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STUDY OF THERMO-OPTICAL PROPERTIES OF BLACK HOLE RADIATIONS

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ABSTRACT :

Black holes have become very important part of the solar system. Although most of the properties of the black holes have been predicted theoretically and they have been verified by observation. However, new observations are always found out, which require proper theoretical support. This article is a step to describe some of the thermo optical properties of the black holes. The rotational spectra produced due to the gas which is sucked from the normal star and spirals towards the black hole event horizon has also been investigated .The elementary black holes produced during Hadrons collision and their properties have also been studied in this article.

KEYWORDS : *Black holes, thermo optical properties, elementary black holes.*

1. INTRODUCTION:

The black hole is a prominent member of the solar family found at the center of almost all the milky ways. It is difficult to say whether it is the cause of the birth of a solar system or it is one of the ultimate ends of the systems. Anything that crosses the boundary known as the event horizon becomes trapped due into it due to its enormous gravitational pull. There are various dimensions of explaining the concept of the black hole. One of the simple concepts is based on the principle of escape velocity. According to it if we consider a spherical body of mass M and radius R, then gravitational potential at the surface of the body is defined as : V = - $\frac{GM}{R}$ .Therefore the potential energy of a body of point mass m at the surface of the spherical body will be : = -V, m = $\frac{-GMm}{R}$ $joul$. Thus amount of energy required to separate the point mass m from M by infinity distance will be given by solving the equation:

$$\frac{1}{2}mv - \frac{GMm}{R} = 0 \quad \text{--1}$$

Where v is the velocity of the point mass m so that, it can go up to infinity distance from the surface of the spherical body . So, this equation gives the value of escape velocity v = $\sqrt{\frac{2GM}{R}}$. This velocity is called the escape velocity which depends on the mass and the size of the spherical body. If we consider the earth as the body of mass M and its radius R, then the escape velocity of the earth is:

$$V_{escape} = \sqrt{\frac{2GM}{R}} = 11200 \text{ meter /second} \quad \text{---}2$$

Since according to Einstein the velocity limit of a particle is :C = velocity of light = 3×10^{8} m/s.

So, if we propose a body which could never allow any particle to escape from its surface , not even the light ,then the value of escape velocity on the surface of this body would be equal to the velocity of light C where :

$$C^2 = 2GM/R \quad \text{---}3$$

$$\text{This gives} \quad \frac{M}{R} \geq \frac{C^2}{2G} = 6.75 \times 10^{26} \quad \text{---}4$$

Now if there is a body of mass M and whose volume is V , such that :

$$\frac{M}{\sqrt[3]{\frac{3V}{4\pi}}} \geq 6.75 \times 10^{26} \quad \text{---}5$$

Equation (4) or equation (5) represents the case of either tremendous mass of the body or extremely small size of the body such that even light particles cannot escape from the surface of the body ,then it is called the black body. This name is coined from the thermodynamics wherein the black body is that which absorbs the radiation of all visible ranges of spectrum. The black hole is the heaviest part of the Milky-Way. It is believed that when all the sources of nuclear fusion in a star are exhausted, the star dies and its dead body is the black hole. These black holes can swallow gas. They can modify the trajectories of nearby stars. They can also have a stable life close to a companion star. We can get the information about the black holes from their effects they render on the surrounding gas and stars. In the past few centuries the black hole physics has made many major breakthroughs in the field of astronomical sciences. Starting from Newton and Einstein, a large number of scientists working in this field have proposed their own theory to explain the observed phenomena in the galaxy, but still the black holes are a puzzle among the scientists. The Indian–American astrophysicist Subramanian Chandrasekhar first speculated in 1930 that the massive stars just cool down and collapse into something denser such as white dwarfs and neutron stars. In 1974, the British theoretical physicist Stephen Hawking discovered that quantum black holes are not as black as classical black holes. He applied quantum theory and found that the black holes can emit thermal radiations also.

The black holes are based on very simple theory to describe. Three parameters are sufficient to characterize them fully. These are mass, angular momentum and electric charge. Astrophysical black holes are even simpler. They have no charge. If they are formed from a rotating collapsing star or from the merger of two neutron stars they must have conserved their rotational energy. So, the black holes may be found in rotating state also. Moreover they can spin up due to their successive interactions. It was once thought that black holes do not emit any radiations, Stephen Hawking discovered that if quantum effects are taken into account, then it can be shown that the black holes can radiate thermal energy and particles. In this way the black hole may shrink until it evaporates. This effect is important for very tiny black holes, but astrophysical black holes are very massive and they would need a time much longer than the age of the Universe to evaporate.

2. ASPECTS OF BLACK HOLES:

The Black hole has several dimensions for their study. It makes the centre of rotations for all the astronomical bodies present in the solar systems.

2.1. Building block of a solar system:

First of all it may be taken as the basic building block of the evolution of the universe. Primordial black holes may have existed during the early stages of the Universe, a few moments after the Big Bang. At that time the temperature and pressure were of such a magnitude that they could have squeezed down to a singularity: however very few primordial black holes of about a billion tons of mass could have survived till date. The lighter black holes must have been evaporated. After the big bang the black hole came in existence first and then the other family members of the universe were formed which were revolving in various orbits about the black hole. So, every galaxy has a black hole around which every element of the Milky Way exists in their stationary orbits. If any how any one of the astronomical bodies breaks away its stationary orbit, it is engulfed by the black hole present at the centre of the galaxy. In this way we can say that the whole galaxy has its existence due to the presence of black hole.

2.2. Death state of a living star:

The death of a living srar is most commonly known as the stellar collapse. There is struggling between the gravity and pressure forces within the star throughout its whole life. Gravity wants to compress the star, while the radiation due to nuclear fusion wants to pushes the matter outwards. When anyhow the fuel of the star is exhausted, the star stops burning. If the mass of the star is not comparable to that of our own sun, it will become fainter. It will cool down as a white dwarf. However if its initial mass is about eight times greater than the Sun, it will collapse and it will bounce back and detonate in a supernova. in this way. Neutron stars are formed. And if the original mass of the star exceeds about 25 times the mass of the sun masses, then at the end nothing can counteract gravity and the whole mass is squeezed into a point of zero volume and infinite density. This point is called a singularity. The singularity is not naked rather it is surrounded by a boundary, called an event horizon. Hence what is left at the explosive end of the life of a very massive star is a singularity surrounded by an event horizon, which is called the black hole.

2.3. Rotational conjugate with other stars:

This is also the basis of Stellar-mass black holes. According to galactic evolutionary models a billion stellar-mass black holes exist in our galaxy. Their masses are estimated to be between three and twenty times that of solar masses. There are some black holes which are in isolated form while there are some black which are lying close to normal stars. Such coupling of black holes and star is called black hole X-ray binaries. Or they are called the micro quasars [1-3]. They emit a relativistic pair of jets. The bright X-ray emission takes place due to the gas which is sucked from the normal star and spirals towards the black hole's event horizon.

Super massive black holes: The core of many galaxies is exceedingly luminous of approximately all wavelengths. This most bright area around the black hole is called Active Galactic Nuclei (AGN). The AGN extend only over a few light minutes or light-days. They are less than one ten-millionth the size of their host galaxy. They are very much brighter than the whole galaxy. They are super massive black holes. They are not isolated rather they are located at the centre of galaxies. They attract the matter in their vicinity with their strong gravitational field. This fast attraction is termed as Accretion. The gas rotates towards the event horizon forming an accretion disc. While the gas spirals in, its energy is converted into heat and it starts to shine brightly. If a Part of the matter escapes off of being gulped down into the black hole are being carried away in two highly collimated radio jets that emerge close to the inner edge of the disc.

In the Milky way of our solar system there is not so much matter around the AGN, so the black hole is starving, so it is much less bright. This galaxy is less active [4]. The motion of the stars in its vicinity provides the best empirical evidence for the existence of a super massive black hole

2.4. Microscopic black holes:

The lightest black holes are called elementary black holes, because they are similar to the elementary particles. These microscopic black holes may be produced due to collisions of hydrogen or helium particles. With the start up of the Large Hadron Collider (LHC) these microscopic black holes received a lot of attention as they might be produced during particle collisions at the LHC. But they must have immediately disintegrated again, so they have no enough time to accrete matter and cause any macroscopic effects. Till date not a single theory has become capable enough to explain all the observed properties of the black holes. However, the thermal properties of the black holes most probably would be explained by applying the black hole thermodynamics [5,6]. The black hole mechanics is given in four parts known as four laws of black hole thermodynamics.

The zeroth law of black hole mechanics states that the surface gravity K of a stationary black hole is constant over its event horizon this is analogous to the zeroth law of thermodynamics according to which the temperature T of a system is constant when it is in thermal equilibrium with another system. The first law of black hole thermodynamics also obeys the conservation of energy of the black hole by relating the change in the black hole mass M to the changes in its area A, angular momentum J and electric charge Q . It can be expressed as:

$$\delta M = \frac{1}{8\pi} K \delta A + \Omega \delta J + \Phi \delta Q \quad \text{------------------------------6}$$

The first law of black hole thermodynamics implies that the surface gravity K, the angular velocity Ω and the electrostatic potential Φ all are constant over the event horizon of any stationary black hole. In this way we see that the first law of thermodynamics and the first law of black hole thermodynamics both are identical. The second law of black hole mechanics is also known as Hawking's area theorem [7]. According to it the area A of a black hole horizon cannot decrease. This is also similar to the second law of thermodynamics, which says the entropy S of a closed system cannot decrease. The third law of black hole mechanics states that the surface gravity K cannot be reduced to zero by any finite sequence of operations [8]. This is analogous to the Nernst theorem of law of thermodynamics. This is also called the third law of thermodynamics. It states that the absolute temperature T of a system cannot be reduced to absolute zero in a finite number of operations. Thus the four laws of black hole mechanics are similar to the four laws of thermodynamics. According to Bekenstein [9], the entropy of the black hole S is proportional to the event area A of the black hole. The temperature T is analogous to the black hole surface gravity K. Hawking made the remarkable discovery that black holes are not completely black but they also emit radiation [10, 11]. It was also found that the black hole radiation had a thermal spectrum. There upon Hawking realized that Bekenstein's idea is consistent and the black hole entropy is proportional to area of the event horizon. According to Hawking the black hole temperature is T = K. /(2π), and η =1/4. In his way we get the famous Bekenstein–Hawking formula for the entropy of a black hole:

$$S_{bh} = S_{BH} = \frac{A}{4} \quad \text{---7}$$

Here the subscript bh stands for 'black hole,' and the subscript BH stands for 'Bekenstein– Hawking. It was observed that the emission from a black hole persisted even when the black hole became effectively static. He pointed out on heuristic grounds that a rotating black hole should amplify certain waves and there should be an analogous quantum effect of spontaneous radiation of energy and angular momentum. Later Misner[12] and Starobinsky [13] confirmed the implication by a Kerr hole of scalar waves in the 'super radiant regime. It is the region where the angular velocity of the wave fronts is lower than that of the waves. Bekenstein showed that implication should occur for all kinds of waves with positive energy density[14]. The argument for this spontaneous radiation was that in a quantum analysis the amplification of wave is stimulated emission of quanta, so that even in the absence of incoming quanta one should get spontaneous emission by using the relation between the Einstein coefficients for spontaneous and stimulated emission. Hawking calculated that there is emission of thermal radiation from the black holes and this was verified by several scientists working in this field [15]. Kerr metric l gives not only the spontaneous but also the thermal emission also. Hawking [16] have calculated the density matrix of the emitted particles and found that it, as well as the expected number in each mode, is precisely thermal. The thermal emission from a black hole has been derived in a variety of ways by several people, so its prediction seems to be a clear on sequence of our present theories of quantum mechanics and general relativity.

3. CONCLUSION:

Black holes are perhaps the most highly thermal objects in the universe, though they are very cold for stellar mass black holes. Their phenomenological thermodynamic properties are very well understood, when they are stationary. However, most of the characteristics of their microscopic degrees of freedom are not well known. It may be assumed that black holes are like other information storage devices which keeps all the information about the universe extended around them. So , there are a lot to know about the black holes. There is need to study about where and how the microscopic degrees of freedom store the information. Therefore, although we have gained an enormous amount of information about black holes and their thermal properties in the past 30 years, it seems that there is even much more that we have yet to learn about the black holes.

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