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Schwarzschild Energy Density of Superfluid Quantum Space and Mechanism of AGNs' Jets

Amrit S. Šorli [1,2]

[1] Bijective Physics Institute, Slovenia
[2] Scientific Research Centre Bistra, Slovenia

Štefan Čelan

Scientific Research Centre Bistra, Slovenia

Abstract

Active galactic nuclei (AGNs) are throwing in the interstellar space huge jets of energy in the form of elementary particles. The calculation of the energy density of space in the centre of the black hole with the mass of the Sun shows that in the space-time singularity of such a black hole energy density of space there is so low that atoms become unstable and fall apart in elementary particles. In this sense, AGN is a rejuvenating system of the universe. It transforms its own old matter into fresh energy in the form of jets.

Keywords: Space-time singularities; Energy density of quantum vacuum; AGN; Jets

1. Introduction

Several pieces of research suggest that superfluid quantum vacuum also named superfluid quantum space (SQS) is the physical origin of the universal space [1,2,3,4]. The idea of space-time as the fundamental arena of the universe is replaced by the idea that universal space is a type of energy that has superfluid properties. One of these superfluid properties is that every physical object is diminishing the Planck energy density ρ_{EP} of the superfluid quantum space which is the origin of the universal space in its centre exactly for the amount of its mass m and energy E:

$$E = mc^2 = (\rho_{EP} - \rho_{Ec})V \qquad (1),$$

where ρ_{Ec} is the energy density of the universal space in the centre of the physical object and V is the volume of the object [3]. The "no hair theorem" states that a black hole can be defined by three parameters: mass, electric charge, angular momentum [5]. Considering the variable energy density of universal space, we introduce a new parameter, the "minimal energy density of SQS in the centre of a black hole". By Eq. (1), we get:

$$\rho_{Ec} = \rho_{EP} - \frac{mc^2}{V} \qquad (2)$$

where ρ_{Ec} is the energy density of SQS in the centre of a black hole, m is the mass of the black hole and V is its volume.

2. Calculation of the "Schwarzschild energy density"

"Schwarzschild energy density" one can calculate using Eq. (2):

$$\rho_{E.Sch.} = \rho_{EP} - \frac{3m_{\odot}c^2}{4\pi r_{Sch.}^3},$$

where $m_{\odot}$ is the mass of the Sun, and its correspondent Schwarzschild radius $r_{Sch.}$ is $3 \cdot 10^3 m$.

$$\rho_{E.Sch.} = 4.64 \cdot 10^{113} Jm^{-3} - 1.58 \cdot 10^{36} Jm^{-3}.$$

When in the centre of the stellar object the value of energy density of SQS ρ_{Ec} is smaller as Schwarzschild energy density, the atoms in the centre become unstable and are falling apart into elementary particles:

$$\rho_{Ec} < \rho_{E.Sch.} \rightarrow atoms\ are\ unstable$$

The Schwarzschild energy density offers a new interpretation of space-time singularities in the centre of a black hole: "If, as seems justifiable, actual physical singularities in space-time are not to be permitted to occur, the conclusion would appear inescapable that inside such a collapsing object at least one of the following holds: (a) Negative local energy occurs. (b) Einstein's equations are violated. (c) The space-time manifold is incomplete. (d) The concept of space-time loses its meaning at very high curvature – possible because of quantum phenomena. In fact (a), (b), (c), (d) are somewhat interrelated, the distinction being partly one of attitude of mind" [6]. We suggest that space-time singularity in the centre of black hole indicate that in the centre of a black hole there are critical physical circumstances that we previously defined as "the energy density of SQS e is below the Schwarzschild energy density $\rho_{E.Sch.}$".

According to Newton's Shell theorem in space-time singularity, gravity force does not tend to the infinite value; it tends to zero. Going inside the black hole at the distance d from the surface towards the centre gravity force on a given object with mass m is diminishing regarding the gravity force on the surface according to the Eq. (3):

$$F_{g1} = \frac{mM_1G}{r_1} \qquad (3),$$

where m is the mass of a given object, M_1 is the mass of the black hole shell with the radius r_1, and G is gravitational constant. When r_1 is tending to the zero, M_1 is also tending to the zero, and gravity force F_{g1} is also tending to the zero:

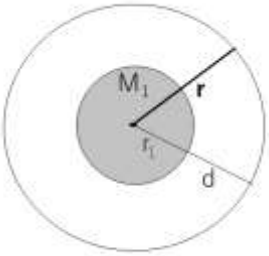

Figure1: Gravity force inside black hole

In the centre of the black hole, there is no gravity force. The extreme physical circumstance in the centre of the black hole is that the energy density of SQS there is below Schwarzschild energy density. This model is adding to the understanding of the interior of black holes which back in 2000 was still an open question: "We have confined ourselves in this paper to a specific example that relaxes the condition of asymptotic flatness while preserving time-symmetry. The starting point here is the static black hole in the Einstein universe which belongs to the family of solutions presented by Vaidya. In this spacetime the black hole is well defined as the Killing horizon. However, the nature of the interior of the black hole is not entirely clear" [7]. In our model black hole interior is well defined by the diminishing of the energy density of SQS that reaches its minimum in the centre of the black hole. There are no "physical singularities" in the black hole. The energy density of SQS in the centre reaches below the Schwarzschild energy density and this causes atoms are falling apart into elementary particles.

3. **Variable energy density of SQS at the distance d from the centre of the stellar objects**

The energy density of the universal space ρ_{Ed} at the distance d from the centre of a given stellar object with mass m and radius r is calculated using the equation below that is developed on the basis of the Eq. (2):

$$\rho_{Ed} = \rho_{EP} - \frac{3mc^2}{4\pi(r+d)^3} \qquad (4).$$

When d is zero, Eq. (4) is equal to the Eq. (2), when d tents towards the infinite, energy density ρ_{Ed} tends towards Planck energy density ρ_{EP}. We will use this

formula to calculate the energy density of SQS in the centre of different stellar objects, considering that these objects are non-rotating. In Table 1 there is the comparation of the energy densities of SQS in the centre of the black hole with the mass of the Sun, in the centre of the proton, in the centre of the Moon, Earth, and Sun:

Table 1. Comparation values of the minimal energy density of space with respect to the centre of indicated objects.

Centre of objects	$\rho_{EP} = 4.64 \cdot 10^{113} Jm^{-3}$
Black hole with mass of the Sun	$\rho_{EP} - 1.58 \cdot 10^{36} Jm^{-3}$
Proton	$\rho_{EP} - 5.45 \cdot 10^{34} Jm^{-3}$
Earth	$\rho_{EP} - 4.97 \cdot 10^{20} Jm^{-3}$
Moon	$\rho_{EP} - 3.01 \cdot 10^{20} Jm^{-3}$
Sun	$\rho_{EP} - 1.27 \cdot 10^{20} Jm^{-3}$

In the centre of a proton, the minimal energy density of SQS is for the order of 10^2 too high for the proton to become a mini black hole as proposed by Hawking [8]. Voyager did not discover mini black holes in interstellar space [9]. The energy density of SQS in the proton centre is lower than in the centre of Sun, Earth and Moon because these stellar objects are made out of atoms where there is a vast empty space between the nucleus and electrons orbits. Proton's mass is very small compared with the mass of the Sun, but it diminishes the energy density of an extremely small area of space compared with that of Sun, that diminishes the energy density of an extremely big area of universal space; that's why the gravity force of the Sun has such a long-range.

We will compare the energy density of SQS of a stationary black hole with the mass of the Sun and energy density of SQS of the Sun at given distances from the centre (Table 2).

Table 2. Comparation values of the minimal energy density of SQS with respect to the distance by centre of indicated objects.

Sun centre $\rho_{EP} - 1.27 \cdot 10^{20} Jm^{-3}$	**Black hole** centre $\rho_{EP} - 1.58 \cdot 10^{36} Jm^{-3}$
Distance from the centre	Distance from the centre
10^2 km $\rho_{EP} - 1.27 \cdot 10^{20} Jm^{-3}$	$10^2\ km$ $\rho_{EP} - 3.91 \cdot 10^{31} Jm^{-3}$
10^3 km $\rho_{EP} - 1.26 \cdot 10^{20} Jm^{-3}$	$10^3\ km$ $\rho_{EP} - 4.24 \cdot 10^{28} Jm^{-3}$
10^4 km $\rho_{EP} - 1.22 \cdot 10^{20} Jm^{-3}$	$10^4\ km$ $\rho_{EP} - 4.27 \cdot 10^{25} Jm^{-3}$
10^5 km $\rho_{EP} - 8.48 \cdot 10^{19} Jm^{-3}$	$10^5\ km$ $\rho_{EP} - 4.28 \cdot 10^{22} Jm^{-3}$

Table 2 (continued). Comparation values of the minimal energy density of SQS with respect to the distance by centre of indicated objects.

10^6 km	$\rho_{EP} - 8.77 \cdot 10^{18} Jm^{-3}$	10^6 km	$\rho_{EP} - 4.28 \cdot 10^{19} Jm^{-3}$
0.1 AU	$\rho_{EP} - 1.11 \cdot 10^{16} Jm^{-3}$	0.1 AU	$\rho_{EP} - 1.28 \cdot 10^{17} Jm^{-3}$
0.5 AU	$\rho_{EP} - 9.94 \cdot 10^{13} Jm^{-3}$	0.5 AU	$\rho_{EP} - 1.02 \cdot 10^{14} Jm^{-3}$
1 AU	$\rho_{EP} - 1{,}26 \cdot 10^{13} Jm^{-3}$	1 AU	$\rho_{EP} - 1.28 \cdot 10^{13} Jm^{-3}$
10 AU	$\rho_{EP} - 1{,}27 \cdot 10^{10} Jm^{-3}$	10 AU	$\rho_{EP} - 1.28 \cdot 10^{10} Jm^{-3}$

Going from the centre of the black hole, the energy density of the SQS is increasing at a much higher rate than going away from the centre of the Sun. At the distance of 1 AU from the centre of both stellar objects, the energy density of SQS is at the same rate comparing the Planck energy density and is increasing by the same values with the increase of the distance.

4. The quantum mechanism of AGNs' jets

In the centre of black holes, atoms are transforming back into elementary particles. This creates enormous pressure and if gravity pressure of the black hole is not big enough, such a black hole explodes in a supernova [10]. When the black hole gravity pressure is strong enough, as it is the case for example with the black hole in the quasar SMSSJ215728.21–360215.1 which has about $(3.4 \pm 0.6) \cdot 10^{10}\ M_{\odot}$ [11], the transformation of matter into elementary particles creates the explosion that opens the hole in the direction of the rotational axis (Figure 2).

Figure 2: Cross-section of a black hole in the centre of the quasar SMSSJ215728.21–360215.1

Through this hole, in the direction of rotation, the black hole is throwing a jet of elementary particles into the intergalactic SQS (Figure 2).

Figure 3: Jets of a black hole in the centre of a galaxy (with permission of Southern European observatory).

Centres of AGN's where energy density of SQS is lower than Sch. energy density are mechanisms where the matter falls apart into elementary particles and forms jests. We give in this article a solution to the mystery of jets production following Einstein's idea that matter can be transformed into energy and vice versa: "Relativistic magnetized jets from active galaxies are among the most powerful cosmic accelerators, but their particle acceleration mechanisms remain a mystery" [12]. These jets are building material for new stars formation; black holes are then rejuvenating systems of the universe: "old" matter is transformed into "fresh" energy in the form of AGNs jets.

5. Time and cosmology

In our model universe is non-created and eternal, black holes are rejuvenating the universe and keeping its entropy stable. The model of space-time is replaced by the model of time-invariant SQS where time is the duration of the universal change running in time-invariant SQS [13].

Research published back in 2018 also suggest that universe is a non-created system, it proposes "cyclic universe" where space-time has introverse and extroverse component: "The best way to discuss the CBE model is by using a language where the spacetime occupied by the universe is divided into two subregions denoted by introverse and extroverse respectively which we must define carefully because it will be the entanglement entropy between these two subregions which will play a central role in the cyclicity" [14]. In our view thinking that the universe evolves in some physical time should be re-examined in detail. We do not have any data that time is the 4th dimension of universal space; our research confirms universal changes run in time-invariant universal space where there is no physical past and there is no physical future. Understanding that time is the duration of changes enters into existence when measured by the observer is crucial for cosmology progress [13]. As Albert Einstein has told us: "People like us who believe in physics know that the distinction between past, present and future is only a stubbornly persistent illusion" [15].

The Big Bang cosmology where universe has started in some remote past and what was before is somehow beyond scientific comprehension has several unsolvable troubles that the scientific community needs to address in order to make progress in cosmology. Gurzadyan and Penrose have proposed a "conformal cyclic

cosmology" model where the universe is non-created and eternal [16]. Article published by Luiz Cesar Martini back in 2014 has proposed that before the hypothetical explosion universe already existed. He named it: "primitive universe" [17]. Luiz has introduced "Dimensional Continuous Space-time Theory" in the sense that space-time as the fundamental arena of the universe is a non-created continuous reality. He sees the universe existing in some physical time that occurs to us as non-existent. That universe is timeless is also proposed by Fiscaletti back in 2018: "The model of the 3D quantum vacuum which acts as a non-local, immediate information medium in ruling the behaviour of quantum matter as well as in the quantum gravity domain implies that universe is a timeless phenomenon where time is merely a mathematical parameter measuring numerical order of material changes and motions" [18].

The idea of timeless (time-invariant) universe suggests: the only universe that we have experimental proof of its existence is the universe we can observe and measure. All the rest is a hypothetical prediction. AGN's and their jets are strong experimental evidence that the universe is a self-creating system with no beginning and no end.

6. Conclusions

The law of energy conservation requires that AGN's jets must have some physical sources. It is shown in this article that these jets are originated in the process of matter falling apart in the centres of AGNs, where there are space-time singularities and energy density of SQS is below the Schwarzschild energy density.

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