Black Hole: The Reverse of Sonoluminescence

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Abstract: ***Black holes and Sonoluminoscence have been independently studied but a study comparing both phenomena was yet to be accomplished. Here we study the similarities and differences between both the phenomenon by comparing the mechanism, the effects as a result of the phenomenon, the conditions for the phenomenon to take place, and a comprehensive hypothesis on the possibility of how both the phenomenons would react in the presence of each other. The research takes place to understand how Sonoluminsocence, a phenomenon that is widely associated to take place in a medium present on earth, would behave differently when placed in an area of gravity of a black hole. The subject Sonoluminscence is chosen because it is in some way the reverse of the phenomenon of Blackhole when taking into consideration the mechanism and also similar in the emission of light waves as a result of accelerating particles.***

Keywords: Black hole, Sonoluminosecne, Accelerating particles, Ultraviolet emission of Light, Mechanism of a black hole, Mechanism of Sonoluminosence

1. General Theory of Relativity

General relativity is the findings of Albert Einstein on how gravity affects the fabric of space-time. 10 years later in 1915, Einstein expanded the theory of special reality to argue that space and time are inextricably connected but his theory didn't acknowledge the existence of gravity until decades of research finally reviled that massive objects warp the fabric of space-time. this bend in space-time is gravity

Einstein observed that the classical gravitational field might be explained as the motion of objects - stars, planets, and even light - on the stretched and curved surface of space-time. While the notion may appear straightforward, the formulation of general relativity is difficult. One reason general relativity appears so strange to us is that its consequences are subtle from our point of view. They only come into play if you wish to make highly exact gravity measurements while traveling at near the speed of light or if you chance to be in a region of extreme gravity (like very, very close to a black hole).

100 years later, the general theory of reality still holds true. Recent breakthroughs in physics such as 'blading' black holes further make the theory stronger.

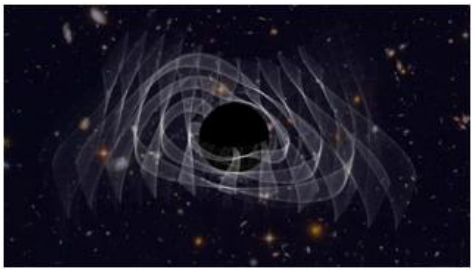

Figure 1: An illustration of a supersized black hole resulting from the merger of two smaller black holes. The collision has caused the black hole to ring and radiate gravitational waves (white)

Credit: Maximiliano Isi/MIT

2. Introduction to sonoluminescence

The phenomenon of single-bubble sonoluminescence occurs when an acoustically trapped and periodically driven gas bubble collapses, leading to light emission. The spectrum of the emitted light tends to peak in the ultraviolet and depends strongly on the type of gas dissolved in the liquid. There are a lot of factors such as liquid compressibility, heat conduction, EOS, surface tension, and the existence of shock-free picosecond pulse that affect sonoluminescence and its formation. Factors such as the type of gas dissolved in the liquid and trace amounts of noble gas change the amount of light emitted.

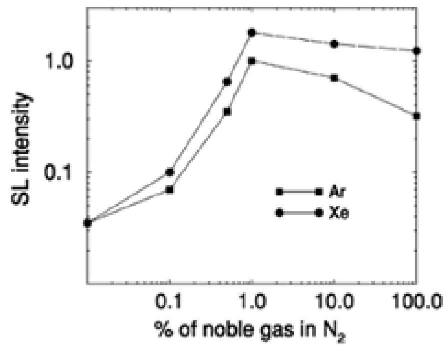

Figure 2: Comparison of air bubble radius vs time in one period with various RP equations, for R_0 =4.5 µm, f = 26.4 kHz, 0.0725 kg s^{-2}, and P_a1.275 atm.

Source: Physical parameters affecting sonoluminescence: A self-consistent hydrodynamic study,VOLUME 57, NUMBER 4

The current explanation for the phenomenon states that sonoluminescence occurs due to the enormous temperature and pressure at the time of the collapse, leading to partial ionization of the gas inside the bubble and thermal emissions such as bremsstrahlung. Shock waves inside the bubble do not play a prominent role in the process and can be rolled out.

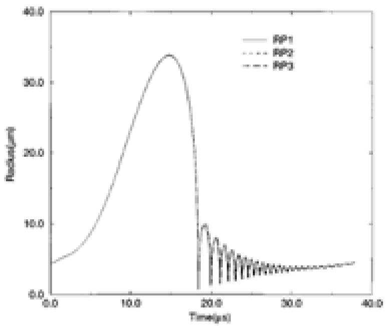

Figure 3: Graph showing the relation of the intensity of light produced by sonoluminescence due to the presence of noble gases.

Source: Single bubble sonoluminescence, reviews of modern physics

One way of finding the appropriate cavitation condition is by using high-intensity ultrasound, a spark discharge, a laser pulse, or following the liquid through a venturi tube. Spectral measurements show that SL originates mainly from the recombination of free radicals created within a bubble's high temperature and high-pressure environment undergoing adiabatic compression, as may happen during transient cavitation or highly non-linear but stable cavitation. This phenomenon is not likely to occur in carbonated liquid due to the high presence of dissolved gases like carbon dioxide. A common occurrence of this phenomenon occurs in a boat turbine as it moves through water and in a famous bottle cracking trick, where hitting the bottle from the top causes the bottle to crack. Anything travelling at superficial speed causes this phenomenon to occur, for example, a bullet through water, Mantis Shrimp's claws in water, etc.

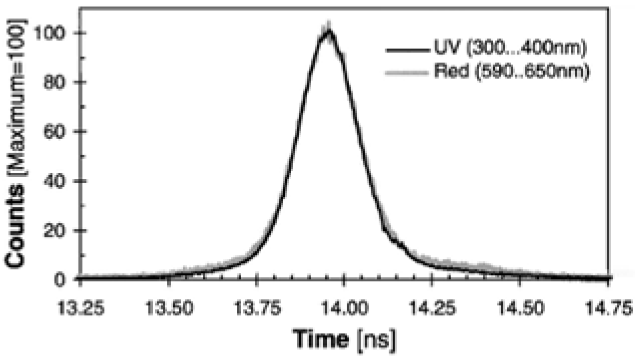

Figure 4: First measurement of SBSL pulse widths. The parameters were Pa51.2 bars, f520 kHz, and the gas concentration was 1.8-mg/l O2.
Source: Single bubble sonoluminescence, reviews of modern physics

Introduction to the mechanics of black hole

A black hole is a region in space-time where the gravitational field is so strong that not even light can escape. The bend in space-time is larger than that of a neutron star and way large than that of the sun. A black hole is formed when a supermassive star dies. When such a star has exhausted the internal thermonuclear fuels in its core at the end of its life and the core becomes unstable and gravitationally collapses upon itself. The mass of the star remnant compresses the star from all sides leading to the formation of a black hole. The role of gravitational charge is played by mass whose value is proportional to the total energy of the system. Hence, all objects with nonzero energy participate in gravitational interaction. Objects entering a black hole are subjected to very high gravitational forces which can cause intermolecular space to seize at infinity. The matter is losing space between the atoms and can be referred to as the "void of space.".

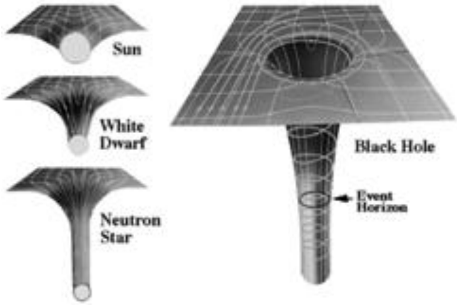

Figure 5: Bending of space-time fabric of black holes, neutron stars, white dwarfs, and the sun.
Source: physics stack exchange, Is space stretched with no limits by a black hole?

What happens to Matter as it enters the black hole

As matter enters the black hole, the sufficient mass of the matter will cause gravitational attraction within the matter itself to overcome all other forces and matter begins to collapse up to a point called a singularity. Singularity is the centre of the black hole; it has infinite mass and density. This region in space-time is distorted and nothing can escape it not even light. Blackhole gets its name from the fact that nothing escapes out and not even light. It's been difficult to study this phenomenon as the general laws of physics tend to not work as predicted.

In 1916, German astrophysicist Karl Schwarzschild derived an equation for the radius of a black hole. This Schwarzschild radius, also called the event horizon, is proportional to the mass of the black hole, M, and written as Rs = (1.48 x 10-27) times M. The radius here lets us find the distance of the event horizon from the singularity. It is at this point that everything that enters will fall into the black hole and the only way to overcome such high gravitational pull is by travelling faster than the speed of light which is impossible for something that has mass.

As matter comes close to the event horizon, it is affected by the gravitational pull of the black hole, and then as it falls and reaches even close, it becomes isolated from the rest of space-time. As matter enters the boundary of the event horizon, it has been practically accepted to have disappeared from the universe. The matter then on further descent into the black hole will be torn into subatomic particles and squeezed into the singularity. As more matter enters the black hole, the size of the event horizon also increases proportionally.

It was believed that everything that enters a black hole will never return, but Stephen Hawking in 1974 found out the Hawking radiation which predicted that the black hole could radiate energy away, but it does so in small quantities. This will take a lot of years, even a small black hole to evaporate will take a lot of time and is not possible to observe during the lifetime of a person.

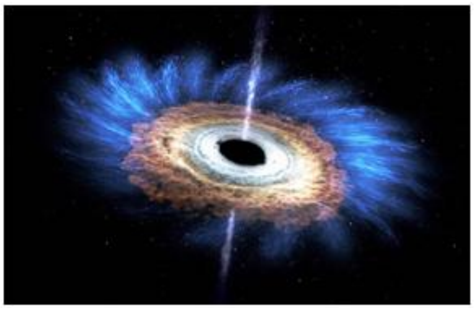

Figure 6
Source: NASA's Goddard Space Flight Cente

The general relation between the mechanism of black holes and sonoluminescence

Cavitation occurs due to the void in a liquid, and the collapse of this void is the reason for the phenomena of sonoluminescence. The matter is getting compressed as it falls into a black hole and loses its intermolecular space. If we look closely, we can see that what happens in sonoluminescence is the opposite of when matter falls into a black hole in terms of its mechanism.

Taking a closer look at the wavelength of the two phenomena, we can see both release light in the wavelength of about 400 nanometres (ultraviolet spectrum). As the matter falls toward the black hole, it gains energy and heats up, emitting ultraviolet light, X-rays, and gamma rays. For stellar black holes, this can happen if a black hole passes through a cloud of interstellar matter or" steals" matter from a close binary companion. Sonoluminescence also leads to the emission of ultraviolet light, and one of the reasons for Sonoluminescence to occur is the acceleration of a solid in a medium. This leads us to suggest a possible explanation for ultraviolet light emission as a result of accelerating matter radiating energy present in both phenomena.

Sonoluminescence in Black holes

The generalized explanation for both phenomena taught us that Ultraviolet emission is similar in both phenomena because of accelerating matter radiating energy and the difference in the mechanism of both phenomena.

One question we can ask is what will happen if Sonoluminescence takes place as it falls into a black hole under the right conditions.

Based on my study of both phenomena, we can possibly see the differences in both phenomena working against each other. Since the force of gravity of a black hole is far superior to the force of collapse of the void in sonoluminescence, the difference in the force acting in the opposite directional vectors will lead to one being cancelledcompletely (the force of gravity of black hole will overpower the force of collapse of Sonoluminescence). At a certain distance from a black hole, the net force could be 0 and at a greater distance, the force of sonoluminescence would be greater than that of a black hole. One thing to note is that Sonoluminescence is a one-time phenomenon that takes place over a concise period between 35 and a few hundred picoseconds while the gravitational effect of a black hole has a prolonged effect covering all areas under the influence of the gravity of the black hole. A possible observation we can note is a difference in the time duration of Sonoluminescence at different intervals as it falls into a black hole. Considering the general theory of relativity, it would be quite interesting to predict the effect of time and gravity at different distances from the black hole.

Another observation we can note is the effect of temperature and pressure increase as it falls leading to a possible greater force at which the collapse of the void in the matter occurs. Sonoluminescence thrives in such conditions.

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