtonian Gravitation with General Relativity and proposes that the gravitation on the surface of any black hole is constant and is only related to the velocity of light in vacuum.

The main emphasis in this paper is to justify that when surrounding matter is accreted inside a black hole or two black hole merges together, it does not violate the Second Law of Thermodynamics – the entropy is still non decreasing. At the same time we need not have to revise the Second Law of Thermodynamics. If we see the change in entropy form outside the black hole event horizon, there is a decrease in entropy, while if it is visualized from inside the event horizon, there is definitely an increase in entropy. We need not take the help of surrounding space radiation of the black hole and formulate a revised version of Second Law of Black Hole Thermodynamics.

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