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SHORT COMMUNICATION

The Cerberus project: a heuristic model for a blackhole based on rigid body considerations of rotation of a Kerr-Newman blackhole

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ABSTRACT

In view of the rigid body rotational character of a Kerr-Newman blackhole, a completely novel model of a blackhole is proposed revamping in the process our current perception of the universe. The research involved is just a proposal in its baby stage.

***Keywords*:** Gravitational collapse, blackhole, Kerr-Newman blackhole, general relativity

1. INTRODUCTION

The classical theory of relativistic gravity ─ the general theory of relativity ─ asserts that a gravitationally collapsing star of mass M will shrink, in short time as measured by an observer on the surface, to a radius of the order of $2GM/c^2$, known as its *gravitational radius* or *Schwarzschild radius*, at which the gravitational field becomes so strong that no further radiation or anything else can escape to infinity, the region of spacetime from which it is not possible to escape to infinity is a blackhole. The boundary of the blackhole, called as the *event*

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horizon, is an outgoing null *hypersurface* that just fails to reach infinity. The existence of finite entropy [1] as predicted for the blackholes implied the possibility of radiating blackholes [2], in turn proven conclusively by the quantum considerations of a blackhole neighborhood. We now have a standard result verified many times (see for example [3] and references therein) that blackholes emit radiation, now known as the Hawking Radiation. The noteworthy feature of the Hawking radiation tunneling through the event horizon of the blackhole is that it possesses an exact thermal spectrum.

Consequently, it is observed that the dynamics of blackholes runs competitively on the same lines as that of classical thermodynamics. The thermal radiation emitted by a blackhole corresponds to a temperature of

$$T_H = \frac{\kappa \hbar}{2\pi k_B c}, \tag{1}$$

where: K is the surface gravity of the blackhole given by

$$\kappa = \frac{4\pi (r_+ c^2 - GM)}{A}. \tag{2}$$

This once again doubly implies the premise of finite entropy which expressed by the Bekenstein-Hawking formula:

$$S_{BH} = \frac{k_B}{4 l_{Pl}^2} A, \tag{3}$$

where: l_{Pl} is the Planck's length expressed by $l_{Pl} = \sqrt{\frac{G\hbar}{c^3}} \approx 10^{-33} cm$.

In the above and henceforth A is the area of the event horizon of the blackhole mathematically defined as

$$A = \frac{4\pi G}{c^4}\left(2GM^2 - Q^2 + 2\sqrt{G^2 M^4 - J^2 c^2 - GM^2 Q^2}\right). \tag{4}$$

The quantity r_+ in eq. (2) is defined by the relation:

$$r_+ = \frac{1}{c^2}\left(GM + \sqrt{G^2 M^2 - \frac{J^2 c^2}{M^2} - GQ^2}\right). \tag{5}$$

The solution of the coupled Einstein-Maxwell field equations

$$R_{ab} - \frac{1}{2} g_{ab} R = -\frac{8\pi G}{c^4} T_{ab}, \tag{6}$$

$$F^{ab}_{;b} = 4\pi J^a, \tag{7}$$

and

$$F_{ab;c} + F_{bc;a} + F_{ca;b} = 0, \tag{8}$$

subject to the constraints imprinted by mass *M*, angular momentum *J*, and charge *Q*, (at radial infinity) and subject to the existence of a physically non-singular horizon describes the *Kerr-Newman geometry* of a blackhole with mass *M*, angular momentum *J* and charge *Q*. For a general Kerr-Newman blackhole, Ω, the angular frequency of rotation of the hole is given by

$$\Omega = \frac{4\pi J}{MA}, \tag{9}$$

and Φ, the potential of the event horizon is given by

$$\Phi = \frac{4\pi Q r_+}{A}. \tag{10}$$

The theoretical foundations of the subject of blackhole dynamics were laid by the works of Bekenstein [1], Hawking [2], Bardeen, Carter and others [4]; systematic and complete treatment is given by Straumann [5]. The statistical theory of internal (unobservable) configurations and micro-canonical ensemble in the blackhole framework has been developed and discussed in considerable detail by Hawking [6]. As a consequence to the theory of blackhole dynamics, the possibility of developing *blackhole dynamic potentials*, mutually associating them and developing fundamental relations between the blackhole parameters: *M, J, Q, K,* Ω *and* Φ, with the use of these potentials becomes inevitable and feasible.

Any Kerr-Newman blackhole i.e., a blackhole of given mass, angular momentum and charge can have a large number σ of different unobservable internal configurations which reflect the possible different initial configurations of the matter which collapsed to produce the hole. The logarithm of this number σ can be regarded as the entropy of the blackhole and is a measure of the amount of information about the initial state, which was lost in the formation of the blackhole. This is written mathematically as

$$S_H = ln\sigma \tag{11}$$

Bekenstein suggested that the area of the event horizon of the blackhole is a measure of its entropy which is what is embodied in eq. (3). Further, Bekenstein was the first to suggest that some multiple of K should be regarded as representing in some sense, the temperature of the blackhole. He noted that energy is conserved for blackholes as well as it is for other phenomena that occur in the universe. This is personified in the first law of blackhole dynamics,

$$dE = d(M\,c^2) = \frac{\kappa\, c^2}{8\,\pi\, G}\, dA + \Omega\, dJ + \Phi\, dQ \tag{12}$$

which connects the difference in the energy of two nearby blackhole equilibrium states to the differences in the area A of the event horizons, in the angular momentum J, and in the charge Q.

With respect to the angular frequency of the blackhole (also called its angular velocity) with terminology used in [5], the relevant relation is

$$\Omega = \frac{a}{r_+^2 + a^2} = const. \tag{13}$$

The blackhole thus rotates like a rigid body.

The basic result and also an extremely important one here is that a blackhole rotates like a rigid body. Now, rigid bodies are not subject to the physics of relativity. The proof of this is due to Paul and Tatiana Ehrenfest: Consider a rigid object rotating at relativistic velocities $\Omega \longrightarrow c$. Then the circumferal or peripheral dimensions should experience length contraction for an inertial observer. However, by the very definition of a rigid body, the mutual interparticle distances should be constant, which is not so for a relativistically rotating object.

So, rigid bodies do not exist in the face of relativistic explorations.

The Kerr-Newman blackhole is then no longer amenable to the theory of relativity. Instead, it is an anomalous object which is why conventional General Relativity (GR) predicts an unimpeded gravitational collapse to form spacetime singularities, both, concealed (Cosmic Censorship Conjecture) and naked.

So, in our current research proposal, we treat this anomaly as follows:

Firstly, an anomaly in GR means an anomaly in the Einstein tensor, G_{ab} given by the Einstein field equations (6). An anomaly in the Einstein tensor means an anomaly in the energymomentum tensor. This implies a nonconservation of energymomentum. Since, homogeneity in time implies energy conservation and a homogeneity in space implies momentum conservation; we have either of the two:

(i). A nonhomogeneous spacetime in the K-N blackhole, resulting in possibility of creation of energy in the blackhole which could possibly lead to a Quasi Steady State Cosmology (QSSC) creation field $C_{ab} = C_{;a;b}$, a consequent minibangs as predicted by Hoyle, or,

(ii). An existence of a suitable anomaly cancellation term in the Einstein field equations (6) reading:

$$G_{ab} + K_{ab} = R_{ab} - \frac{1}{2} g_{ab} R + K_{ab} = -\kappa T_{ab} \tag{14}$$

The riddle of extra dark matter type gravity holding the galaxies stable and the riddle of dark energy sending the galaxies hurtling apart from each other in every direction and the shape of the universe will be addressed in this research using our model.

2. AIMS AND FOUNDATIONS

The aims of this project may be summarized as follows:

(i). It will be shown that this anomaly cancelling field K_{ab} plays a role inside the blackhole what the Hoyle-Narlikar creation field (C-field) plays at the site of a supermassive blackhole, in the form of minibangs as single creation events at the blackhole sites in place of the blackholes themselves.

(ii). In fact, it will argued that blackholes as defined by GR with their singularities, trapped surfaces and all, are not formed as dictated by conventional GR. In fact, a trapped surface may not be formed. If Hawking radiation is emitted by a blackhole then the radiation need not have to wait for the blackhole to form. Radiation can be emitted even during the collapse before the formation of a trapped surface or tunnel through the trapped post its formation. So, there are hints for a non-singular nature of the collapse end state.

(iii). It will be shown that the anomaly cancellation K-field has a negative energy density.

This results in repulsive gravity effect inside the blackhole. Also, more deep an external observer sends in a test probe inside a blackhole, more negative the energy density and more repulsive gravitational effect. The spacetime is now homogeneous and the spacetime inside the blackhole starts to expand.

2. 1. Details of the project

The first part of the project consists of hand calculations [7]. Then to verify the model, data analysis, regression and curve fitting to test the model will ensue. For the data analysis part, data from the space telescope, (Hubble, Chandra X-ray, WMAP results) and the LHC will be required. To this end visits to the Indian Institute of Astrophysics, the Harvard-Smithsonian center and CERN are mandate.

(i). An LHC (Large Hadron Collider) verification is possible to this end, as follows: consider the De Broglie wavelength λ of a matter wave associated with a colliding particle, $\lambda = {}^{h}/_{p}$ where p is the momentum of the particle. This equation is key to probing the structure of the matter. We can see that the probing scale gets finer at the expense of the energy of the collisions. However, near the quantum gravity scale, the Planck scale: $\lambda_{Pl} = \left(\frac{G\hbar}{c^3}\right)^{1/2} \approx 10^{-33} cm$, a collision can definitely produce blackholes of Planck mass that encode one qubit of information. The dimension of a blackhole is $\lambda = {}^{2GM}/_{c^2}$ now scales coarser (coarse graining) and as this happens the negative energy density of our K-field gets more prominent and probing this and detecting this is possible.

(ii). What is the origin of our K-field? Does it lead to a new universe whose one of many mouths is a blackhole? Or does it lead to another blackhole in the same universe? If this model is successfully verified, the GRT will change its outlook and blackholes will be viewed in different light. This is why our proposed model is very important.

The negative nature is ascribed to the convention that the particle and all such particles curve spacetime whereas physics is simple when it is analyzed locally i.e., in spacetime devoid of effects of gravitation (locally Lorentzian). As seen from (6) and the thereby modified (14), the energy of the K-field appends to the spacetime curvature inside the blackhole, the corresponding energy-momentum tensor takes the form:

$$T^{ab}_{(K)} = -k_0 (K^a K^b - \frac{1}{2} g^{ab} K^j K_j). \tag{15}$$

for $k_0 > 0$, we have $T^{00}_{(K)} < 0$. The K-field thus, has a negative energy density that produces a repulsive gravitational effect making the spacetime in the neighborhood of the test particle under question to expand. This negative energy density thus creates a wormhole or wormhole-like situation.

The action of the K-field is expressed by:

$$\mathrm{L}_K = (\partial_k \partial^k)(K^k K_k) - \mu_0^2 (K^k K_k) - k_0^2 (K^k K_k)^2, \tag{16}$$

where: L_K is the effective Lagrangian of the K-field with μ_0 being the mass of the test particle. The energy density required by the wormhole is negative (as measured by a stationary observer). This wormhole characterized by a constant 'b' with dimensions of length and is characterized by the line element,

$$ds^2 = -dt^2 + dr^2 + (b^2 + r^2)[d\theta^2 + \sin^2\theta\, d\varphi^2] \tag{17}$$

which is our solution to the Einstein field equations (6) in orthonormal basis with $K_{ab} = 0$.

The constants μ_0, k in (16) determine the value of 'b' as well as of the duration of existence of the wormhole.

2. 2. Some more radical perspectives

To this end, from the many mouths picture of a blackhole network, view the following: on the surface of the sun, there are many magnetic poles and the prominences that jet outwards get intertwined as the poles move and finally there is an explosive flare. Similar situation can be pictured for the multi-blackhole picture. Only here, the galaxies, whose central blackholes are those supermassive ones, will move apart periodically or aperiodically with negative energy flares blowing them apart.

3. CONCLUSIONS

It is truly very early to conclude anything. However, the blackholes will definitely be viewed in a new light after this project. One thing is for sure – it is not necessary for a gravitating configuration to begin collapse with smooth initial value data and then form a blackhole as the collapse end state, all this just to radiate by the Penrose and Hawking modes or even by the Blandford – Znaczjek or any other mode. The gravitational attraction is lesser before the formation of the blackhole so that the pre-blackhole configuration will emit the radiation.

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Biography

Koustubh Kabe is Dr. Phil (PhD) / Sc.D. in Theoretical Physics. He has published several research papers investigating into the foundational issues of gravitational physics and the understanding of time and quantum gravity. He is also working on the problem of gravity and the cosmological implications in the framework of string theory. He is currently studying Quantum Measurement in addition to all of the above. His research interests are in the fields of General Theoretical Physics, Physical Mathematics, Theoretical Astrophysics, Theoretical High-energy Physics, Modern Theoretical Physics, Physical Cosmology, Geometric Analysis, Number Theory, Algebraic Geometry and lastly, Philosophy, Epistemology and Pedagogy behind Physical Theories. He is an author of a book titled "*Blackhole Dynamic Potentials and Condensed Geometry: New Perspectives on Blackhole Dynamics and Modern Canonical Quantum General Relativity*".

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