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Survey on black hole

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ABSTRACT

A Black hole is a hole which absorbs everything and emits nothing, infects sunlight also never escape from the black hole's gravitational effect. According to the general theory of relativity, it is the result of the curving of space-time caused by being composed of dense mass. Surrounding a black hole there is a position of no return, called the event horizon. Stellar black holes are made when the center of the very big star falls in upon itself or collapses. When this happens, it causes a supernova. A supernova is a bursting star. Supernova blasts part of the star into the universe. When galaxy made, same time supermassive black holes were made. Surrounding the black hole nothing can return, this boundary known as the event horizon. It is known as "Black" because it absorbs all the light which hits on it, emit nothing, just like a perfect black body in thermodynamics. The name black hole is taken from the incidence happened in Calcutta. In the theory of quantum mechanics black holes have a temperature and according to this theory, it emits Hawking radiation, which makes them slowly get smaller.

Keywords— *Astronomy, Astrophysics, Physics, Quantum physics, Stephan Hawking theory*

1. INTRODUCTION

- The idea of a black hole first introduced by Joh Mitchell and Pierre-Simon Laplace.
- Einstein introduced the existence of black hole by his General theory of relativity
- John Wheeler gave the term Blackhole.
- Black holes are basically a large amount of matter which is packed into a tiny space.
- Associated with the huge gravitational field.
- Even light never escape the gravitational effect of a black hole.
- Black holes have never been observed directly as the light is not reflected in them.
- Precieved by observing their effects on nearby matter.
- Created by the death of a star.
- Gravity compresses the star when the star runs out of its nuclear fuel.
- The star starts to collapse under its own gravity field.
- The outer layer of the star explodes as a supernova while the center collapses inwardly. Then a black hole is created.
- The white dwarf is the stars like the sun after they have consumed their nuclear fuel.
- If the mass of any star is greater than the mass of the sun but less than or equal to three times the mass of our sun is known as Neutron Star.
- Greater than three suns→ Blackhole.

2. PARTS OF A BLACK HOLE

- **Event horizon:** The point of no return.
- **Singularity**: There is a gravitational singularity in the center of the black hole, a one-dimensional point which contains a huge mass in an infinitely small space, where density and gravity become infinite and there are space-time curves infinitely, and where the laws of physics as we know them to cease to operate.
- **Ergo sphere**: If a black hole is rotating, as it spins its mass cause space and time to rotate around it.
- **Schwarzchild radius**: Radius of event horizon at which the scale velocity of particle equals the speed of light.

3. TYPES OF BLACK HOLES

- **Miniature black holes**: event horizon as small as atomic particles; created during the big bang, compressed into the really small point that later explode and created massive explosions.
- **Supermassive black holes**: increases in size; gravitational force equal to a 10 billion suns.

4. WHITE HOLES

- Not yet proven to exist.
- An exact opposite of a black hole.
- It never absorbs materials in space, but only eject out materials.
- Chandrasekhar limited.
- The Chandrasekhar limitation is now accepted to be approximately 1.4 times the mass of the sun;
- Any white hole with less than this mass will stay a white dwarf forever, while a star that exceeds this mass is destined to end its life in that most violent of explosions: a supernova.

5. SPAGHETTIFICATION

- A theory as to what happens when a person is absorbed into a black hole.
- The gravity inside a black hole stretches your molecule so far that you become a thin piece of spaghetti, before completely disintegrating.
- Gravitational lens
- A gravitational lens is a distribution of matter (such as a cluster of galaxies) between a distant light source and an observer, it is capable of bending the light from the source as the light travels for the observer.
- Hawking paradox/information paradox.
- Black holes hungrily swallow everything.
- But information/mass never be created and never be destroyed.
- If what goes into a black hole is lost forever then conservation laws don't hold.
- Solution: conserved in a parallel universe

6. THE TUG OF GRAVITY

Albert Einstein said that all the laws of physics are the same for all non-accelerating observers and that the speed of light in a vacuum was independent of the motion of all observers. This theory is known as the special theory of relativity. It gave a new framework for all of physics and proposed new concepts of space and time.

After that Einstein spent 10 years trying to include acceleration in the theory and published his theory of general relativity in 1915. In this theory, Einstein said that massive objects cause a distortion in space-time, which is felt as gravity.

Two objects exert a force of attraction on each another known as "gravity." Sir Isaac Newton introduced the gravity between two objects when he formulated his three laws of motion. The force applying between two bodies depends on how massive each one is and how far apart the two lie. Infect the center of the Earth is pulling you toward it (keeping you firmly lodged on the ground), your center of mass is pulling back at the Earth. But the more massive body barely feels the tug from you, while with your much smaller mass you find yourself firmly rooted to that same force. Even Newton's laws assume that gravity is an innate force of an object that can act over a distance.

Albert Einstein, in his theory of special relativity, said that the laws of physics are the same for all non-accelerating observers, and he showed that the speed of light within a vacuum is the same and no matter the speed at which an observer travels. Because of this, he found that space and time were interwoven into a single continuum known as space-time. According to this theory events that occur at the same time for one observer could occur at different times for another.

Thus Einstein worked out the equations for his general theory of relativity, Einstein realized that massive objects caused a distortion in space-time. Imagine setting a large mass in the center of a trampoline. That body would press down into the fabric, causing it to dimple. Hence a marble rolled around the edge would spiral inward toward the body, pulled in much the same way that the gravity of a planet pulls at rocks in space.

7. EXPERIMENTAL EVIDENCE

Even instruments can neither see nor has measure space-time, several of the phenomena predicted by its warping been confirmed.
Gravitational lensing: Light surround a massive object, such as a black hole, is bent, causing it to act as a lens for the things that lie behind it. Astronomers routinely use this method to study stars and galaxies behind massive objects.

Einstein's Cross, a quasar in the Pegasus constellation, is a good example of gravitational lensing. The quasar is about 10 billion light-years from Earth and sits behind a galaxy that is 450 million light-years away. Four images of the quasar appear around the milky galaxy because the intense gravity of the galaxy bends the light coming from the quasar.

Gravitational lensing allows scientists to see some pretty cool things, but until recently, what they spotted around the lens has remained fairly static. Hence the light traveling around the lens takes a different path, each traveling over a different amount of time, scientists were able to observe a supernova occur four different times as it was enlarged by a massive galaxy.

One of another interesting observation, NASA's Kepler telescope spotted a dead star, known as a white dwarf, orbiting a red dwarf in a binary system. Although the white hole is more massive, it has a far smaller radius than its companion.

Avi Shporer of the California Institute of Technology introduced in a statement. That the technique is equivalent to spotting a flea on a light bulb 3,000 miles away, roughly the distance from Los Angeles to New York City"

Changes in the orbit of Mercury: The orbit of Mercury is shifting very gradually over time, due to the curvature of space-time around the mass of the sun. In a few billion years, it will happen to collide with Earth.

Gravitational redshift: The electromagnetic radiation of an object is stretched out slightly from a gravitational field. Think about the sound waves that emanate from a siren on an emergency vehicle; as the vehicle moves toward an observer, sound waves are compressed, but as it moves away, they are stretched out or redshirted. This effect is known as the Doppler Effect, the same phenomena occur with waves of light at all frequencies. In 1959, two scientist, Robert Pound, and Glen Rebka shot gamma-rays of radioactive iron up the side of a tower at Harvard University and found them to be minutely less than their natural frequency due to distortions caused by gravitational effect.

Gravitational waves: Violent events, such as the collision of two black bodies, are thought to be able to create ripples in space-time known as gravitational waves. In 2016, the Laser Interferometer Gravitational-Wave Observatory (LIGO) introduced that it found evidence of these tell-tale indicators.

In 2014, scientists introduced that they had detected gravitational waves left over from the Big Bang using the Background Imaging of Cosmic Extragalactic Polarization (BICEP2) telescope in Antarctica. It's thought that such gravitational waves are embedded in the cosmic microwave background. Hence further research revealed that their data was contaminated by dust in the line of sight.

Jan Tauber, the European Space Agency's project scientist for the Planck space mission to search for cosmic waves, said in a statement that searching for this unique record of the early universe is as tricky as it is exciting, LIGO introduced the first confirmed gravitational wave on September 14, 2015. The pair of instruments, based out of Louisiana and Washington, had recently been introduced and were in the process of being calibrated before they went online. The first detection was very large and, according to LIGO spokesperson Gabriela Gonzalez, it took the team several months of analyzation to convince themselves that it was a real signal and not a glitch.

LIGO said during at the 228 American Astronomical Society meeting in June 2016 that "We were very lucky on the first detection that it was so obvious". A second signal was founded on December 26 of the same year, and a third candidate was mentioned along with it. While the first two signals are almost definitively astrophysical—Gonzalez introduced that there was less than one part in a million of them being something else—the third candidate has only an 87 percent probability of being a gravitational wave.

Together, the two firm detections provide evidence for pairs of black body spiraling inward and colliding. As time passes, Gonzalez anticipates that more gravitational waves will be detected by LIGO and other upcoming instruments, and the one planned by India.

Gonzalez said that we can test general relativity, and general relativity has passed the test.

Black body: now we talk about mass and spin rotation of the black body. It regularly spins with very fast speed. Due to this spin rotation, its volume spread regularly just like pot maker instrument spin very fast and due to its spin pot matter spread in its volume and in round shape. But it spread only in a limited shape because its upper side shape takes a very thin form so it's some part of upper side break down and differ from it and pot matter again come in its small shape but if we include regularly pot matter inside its spin rotation then with the break down its part it spread in big volume with the help of pot matter included. Similarly in black holes, its volume spread with respect to its spin rotation and other matter included in due to its gravitation but its upper thin part break down again and again with its shape spread but its broken part can't go far away from it because of its gravitation and black body itself eat its broken part. This process continues in regular form. Due to this process, black body spread but with very low speed. If other matters don't come in the black body's effective area then the black body can't eat matter and it has to eat its broken part. One day it will happen that black body reduces itself and destroy it due to its higher gravity.

Now we discuss the temperature of black hole .we knows that according to Stephen Hawking mass of black hole anti-proportional to its temperature. And we know that the mass of a black hole is very greater so its temperature is very low and the black hole becomes cool.

He was definitely the greatest genius of our time. Stephen Hawking peered behind the curtain of reality and glimpsed the real workings of the universe. We inspired from him to pursue our curiosity, no matter the obstacles. Hence, his true legacy is his work. He made found contributions across physics from quantum theory to cosmology. Our tribute is to bring him the most famous discovery. He was Matt O'Dowd. This is "Time-Space." And that time for Hawking radiation. After Einstein introduced his great general theory of relativity in 1915, physicists realized that it allowed for the possibility of catastrophic gravitational collapse. In places of extreme density like the dead core of a massive star, time and space could be dragged inwards to create a hole in the universe, a boundary in spacetime called an event horizon that could be entered, but from beyond which nothing could return. Once introduced, there was nothing in theory or imagination that could bring material consumed back to the outside universe. These black body should exist forever, only growing, never shrinking, or so we thought, until 1974 when a young physicist named Stephen Hawking published a paper in "Nature" entitled black hole explosions. In that paper and in a follow-up 1975 paper, he attempted a new union of quantum mechanics and general relativity to show that black holes should not be so black after all. They must leak. They should admire what we now know as Hawking radiation. There's a popular explanation of how Hawking radiation works. It happened something like this. And Empty space seethes with activity. Those pairs of virtual particles, matter, and antimatter, spontaneously appear and then annihilate each other, briefly borrowing energy from the vacuum itself. But when this happens near a black body, sometimes, one of the pairs will be swallowed by the event horizon, leaving the other free to escape and taking its stolen energy with it. That energy never comes from anything. Thus the black hole itself pays the debt by slowly leaking away its mass. But how can accurate it? Even we follow the narrative of Hawking's original calculation, the story sounds rather different. We came a long way over the past few months, building up the knowledge we'll need to follow that calculation. Now take a deep dive into the quantum field theory of curved spacetime to glimpse the true nature of Hawking radiation. Hence, a quick QFT refresher can't hurt. Thus Space is filled with quantum fields. And they can oscillate with different frequencies, much like the many possible vibrational modes on a guitar string. Hence a particle is like a note on the string and like a real guitar note, real particles tend to be comprised of many vibrational modes. These underlying vibrational modes are still present in the absence of real particles. They fluctuate in energy because of quantum uncertainty. And these fluctuations give us what we think of as virtual particles. Hence don't take the existence of virtual particles too seriously. And they're really just a tool for calculating the infinite ways in which a fluctuating quantum field can behave. Another way that quantum fields are very different to guitar strings is they can have both positive and negative frequencies. And negative frequency can be thought of as a mode that travels backward in time and can be interpreted as corresponding to antimatter. And that's a whole level of weird all on its own, and we talk about it here. Hence when a quantum field is in a vacuum state, there's a balance between positive and negative frequency modes, which you can crudely think of as a balance between virtual matter and antimatter particles. Those all virtually annihilate or cancel out so that no real particles exist. These are all fine in flat space. On the other hand, the spatial curvature can mess with the balance of the underlying quantum field modes by introducing horizons. Hence horizons cut off access to certain modes of the quantum fields, disturbing the balance that defines the vacuum. Stephen Hawking said that black holes with their insane space-time curvature would wreak havoc on quantum fields in their vicinity. But they knew what would the effect be? For an answer that question properly, he would need a full union of general relativity and quantum mechanics, a theory of quantum gravity, a theory of everything. Hence it didn't exist then, and it doesn't exist yet. And not to be deterred by the impossible, Hawking came up with an ingenious workaround. The narrative of Hawking's mathematics happens something like this. Stephen imagined a single space-time path, a light speed trajectory called a null geodesic. And it extends from far in the past to far in the future. That was a perilous path. That passes through the location of a black hole in the instant before it forms. It is the very last trajectory to do so. It again emerges barely ahead of the forming event horizon. He imagined a simple quantum field tracing this path, a field that is in a perfect vacuum state before the formation of the black hole. On the other hand, he found that the close shave with the black hole disturbs the fundamental vibrational modes that define the fluctuations of the vacuum. And with the time this trajectory has found its way back out into flat space again, those fluctuations look like real particles. A distant future observer sees radiation coming from the black body. Hawking's imaginary path from the distant past to the distant future was excellent. It allowed him to compare the state of the vacuum in two regions of flat space far from the black body, regions where the nature of vacuums, quantum fields, and particles are perfectly well understood. But to understand the effect of the close encounter with the black body, he required an uneasy marriage of quantum mechanics and general relativity. Hence in the absence of a theory of quantum gravity, Hawking needed a hack and that hack was the Bogoliubov transformations. Said that three times fast. These can be used to approximate the effect of curved time-space on quantum fields by smoothly connecting regions of flat space. They introduced a sort of mixing of the positive and negative frequency vibrational modes that are caused by that curved space. The physical interpretation of this mixing via the Bogoliubov transformations is difficult. Thus, there isn't just one valid interpretation. Hawking's calculation observed scattering theory. Certain modes of the quantum field are scattered or deflected by the gravitational area of the forming black body. They have pocked off their narrow escape path, so are lost behind the forming event horizon. On the other hand, other modes avoid scattering and continue unscathed. With the loss of certain fundamental modes, the vacuum state must be designed from the remaining modes. That deformed vacuum looks like it's full of particles. The nature of the lost modes tells us what Hawking radiation looks like. The black hole tends to scatter modes with wavelengths same as to their own sizes and the quantum field that emerges is distorted in the same wavelength range. And so it produces wave packets. These wave packets produce particles that also have wavelengths about as large as the event horizon. So the more massive the black hole, the longer, and high frequency the wavelength of its radiation. Hawking calculated the frequency distribution of this radiation and found something excellent. It sure looked exactly like thermal radiation figure 1.

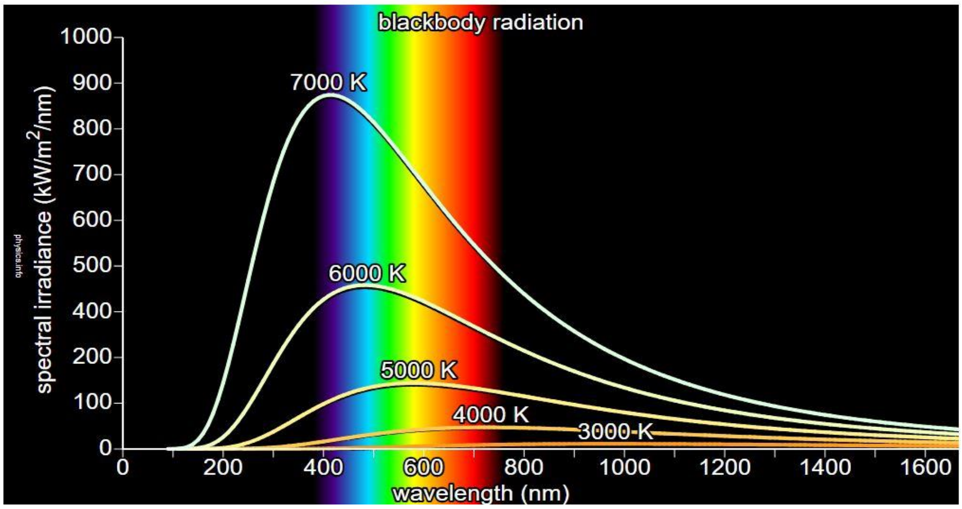

Fig. 1: **John Strutt, Lord Rayleigh, and James Jeans Ultraviolet Catastrophe**

A black body is an idealized object which absorbs and emits all frequencies. Classical physics can be used to derive an equation which describes the intensity of blackbody radiation as a function of frequency for a fixed temperature- the result is known as the

Rayleigh-Jeans law. Although the Rayleigh-Jeans law works for low frequencies, it diverges as f2; this divergence for high frequencies is called the ultraviolet catastrophe).reference site (https://physics.info/planck/)

The black body should have a heat glow with an apparent temperature that depends on their mass. Temperature is proportional to the surface area of the event horizon. Big black holes should appear cold, radiating excruciatingly slowly. But very small black holes should appear hot. The smallest should radiate explosively. For what about the whole picture of particle/antiparticle pairs being pulled apart by the event horizon? So for this Hawking's math describes splitting or mixing of these pure positive and negative frequency modes. It's very fair to interpret this mixing as the promotion of what were once virtual particles into reality and for the escaping modes, there exist a corresponding set of modes linked by quantum entanglement that is trapped behind the event horizon. We can interpret these as corresponding to the swallowed antiparticle partner. So the split matters/ antimatters a part of the picture is reasonable. But there is a reason to dismiss aspects of this picture. Firstly of all, this radiation is not localized. We should remember that Hawking radiation has wavelengths the size of the event horizon, the size of the entire black hole and these are the de Broglie wavelengths of created particles. And they told that there is an enormous quantum uncertainty in the location of these particles. Hawking radiation should appear to come from the global black hole. Never from specific points on the event horizon. In fact, an observer in freefall through the horizon can never see anything. For them, space is locally flat. The vacuum must look like a vacuum. This scattering of wavelength is visible only to distant observers. Well, there is one exception and when you turn on your jetpack and hover a fixed distance above the event horizon, then you do see particles. We would look at its relationship to Hawking radiation in the future. Radiations are mostly going to be photons and other massless particles. Particles come with mass, the energy of the radiation has to be high enough to cover the rest mass of the particle. So it’s to interpret the narrative of Hawking's calculation as the splitting of entangled matter and antimatter pairs, even if it really is just a heuristic interpretation. It's the cause of the splitting that's hard to pin down. And positive and negative frequency modes being mixed due to scattering, perhaps, by the as yet undiscovered graviton. Other scientists have derived Hawking's result with very different-seeming narratives. We know, in 2001, Parikh and Wilczek got the same thermal spectrum for Hawking radiation by thinking about particles escaping from beneath the event horizon through quantum tunneling. The common thread is quantum uncertainty. As we know, uncertainty in position or momentum can lead to particle pairs that we'll want in the same location or modes that we'll want on the same world line becoming separated by the event horizon. And, uncertainty in energy can lead to particle creation. You know, it's hard to avoid the conclusion that black holes emit particles. On the other hand, different derivations lead to exactly the same result or that the radiation looks thermal can't be by chance. Hence it's hard to make Hawking radiation go away in the math. And believe me- Stephen Hawking himself tried. And, these calculations are all hacks, albeit absolutely brilliant ones. But without a full quantum theory of gravity, the origin of Hawking radiation will remain mysterious. And there are other mysteries that we haven't touched on. Now we think what happens to the particles or modes trapped by the black hole? But how do they end up reducing the black hole's mass, instead of increasing it? After then there's the famous information paradox in which Hawking radiation appears to destroy what should be a conserved quantity-- quantum information. And we'll tackle all of these in future episodes. However, we must conclude that black holes radiate and in doing so evaporate. And the scariest monsters of general relativity are ultimately unraveled by the brilliant mind of Stephen Hawking and a mysterious quirk of quantum space-time.

8. CONCLUSION

Hence, Blackhole is a hole which absorbs everything and emits nothing. In fact, it absorbs light which is traveling close to it. A black hole has zero volume and has infinite density and infinite mass. Just because it has infinite mass, it has a very low temperature. Black hole continuously spins very fast and shrink itself. Actually at the center of a Blackhole are sources of the extreme amount of energy and it is responsible for some of the most luminous object in our universe and some pretty hefty beasts in our own Galaxy.The temperature of a Black hole is denoted by the “Radiation temperature” of the radiation which comes from it. The radiation coming from Blackhole is so weak and so cool that the temperature is only one ten-millionth of a degree above the absolute zero. This is colder than scientist could make things on earth up until just a few years ago.

A Black hole is a region of a spacetime exhibiting such strong gravitational effect that nothing hot even particle and electromagnetic radiation such as light can escape from inside it from the boundary event horizon “No escape is possible”. In many ways, a Blackhole acts like ideal black body, as it reflects no light. A black hole made by the death of big stars.

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