The Revised Theory of Black Holes and Accretion Discs

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Abstract: Escaping information from black holes (BHs) produce firewalls at the event horizon. Such walls of fire absorb anything falling in black holes so they destroy them. It leads to conclusion that black hole understood as singularity with event horizon cannot be realized by Nature and that General Relativity (GR) and Quantum Physics (QP) are the incomplete theories. To solve the information paradox, Hawking proposes to replace the event horizon for apparent horizon i.e. for horizon widened due to quantum fluctuations in such a way that light can escape but there is lack of a mathematical description. Here, within the Scale-Symmetric Theory (SST), we solved the information paradox in a different way. The key to solve the many unsolved problems concerning black holes are the interactions of nuclear matter with the luminal Einstein spacetime both composed of the neutrino-antineutrino pairs (they dominate) and neutrinos (detection of the pairs is much difficult than neutrinos) - there appear the ordered virtual motions in spacetime, dark-matter structures and advection. Incompleteness of GR and QP causes that altogether with good solutions we obtain solutions that cannot be realized by Nature and singularities are such solutions. SST shows that there are objects with circular orbit for photons and abstract event horizon but without singularity - we will call such objects the modified black holes (MBHs). The RHIC experiment showed that inside baryons are dense gluon fields. On the other hand, the SST shows that intensity of the superluminal quantum entanglement (it follows from the extended GR) close to the Planck scale is tremendous so the cores of baryons are indestructible. It leads to conclusion that MBHs are built of modified neutron black holes (MNBHs) which are the biggest neutron stars. When we take into account also the gravitational interactions then matter winds around the central point of MBH at a continuously decreasing distance from the point, next spirals on surfaces of the MNBHs towards their poles, and next twists along the relativistic jet. Among many other things, we calculated maximum efficiency of accretion process (41.42%), radii of the accretion discs, described the mechanism of production of the dark-matter structures, gravitational redshift and answered why the luminal Einstein spacetime does not collapse to separated black holes.

1. Introduction

Existence of black holes (BHs) follows from General Relativity (GR). But escaping information (quantum physics (QP) says that information cannot be destroyed) produces firewalls at the event horizon. Such walls of fire absorb anything falling in black hole. It leads

to conclusion that black hole understood as singularity with event horizon is a science fiction and that the two leading theories, i.e. GR and QP, are the incomplete theories. To solve the information paradox, Hawking proposes to replace the event horizon for apparent horizon i.e. for horizon widened due to quantum fluctuations in such a way that light can escape but there is lack of a mathematical description [1].

Here, within the Scale-Symmetric Theory (SST), we solved in a different way the information paradox and we solved a few unsolved problems such as, for example, why there are produced relativistic jets along polar axes, why maximum efficiency of accretion process is 41.42 %, what is the mechanism for angular-momentum redistribution, why accretion disc cannot transform into a torus, what determines radii of the accretion discs, why the continuum spectrum is partially non-thermal, what is density and what are the radial and angular velocities of matter, what is pressure, why the luminal Einstein spacetime does not collapse to separated black holes, where is energy emitted by photons due to the gravitational redshift (is it non-local?), what is the mechanism of production of the dark-matter structures and how such structures interact with matter, what is internal structure of a black hole, and so on.

The key to solve the listed problems are the interactions of nuclear matter with the luminal Einstein spacetime both composed of the neutrino-antineutrino pairs (they dominate) and neutrinos (detection of the pairs is much difficult than neutrinos) – there appear the ordered virtual motions in spacetime, dark-matter structures and advection.

Our intuition tells us that existence of singularities, i.e. sizeless points with infinite gravitational-mass density, follows from incompleteness of GR and QP. It causes that altogether with good solutions we obtain solutions that cannot be realized by Nature and singularities are such solutions. SST shows that there are objects with circular orbit for photons and abstract event horizon but without singularity – we will call such objects the modified black holes (MBHs). The RHIC experiment showed that inside baryons are dense gluon fields [2]. On the other hand, the SST shows that intensity of the superluminal quantum entanglement (it follows from the extended GR) close to the Planck scale is tremendous so destruction of the cores of baryons due to gravitational collapse is impossible. It leads to conclusion that the MBHs can be built of modified neutron black holes (MNBHs) which are the biggest neutron stars. When we take into account also the gravitational interactions then matter winds around the central point of MBH at a continuously decreasing distance from the point, next spirals on surfaces of the MNBHs towards their poles, and next moves spirally along the virtual luminal jets which has a shape of a tube.

The extended General Relativity (GR) leads to the Higgs field composed of non-gravitating tachyons [3A], [4]. The succeeding phase transitions of the superluminal Higgs field described within the Scale-Symmetric Theory (SST) show that during the inflation a part of this field transformed into the luminal Einstein spacetime composed of the neutrino-antineutrino pairs which are the lightest principle-of-equivalence bosons carrying unitary spin [3A], [3B]. The luminal gravitating Einstein-spacetime components are built of the superluminal entanglons responsible for quantum entanglement. All principle-of-equivalence particles consist of confined (due to the Mexican-hat mechanism [3A], [5]) or/and entangled the neutrino-antineutrino pairs and neutrinos [3A]. Within the SST we described mathematically how neutrinos acquire their mass [3A]. Today, i.e. after the inflation, due to the inner, superluminal, non-gravitating, tremendous energy frozen inside neutrinos they are the indestructible particles [3A]. Their oscillations do not follow from some changes in their internal structure – they follow from the exchanges of the free neutrinos for neutrinos in the neutrino-antineutrino pairs the luminal Einstein spacetime consists of or from decays of the unstable tau-neutrinos which are built of three different stable neutrinos (only the electron-neutrinos, muon-neutrinos and their antiparticles are the stable neutrinos) [3A].

Due to the four succeeding phase transitions of the Higgs field, there are in existence the five scales i.e. the superluminal Higgs-field scale directly associated with the gravitational fields, superluminal-quantum-entanglement scale, luminal Planck scale concerning the Einstein-spacetime components and neutrinos, electric-charges scale and cosmological scale [3A]. The main part of the SST leads to internal structures of bare objects and to the origin of the physical constants [3A]. The phenomena characteristic for the electric-charges scale lead to the structure of the core of baryons and next to the atom-like structure of baryons [3A].

2. Why in our Cosmos a gravitational collapse of the cores of baryons is impossible?

Emphasize that within the model of nucleons presented within the SST we calculated with very high precision their masses, spins, charges, magnetic moments, mean square charges, and so on [3A], (http://vixra.org/author/sylwester_kornowski). Obtained results are consistent or very close to experimental data.

Core of a baryon consists of the torus and central condensate which is the modified black hole with respect of the nuclear weak interactions. The neutrino-antineutrino pairs in the condensate interact both gravitationally and due to the Mexican-hat mechanism [5]. Mean distance between the pairs in the condensate is about $L_{Condensate} = 3.926 \cdot 10^{-32}$ m ($R_{neutrino} = 1.11846 \cdot 10^{-35}$ m) [3A]. The surface of the torus consists as well of the neutrino-antineutrino pairs with the side of the grid equal to $L_{Torus} = 0.70826 \cdot 10^{-34}$ m [3A]. This is due to the shortest-distance superluminal quantum entanglement. The core of baryons as a whole is the modified black hole with respect of the nuclear strong interactions [3A].

The quantum entanglement is tremendously strong when distance between the neutrino-antineutrino pairs is L_{Torus} (or $L_{Torus}/3$) [3A], – the coupling constant is $\alpha_{Entanglement} = 3.1 \cdot 10^{92}$ [3A]. Now we can calculate the intensity $\gamma_{Ent,2\pi R}$ for the $L_{Condensate}$ quantum entanglement

$$\gamma_{Ent,2\pi R} = \alpha_{Entanglement}\, v_{entanglon}\, \hbar / [L_{Torus}^{2}\, m_{entanglon(luminal\text{-}equivalence)}] \approx$$

$$\approx 1.7 \cdot 10^{162}\ [\mathrm{N/kg} = \mathrm{m/s^2}], \qquad (1)$$

where

$v_{entanglon} = v_{close\text{-}string} = 0.72693 \cdot 10^{68}$ m/s, and

$m_{entanglon(luminal\text{-}equivalence)} = 2\, m_{close\text{-}string}\, (v_{entanglon} / c)^2 = 2.7517 \cdot 10^{32}$ kg [3A].

We can compare the obtained value with the acceleration due to gravity near the surface of the Earth – it is about 10^1 m/s^2. The tremendously strong L_{Torus} quantum entanglement stabilizes the mean distance between the interacting neutrino-antineutrino pairs i.e. for this distance there appears tremendously deep vertical potential well so cores of baryons are indestructible. Just most dense nuclear plasma consists of the cores of baryons packed to maximum. It causes that collapse of neutron star to a singularity is impossible. In centres of neutron stars there is very small region occupied by the densest nuclear plasma. It causes that there should be in existence the modified gravitational black holes (MBHs) composed of modified neutron black holes (MNBHs) and neutron stars i.e. structure of the MBHs is grainy. There are not in existence black holes containing singularity.

3. What is mass of the modified neutron black holes (MNBHs)?

The SST shows that in the nuclear strong fields, i.e. in fields having internal helicity, the rotating luminal neutrino-antineutrino pairs behave as gluons (there are 8 types of gluons) whereas in the electromagnetic and/or gravitational fields, i.e. in fields that have not internal

helicity, the rotating neutrino-antineutrino pairs behave as photons (there is 1 type of photons) [3A]. We can say that the neutrino-antineutrino pairs are the carriers of gluons and photons. SST shows that gravitational mass of the neutrino-antineutrino pairs is $M_{Neutrino\text{-}pair} \approx 6.67 \cdot 10^{-67}$ kg [3A] so emitted neutrino-antineutrino pairs carry away gravitational mass and the potential gravitational energy.

Mass of collapsing to singularity a neutron star calculated within the mainstream theories is incorrect. Neutron stars behave as liquid crystal. There are the flat structures and the elongated rectangular prisms. The flat structures in such liquid crystal are the squares with neutrons in their vertices whereas the elongated rectangular prisms consist of parallel neutron squares (they are the analogs to the structures in the atomic nuclei – such model leads to the nuclear binding energies of atomic nuclei consistent with experimental data [7]). In the neutron stars there is a lattice with mean side equal to $(A + 4B) / sqrt(2)$, where $A + 4B = 2.7048$ fm is the radius of the last shell for the strong interactions in nucleons that follows from the atom-like structure of baryons [3A].

Calculate the mass of modified neutron black hole i.e. the upper limit for mass of neutron star. On the equator of such a black hole, the neutrons are moving with a speed close to the speed of light in "vacuum", c, but such an object is a sphere because inside it the Einstein spacetime rotates with the same angular velocity as the modified neutron black hole – we will prove it in details later – it follows from the fact that inside baryons are parts that mass density is much higher than the mass density of the Einstein spacetime [3A] (surface density of the torus/charge in the core of baryons is about 300,000 times higher than a plane in the Einstein spacetime) so the interactions between the tori and spacetime (due to the quantum entanglement) cause that the zonal velocities are the same. It means that the modified neutron black hole is in the rest in relation to the Einstein spacetime so the neutrons in the very fast rotating MNBH have the rest mass only. The nucleons in such an object are placed in vertices of cubes and the lattice constant is equal to $a_L = (A + 4B) / 2^{1/2}$ [3B]. Binding energies of the neutrons are confined inside neutron stars so we can neglect them in the calculations.

The radius of the MNBH is r_{MNBH} and the mass m_{MNBH} that satisfies the following formula:

$$r_{MNBH} = G\, m_{MNBH} / c^2. \tag{2}$$

If N_1 denotes the number of neutrons in such modified neutron black hole then

$$4\, \pi\, r_{MNBH}{}^3 / 3 = N_1\, a_L{}^3, \tag{3}$$

and

$$m_{MNBH} = N_1\, m_{neutron}. \tag{4}$$

Solving the set of formulae (2)-(4) we get
$N_1 = 2.946 \cdot 10^{58}$,
$m_{MNBH} = 4.935 \cdot 10^{31}$ kg i.e. about 24.81 solar masses,
$r_{MNBH} = 3.664 \cdot 10^{4}$ m i.e. 36.64 km.

The mass density of the modified neutron black hole, ρ_{MNBH}, is

$$\rho_{MNBH} = m_{neutron} / [(A + 4B) / 2^{1/2}]^{\,3} = 2.394 \cdot 10^{17}\ \text{kg/m}^3. \tag{5}$$

More massive MBHs consist of the MNBHs.

4. The key to solve the problems concerning modified black holes are the interactions of nuclear matter with the luminal Einstein spacetime both composed of the neutrino-antineutrino pairs (they dominate) and neutrinos

Most important is the fact that the dynamic pressure of the luminal gravitating Einstein spacetime is tremendous: $p_{Dyn,E.spacetime} = \rho_E \, c^2 \, / \, 2 = 0.4953 \cdot 10^{45}$ Pa, where $\rho_E = 1.1022005 \cdot 10^{28}$ kg/m^3 [3A]. It causes that the repulsive force acting on a neutrino-antineutrino pair in the luminal spacetime near or inside a modified black hole, due to the dynamic pressure, is much higher than gravitational attraction by the MBH. It leads to conclusion that mass density of the ground state of the Einstein spacetime is invariant and can be changed locally only via some interactions stronger than the gravitational interactions such as the interactions that follow from the quantum entanglement for the two shortest distances, or that results from the Mexican-hat mechanism or ordered motions of the neutrino-antineutrino pairs (we will call them the virtual motions) that decrease the local dynamic pressure defined by the chaotic motions of the neutrino-antineutrino pairs in the Einstein spacetime.

The gluons and photons are the rotational energies of the Einstein-spacetime components which carry them. We can see that the ground state of the Einstein spacetime consists of the zero-rotational-energy carriers of gluons and photons i.e. the ground state of the luminal spacetime consists of zero-energy gluons and photons – they are the non-rotating-spin neutrino-antineutrino pairs. The mean distance between such pairs in the luminal spacetime causes that they interact gravitationally only. Now we will prove that dynamic viscosity of the Einstein spacetime that follows from the gravitational interactions of the components can be neglected.

The SST shows that a neutrino-antineutrino pair in the Einstein spacetime occupies a cube with mean side equal to $L_{E.spacetime} = 3510.2121 \; R_{Neutrino} \approx 3.926 \cdot 10^{-32}$ m, [3A]. Calculate the mean intensity of the gravitational interactions between two adjacent neutrino-antineutrino pairs, $\gamma_{Grav,E.spacetime}$

$$\gamma_{Grav,E.spacetime} = G \, M_{Neutrino\text{-}pair} \, / \, L_{E.spacetime}^{\,2} \approx 5.8 \cdot 10^{-14} \, [\mathrm{N/kg = m/s^2}]. \qquad (6)$$

Calculate the dynamic viscosity that follows from such gravitational interactions, $\eta_{Grav,E.spacetime}$

$$\eta_{Grav,E.spacetime} = \gamma_{Grav,E.spacetime} \, M_{Neutrino\text{-}pair} \, / \, (L_{E.spacetime} \, c) \approx 3.3 \cdot 10^{-57} \, \mathrm{kg/(m\ s)}. \qquad (7)$$

This value is very small so we indeed can neglect the dynamic viscosity of the Einstein spacetime resulting from gravitational interactions of its components.

Calculate now dynamic viscosity that results from the shortest-distances quantum entanglement

$$\eta_{S.entanglement} = \alpha_{Entanglement} \, \hbar \, / \, L_{Torus}^{\,3} \approx 0.92 \cdot 10^{161} \, \mathrm{kg/(m\ s)}. \qquad (8)$$

This value is tremendous so the shortest-distances quantum entanglement is the main interaction of matter with luminal spacetime that can create the ordered virtual flows in the Einstein spacetime. Emphasize also once more that the condensates in centres of the cores of baryons are the modified black holes with respect of the weak interactions which follow from

the Mexican-hat mechanism so the condensates as well can create the ordered virtual motions in the Einstein spacetime when the nuclear matter is moving.

Notice as well that intensity of interactions of nuclear matter with luminal spacetime increases with increasing mass density of the nuclear matter and is highest for most dense nuclear matter i.e. when the tori in the centres of baryons are packed to maximum. Calculate the maximum rest mass density of nuclear plasma. The rest mass of the baryonic core is $M_{Core} = 727.44$ MeV whereas the radius of the torus is $A = 0.6974425$ fm and its height is $2A/3$ [3A]. The maximum rest mass density of nuclear plasma is

$$\rho_{NP,max} = 3\, M_{Core} / (2\, \pi\, A^3) = 1.825 \cdot 10^{18} \text{ kg/m}^3. \tag{9}$$

But due to the relativistic effects, the mass density of nuclear plasma can be much higher – then such plasma produces additional condensates and the core-anticore pairs so the intensity of matter-spacetime interactions is higher. The SST shows that the maximum intensity of matter-spacetime interactions is for energy of nucleon equal to 17.1 TeV – then density of nuclear plasma is close to the density of the Einstein spacetime so speed that follows from advection is very close to the speed of light in "vacuum", c, i.e. the velocities of nuclear plasma and the virtual flows in the Einstein spacetime are the same. Notice that due to the advection, the virtual flows force motions of very dense nuclear plasma, whereas the motions of very dense nuclear plasma produce virtual flows in the Einstein spacetime.

Moreover, rotating nuclear plasma can create the dark-matter structures i.e. concentric circles composed of entangled Einstein-spacetime components. Weak interactions of, for example, stars in rotating spiral galaxies with such dark-matter structures lead to the observed velocities of stars inconsistent with theory of gravitational interactions. Calculated within the SST such velocities are consistent with observational facts [8]. The obtained formula looks as follows

$$v_{Advection,stars} = c\, (2\, \alpha_{Weak(electron\text{-}muon)}\ M_{Galaxy,visible} / M_o)^{1/2}, \tag{10}$$

where $\alpha_{Weak(electron\text{-}muon)} = 9.511082 \cdot 10^{-7}$ [3A] whereas $m_o \approx 8.5 \cdot 10^{11}\ M_{Sun}$ is the upper limit for mass of barred spiral galaxy. For nuclear densities, as it is in MNBHs, we must modify formula (10) i.e. the coupling constant for weak interactions via leptons must be replaced by the coupling constant for nuclear weak interactions $\alpha_{Weak(proton)} = 0.0187229$ [3A]. On the other hand, the typical mass of MNBH is equal to its "visible" mass so formula (10) for interactions of the dark-matter structures with nuclear matter looks as follows

$$v_{Advection,nuclear\text{-}plasma} = c\, (2\, \alpha_{Weak(proton)})^{1/2} \approx 58{,}000 \text{ km/s}. \tag{11}$$

Such spin speed, due to the weak interaction of the dark-matter structures with nuclear matter, has nuclear plasma in the accretion disc or in the relativistic jet near MNBH but emphasize that nuclear plasma on surfaces of the MNBHs a MBH consists of is moving with velocities close to the c.

Consider the motions inside and on surface of a MNBH.

Motions of the Einstein-spacetime components inside the MNBH are forced by constancy of the speed of light, c, and by interactions of the luminal Einstein spacetime with the very dense fields in the cores of baryons i.e. with the tori and the condensates. Most dense plasma is on surface of MNBH so on the equator, the zonal speed of the Einstein-spacetime components is equal to c. The zonal speed of plasma on the poles is equal to zero so from the constancy of c

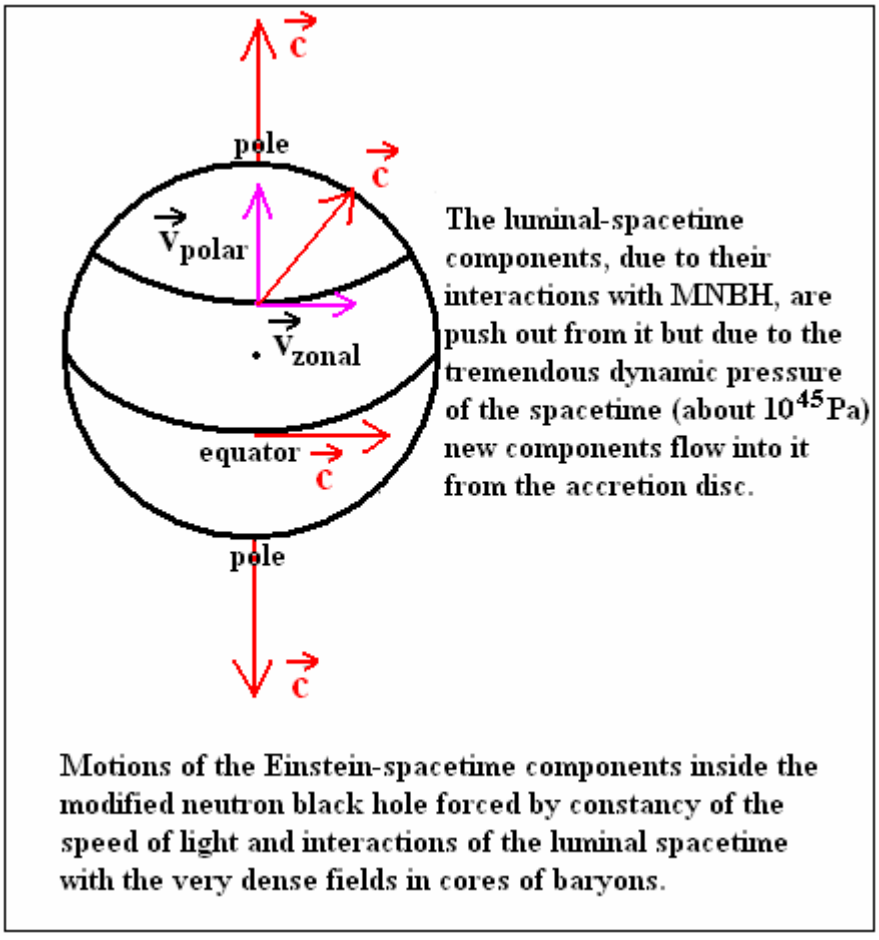
follows that on poles, the Einstein-spacetime components are moving with the speed c along the axis of rotation so there are produced the virtual jets. The ordered motions in the virtual jets decrease the dynamic pressure in the Einstein spacetime so the Einstein-spacetime components leaving the rotating MNBH at lower latitudes twist around the central part of the virtual jet. Each MNBH in a MBH produces such jet (the component jets are parallel) i.e. the cross-section of the resultant jet is close to the equatorial cross-section of the MBH

$$\pi R_{Jet,MBH}^{2} = \pi (G N M_{MNBH} / c^{2})^{2}, \tag{12}$$

where N is the number on the modified neutron black holes in a modified black hole.

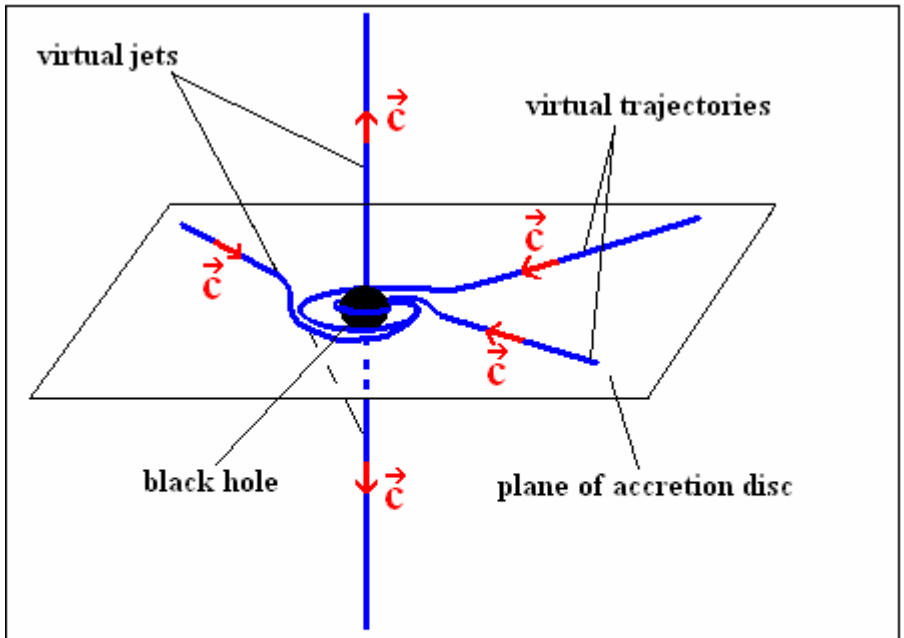
Emphasize that a jet of MBH is a set of component jets produced by MNBHs. Particles moving along the central parts of the component jets can be the extreme-energy cosmic rays because then their energy is not scattered. When distances from a MBH are bigger then matter is carried by the twisting virtual flows due to the advection which follows from the weak interactions.

The luminal-spacetime components, due to their interactions with MNBH, are push out from MNBH but due to the tremendous dynamic pressure of the spacetime (about 10^{45} Pa) new components flow into MNBH especially from the accretion disc of MBH.

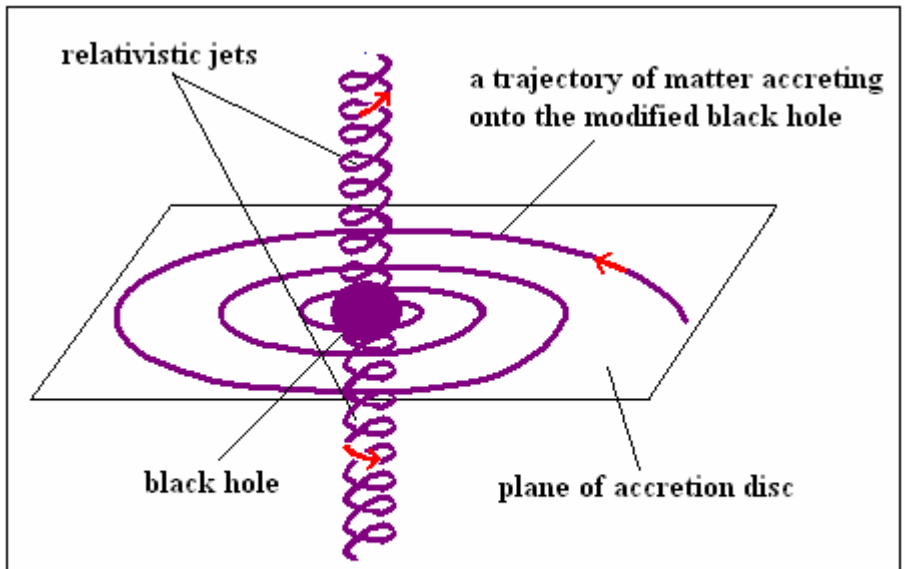


Generally, the zonal velocities of MNBH and the luminal spacetime are the same i.e. the angular velocities are the same so the MNBH is in the rest in relation to spinning spacetime. It causes that only plasma on the surface of MNBH has relativistic mass. The polar velocities of

the Einstein-spacetime components cause that nuclear plasma on the surface of MNBH spirals towards the poles and next twists around the resultant jets.



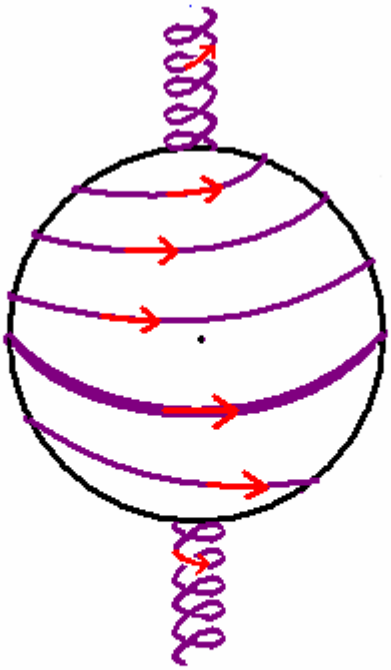
Virtual motions of the luminal Einstein-spacetime components, i.e. of the neutrino-antineutrino pairs, forced by internal structure of the modified black holes and constancy of the speed of light c.



A trajectory of matter accreting onto the modified black holes.

Near MBH, outside the abstract event horizon, the gravitational interactions force the radial virtual motions of the Einstein-spacetime components. It is easy to calculate that the angle between the trajectory of a component on the abstract event horizon and straight line going through the centre of the MBH and the point on the event horizon is 45^{o}. It leads to

conclusion that the trajectories spiral towards the centre of MBH only near the abstract event horizon and inside it. On the other hand, we know that the accreting matter spirals towards the centre of MBH at higher distances as well – just radius of the accretion disc is much bigger than the abstract event horizon. We can explain this discrepancy via production of the dark-matter structures/circles by nuclear matter already in the protogalaxies that formation took place already before the expansion of the Universe [3B]. Due to the expansion of the Universe, radii of the dark-matter structures increased so they are in the accretion discs and halos of galaxies also.



Motions of matter on surface of the neutron black hole (which is nontransparent for baryons) due to the advection that follows from the weak interactions of matter and the luminal Einstein-spacetime components which are push out from the NBH.

5. Radii of the accretion discs

External radii of the accretion discs we can calculate from equality of the advection velocity (formula (11)) and velocity tangent to the dark-matter structures/circles: $R_{Disc} = GM_{MBH}/c^2$

$$R_{Disc} = R_{MNBH}\, M_{MBH} / (2\, \alpha_{Weak(proton)}\, M_{MNBH}) = 1.983 \cdot 10^{-26}\, M_{MBH},$$

$$R_{Disc} \approx 2 \cdot 10^{-26}\, M_{MBH}. \qquad (13)$$

Observational data have higher accuracy for more massive modified black holes. From formula (13) follows that for $M_{MBH} = 2 \cdot 10^{38}$ kg is $R_{Disc} = 0.4 \cdot 10^{13}$ m whereas for $M_{MBH} = 6 \cdot 10^{39}$ kg is $R_{Disc} = 1.2 \cdot 10^{14}$ m. These theoretical results are close to observational facts [9].

For radii smaller than it follows from formula (13), the advection velocity is smaller than it follows from the gravitational interactions. It causes that the accreting matter spirals through

the disc towards the event horizon of MBH and next towards the equators of the MNBHs the MBH consists of.

Due to the virtual flows in the luminal Einstein spacetime forced by interactions of it with moving nuclear matter, information flows into MBH especially via the accretion disc and flows out via the relativistic jets. Moreover, the gravitational fields are directly associated with the superluminal non-gravitating Higgs field, [3A], so gravity is partially non-local – the same concerns the law of conservation of energy.

The neutrino-antineutrino pairs in the virtual flows are polarized in such a way that their trajectories are the magnetic lines. Moreover, the nuclear plasma spiralling from equator of the MNBHs towards their poles create very strong magnetic field along the axes of rotation of the MNBHs. The dynamic pressure causes that the straight and twisted magnetic lines can cross the abstract event horizon. Due to the constant velocity of advection, on the matter acts a force along the relativistic jet. Such force is antiparallel to the gravitational attraction. It causes that matter can cross the abstract event horizon also.

6. Maximum efficiency of the modified black holes

We proved that cores of baryons are indestructible. It means that their rest mass cannot be transformed into radiation.

Polar velocities of nuclear plasma on surfaces of the MNBHs a modified black hole consists of changes from zero on the equators to c on the poles. Mean relativistic polar velocity on surface of MNBH we can calculate for latitude equal to 45^{o}. When distance of the nuclear plasma from MBH increases then it is cooling down i.e. the relativistic energy transforms into radiation. The maximum efficiency we can calculate from following formula

$$P_{Eff,max} = (M_{Relativistic} / M_o - 1)\cdot 100\% = \{1 / [1 - (v_{Rel,mean} / c)^2]^{1/2} - 1\}\cdot 100\% =$$

$$= \{1 / [1 - (\sin 45^o)^2]^{1/2} - 1\} \cdot 100\% = 41.42\%. \quad (14)$$

This value is consistent with value obtained within GR [10].

7. Where is energy emitted by a photon due to the gravitational redshift? Is it non-local?

According to SST, the gravitational fields are the gradients produced in the superluminal, non-gravitating Higgs field (it consists of the non-gravitating tachyons) [3A]. Due to the interactions of the carriers of photons, i.e. of the neutrino-antineutrino pairs, with the superluminal gravitational fields, the rotational energy of a photon can increase or decrease due to transfer of rotational energy from tachyons to the photon or from the photons to tachyons. It is obvious that tachyons can cross the abstract event horizon so there does not appear an information paradox.

Notice that this mechanism can concern the angular momentum of accreting matter as well so there does not appear a paradox concerning the redistribution of the angular momentum.

We can see that gravity is partially non-local so the laws of conservation of energy and angular momentum are valid only when we consider the phenomena globally.

8. Why accretion disc cannot transform into a torus?

The ordered virtual radial flows of the Einstein-spacetime components in the accretion discs decrease the dynamic pressure inside them so there appear forces that compress the discs.

9. Why in the X-ray spectrum near black hole there appear some maxima for about 6.4 keV and 20 – 25 keV and a warm absorber for about 0.84 keV?

It is assumed that the spectrum is dominated by iron line at $5 - 7$ keV and Compton broadened peak from $10 - 30$ keV [11], [12]. There as well appears a warm absorber at about 0.84 keV [13].

But SST provides a different explanation. Consider the condensate in centre of baryons. Its mass is 424.12 MeV but the virtual mass of the Einstein spacetime with the same volume has mass $40{,}363$ times greater i.e. about 17.1 TeV [3A]. Due to the relativistic effects, a virtual mass can become the real mass and vice versa. Such process concerns the production of the Higgs boson with a mass of 125 GeV also [3A], [6]. Within SST we proved that two photons, each carrying energy 3.097 MeV, can produce, due to the relativistic effects, two scalars each carrying energy $40{,}363$ higher i.e. 125 GeV – they are the composite Higgs bosons.

We can see that there can be in existence the inverse process. Consider transformation of quadrupoles (SST shows that there is obligatory the four-particle symmetry [3A]) of pions and quadrupoles of kaons into two photons. We obtain following energies of such photons

$2m_{pion(o)} / 40{,}363 \approx 6.7$ keV,

$2m_{kaon(o)} / 40{,}363 \approx 24.7$ keV.

Due to the relativistic effects, the spectral lines should be broadened. Since kaons have greater mass then the broadening of the "kaon" line should be higher and the observational data show that it is true.

The SST shows as well that at high energies there should be very high number density of holes in the Einstein spacetime with negative energy equal to minus one fourth of the mass of neutral pion i.e. equal to -33.7 MeV. The holes appear due to the weak decays of virtual neutral pions into four neutrinos – in the place of decay there appear four holes. The holes can be the warm absorber

-33.74 MeV $/ 40{,}363 \approx -0.84$ keV.

10. Why the luminal Einstein spacetime does not collapse to separated modified black holes?

Knowing mass density of the luminal Einstein spacetime, we can calculate radius and next mass of the modified black hole with respect of the gravitational interactions composed of the neutrino-antineutrino pairs interacting gravitationally only

$$R_{MBH,E.spacetime} = G M_{MBH,E.spacetime} / c^2, \tag{15}$$

$$R_{MBH,E.spacetime} = c \{3 / (4 \pi G \rho_E)\}^{1/2} = 0.1708 \text{ m}. \tag{16}$$

$$M_{MBH,E.spacetime} = 4 \pi \rho_E R_{MBH,E.spacetime}^3 / 3 = 2.3 \cdot 10^{26} \text{ kg}. \tag{17}$$

Now we can calculate the gravitational pressure exerted on a neutrino-antineutrino pair on the surface of such MBH

$$p_{Gr} = G M_{MBH,E.spacetime} M_{Pair} / (R_{MBH,E.spacetime}^2 \pi L_{Torus}^2) = 2.3 \cdot 10^{19} \text{ Pa}. \tag{18}$$

This attractive pressure is much lower than the repulsive dynamic pressure in the Einstein spacetime so such MBHs cannot be created i.e. the ground state of the Einstein spacetime in respect of the gravitational interactions is the very stable state.

When in the luminal Einstein spacetime the gravitational pressure exceeds the dynamic pressure? It is outside the sphere with the radius equal to about $2.3 \cdot 10^{30}$ m [3B], [14]. Then, the outside regions of the sphere filled with the luminal Einstein spacetime collapse to the stable non-transparent for the Einstein spacetime physical boundary [3B], [14]. Such process took place at the end of the inflation described within the Scale-Symmetric Theory. There as well was produced the stable boundary for the Higgs field [3B]. It stopped the expansion of the ground states of both the superluminal Higgs field and the luminal Einstein spacetime and causes that, generally, physical constant are invariant. Emphasize that our Universe expands not due to expansion of the ground state of the luminal Einstein spacetime or Higgs field – it expands due to the expanding dark energy which density is much lower than the luminal Einstein spacetime [3B] – it causes that the luminal Einstein spacetime is practically flat. The dark energy consists of the additional Einstein-spacetime components that increase insignificantly the dynamic pressure inside our Universe – it causes the expansion of it. Masses curve the superluminal non-gravitating Higgs field and such curved fields are the gravitational fields. Densities of the gravitational fields are much lower than the luminal Einstein spacetime (about $4 \cdot 10^{42}$ times [3A]) so the spacetime as a whole is flat but there are the curved gravitational fields. Properties of the superluminal non-gravitating gravitational fields differ very much from properties of the luminal gravitating Einstein spacetime (it produces the superluminal quantum entanglement) responsible for the Standard-Model interactions so unification of the classical GR with the quantum physics within the same methods is impossible.

11. Distribution of the modified neutron black holes in a modified black hole

Consider a modified black hole composed of N_{MNBH} modified neutron black holes. We know that the L_{Torus} quantum entanglement between the neutrino-antineutrino pairs on surface of the torus is tremendously strong and causes that the torus is the very stable structure. So we can assume that on equator of each MNBH is produced loop composed of nuclear plasma and such loops are exchanged between the MNBHs. Then distance between interacting two MNBHs should be about $2\pi R_{MNBH}$. To stabilize the MBH, there should be a loop composed of the MNBHs with parallel axes of rotation. Radius of such loop, R_{Loop}, is

$$R_{Loop} = N_{MNBH}\, 2\, \pi\, R_{MNBH} / 2\, \pi = N_{MNBH}\, R_{MNBH}. \tag{19}$$

On the other hand, the radius of the modified black hole, R_{MBH}, is

$$R_{MBH} = G\, N_{MNBH}\, M_{MNBH} / c^2 = N_{MNBH}\, R_{MNBH}. \tag{20}$$

We can see that $R_{Loop} = R_{MBH}$. Moreover, such distribution of the MNBHs is symmetrical in relation to the accretion disc of the modified black hole. Notice as well that such distribution of the MNBHs causes that the resultant relativistic jet of the modified black hole has a shape of a tube with the cross-section very close to the cross-section of the loop composed of the MNBHs.

The spin speed of the MNBHs in the loop is determined by advection. It additionally twists the magnetic lines.

12. Summary

Black holes understood as singularity with event horizon are the incoherent objects. General Relativity (GR) and Quantum Physics (QP) neglect the fact that below the Planck scale there are the non-principle-of-equivalence superluminal objects (their existence follows from the

extended GR described within the Scale-Symmetric Theory. Moreover, such non-gravitating superluminal objects concern the internal structure of gravitational fields and the quantum entanglement i.e. concern the very important areas of knowledge. It causes that GR and QP are the observational theories, not the real theories of Nature. Their incompleteness causes that altogether with good solutions there appear solutions that cannot be realized by Nature and the singularities and mini gravitational black holes are such solutions (we proved it in this paper).

Here, applying the Scale-Symmetric Theory, we showed that neutron stars, due to the tremendously strong forces, resulting from the quantum entanglement, acting between the entangled Einstein-spacetime components (i.e. between the neutrino-antineutrino pairs) for the two shortest distances, as it is on surface of the torus in the core of baryons, cannot collapse due to gravitational interactions to black hole understood as singularity with event horizon. In reality the modified black holes (MBHs) consist of modified neutron black holes (MNBHs).

The upper limit for mass of neutron stars calculated within the mainstream theories is incorrect. It follows from the incompleteness of GR and QP. The mass of modified neutron black hole calculated within the Scale-Symmetric Theory is 24.81 solar masses.

The surface of the torus and the condensate in the cores of baryons are the very dense fields. The interactions between these very dense fields with the luminal Einstein spacetime cause that moving/rotating nuclear matter produces ordered virtual flows in the spacetime. Such virtual flows flow into modified black holes but due to the tremendous dynamic pressure in the luminal spacetime, they can flow out from the MBH. Due to the weak interactions of the virtual flows with nuclear matter there appears advection so the virtual flows carry the nuclear matter. Moreover, the ordered virtual motions decrease dynamic pressure so nuclear matter is collimated in the accretion discs and in the relativistic jets.

Presented here dynamics shows that the accreting matter spirals inward towards the equators of the MNBH a MBH consists of, next spirals towards the poles of the MNBH and next twists around the virtual jets produced by each MNBH. It solves the information paradox.

The gravitational fields are the gradients in the superluminal Higgs field composed of the non-gravitating tachyons. Rotational energy of photons and angular momentum of nuclear matter can be transferred to tachyons and vice versa. It causes that such processes are non-local and they solve the information paradox as well.

Here we solved as well following problems: why maximum efficiency of accretion process is 41.42%, why accretion disc cannot transform into a torus, what determines radii of the accretion discs, why the continuum spectrum is partially non-thermal, what is density and what are radial and angular velocities of matter, what is pressure, why the luminal Einstein spacetime does not collapse to separated black holes, what is the mechanism of production of the dark-matter structures, how such structures interact with matter, what is distribution of MNBHs in a MBH, and so on.

The obtained results are consistent with observational data.

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