Black holes mass density and definition of the maximum energy of stability for a particle

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1 Black holes average mass density and its relation with radiation temprature and radiation luminosity

A black hole is not getting considered as a whole singularity with infinite density. In the centre of a black hole is a gravitational singularity, a one-dimensional point which contains a huge mass in an infinitely small space, where density and gravity become infinite and space-time curves infinitely. Since the average density of a black hole inside its Schwarzschild radius is inversely proportional to the square of its mass, supermassive black holes are much less dense than stellar black holes (the average density of a $108M\odot$ black hole is comparable to that of water). Hawking radiation is blackbody radiation that is predicted to be released by black holes, due to quantum effects following a distance after the event horizon. This is getting considered as a form of radiation. From the radiation temprature and radiation luminosity we shall calculate the black hole's average mass density. The average mass density of a black hole is proportional to the temprature and luminosity of hawking's radiation, and is getting deduced by acceptance of the issues that:

Hawking radiation temperature:

$$T_H = \frac{\hbar c^3}{8\pi G M \kappa_B} \tag{1}$$

Bekenstein–Hawking luminosity:

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$$P = \frac{\hbar c^6}{15360\pi G^2 M^2} \tag{2}$$

Energy density is the amount of energy stored in a given system or region of space per unit volume. In fact U is the amount of the density of energy. $U = \frac{E}{V}$, where E is energy and V is the volume.

The average mass density, or more precisely, the average volumetric mass density, of a substance is its mass per unit volume that for a whole black hole is the average mass of the infinitely dense mass at the center in addition to the small mass of the surrounding area from the center to the event horizon per unit volume.

Therefore density is defined as mass divided by volume:
$\rho = \frac{m}{V}$, where ρ is the mass density and m is mass.
Since $V = \frac{E}{U}$ and $V = \frac{m}{\rho}$, therefore:

$$\rho = \frac{mU}{E} \tag{3}$$

For $V = \frac{4}{3}\pi r^3$, and $E = mc^2$, therefore:

$$\rho = \frac{U}{c^2}\square \tag{4}$$

$$\rho = \frac{E}{Vc^2}\square \tag{5}$$

and for every particle with a specific mass and a specific radious, the mass density is equal to:

$$\rho = \frac{3m}{4\pi r^3}\square \tag{6}$$

There is already an equation for the energy density asserts for a blackbody the total energy inside the box is thus given by $\frac{U}{V} = \frac{8\pi^5(\kappa_B T)^4}{15(\hbar c)^3}$. It follows the theory that a photon gas is a gas-like collection of photons, which has many of the same properties of a conventional gas like hydrogen or neon – including pressure, temperature, and entropy. The most common example of a photon gas in equilibrium is black body radiation.

And the deduced assertion here would be the average mass density of the black hole... From the equations (1) and (3) and (4) that $c^3 = \sqrt[\frac{3}{2}]{\frac{U}{\rho}}$ and (6), we can deduce:

$$\rho = \frac{U}{\sqrt[\frac{3}{2}]{\frac{T_H 8\pi G M \kappa_B}{\hbar}}}\square \tag{7}$$

and from (6) we have $M = \frac{4\rho\pi r^3}{3}$ and therefore:

$$\rho = \frac{3\hbar c^3}{32 T_H \pi^2 G \kappa_B r^3}\square \tag{8}$$

This also yields the average mass density of the black hole through the Bekenstein–Hawking luminosity (2), under the assumption of pure photon emission (no other particles are emitted) and under the assumption that the horizon is the radiating surface.

$$\rho = \frac{\sqrt[3]{U\hbar}}{15360P\pi G^2 M^2}\square \tag{9}$$

and following (2), and (6) that $M^2 = (\frac{4\rho\pi r^3}{3})^2$:

$$\rho = \frac{3c^3\sqrt{P\hbar}}{Gr^3\sqrt{245760\pi^3}}\square \tag{10}$$

2 Definition of an infinitely large mass at the center of black holes with an unknown amount of energy, and the maximum energy of stability for particles

Alike elementary particles that can hold a specific amount of energy, and when they gain a critical mass they do fission to release energy, there is a same thing for massive galaxies. Following some calculations we can determine the amount of energy that each particle can confine and hold inside itself is a constant number, but when a particle has a weak protective shell around itself it decays easier. The amount of energy per volume that the center of our galaxy can hold is the same as the amount of energy per volume that a small atom can hold. But a black hole has a strong protective shell that even the light cannot scape. Therefore it is possible that it may never have a critical energy density to get decay. It also decays through fission of the smallest forms of virtual particles such as bosons. Shells of a group of particles and matter may become (decayable) radioactive elements. But a single quantity of matter may become a radiative quantity, like a black hole or a micro black hole that lose mass through the Hawking radiation.

A stable atom in joles per m (qubic) can gain a maximum energy density of $U = \frac{3.47\times10^{-25}c^2}{5.23599\times10^{-43}} = 5.9561407303489884434462250691846 \times 10^{34} J/m^3$

For a radioactive atom in joles per m (qubic) we have $U = \frac{3.9\times10^{-25}c^2}{5.23599\times10^{-43}} = 6.6942215701328688557464477743464 \times 10^{34} J/m^3$

Ussually consideration of a protective shell for planetary systems and supernovas is useless (meanwhile it is existed in reality) since their mass and energy is usually smaller than the minimum energy for a system burst out particles (the Solar System has the Oort cloud as a protective shell and the Sun has no protective shell).

The energy density of the Sun is small, $U = \frac{1.9891\times10^{30}c^2}{1.4\times10^{27}} = 1.276853383677857142 85\times 10^{20} J/m^3$

The energy density of the Solar System is much smaller even, it is $U = \frac{1.0014M\odot c^2}{V_{Oort\ cloud}}$

A nuclei as a tiny particle has a weaker protective shell.

Since the mass of elementary particles is too small, we use eV for measuring the mass and therefore the energy density. It's energy density is big enough, $U = \frac{1(2300000.c^2)+2(4800000.c^2)}{1.13097\times10^{-46}} = 9.4564942022334809941908273429003 \times 10^{69}$

An atom as a larger particle has a stronger protective shell.

The energy density of the largest stable atom as we use eV for its mass unit could be as big as,$U = \frac{83Proton_{energy}+126Neutron_{energy}}{V_{nucleus}} = 3.3687685829476146058338537697742\times 10^{70}$

When the amount of energy increases the atom would get unstable.

Thus we may conclude that the energy density before the center of a galaxy (and not a solar system which is not capable to do such reaction) does fission to release energy could be: $U = \frac{mc^2}{\frac{4}{3}\pi r^3} \leq 7 \times 10^{34} J/m^3$.

Meanwhile the mass density (ρ) changes by an extremely low rate in the proposed status, at the moment just before the stellar fission burst of energy $\rho = \frac{U}{c^2}$ is too big, and there is a same thing for the mass density of sub-atomic elementary particles during nuclear decay.

References

[An Introduction to Black Holes, Information And... - L. Susskind, 2004.]