

STUDYING THE NATURE OF EXOTIC BLACK HOLES

M. Melibaev

Kokand State University, Uzbekistan.

email: mmelibaev@mail.ru

Abstract: Considered theoretical model of creation Black Holes as solution Schwarzschild metric of Einstein's equation. As considered as final achievements hunger and binary Black Holes Systems which accretion leading to perturbation of space-time metric structure and create gravitational waves.

Key words: Black Holes, space-time metric, perturbation, gravitational waves, accretion

1. Introduction

It is well known that no general analytical solution has been found for the Einstein equation, represented by a second-order nonlinear partial differential equation. For the first time in the history of physics, a particular solution for a spherical symmetric gravitational potential was proposed by the renowned German scientist Schwarzschild. Due to the complexity of the mathematical formalism, we have attempted to simplify it. We represent the Einstein equation for a spherical symmetric gravitational potential in spherical coordinates as

$$R^{\mu\nu} - \frac{1}{2}g^{\mu\nu}(R - 2\lambda) = \chi T^{\mu\nu} \quad (1)$$

$$\varphi = -G \frac{m}{r} \quad (2)$$

Here $R_{\mu\nu}$ the Riemann-Christoffel tensor or the Ritchie tensor, represented by the covariant derivative of the second order, characterizes the configuration of the pseudo-Riemannian space, $g_{\mu\nu}$ is the fundamental metric tensor characterizing the structure of curved space-time, R is the average curvature of the space-time continuum, λ is the cosmological parameter of the universe, $\chi=8\pi G/c^4$, $T_{\mu\nu}$ is the energy-momentum tensor, G is the gravitational constant. The potential φ is part of $T_{\mu\nu}$, m is the total mass.

Thus, we finally find the space-time metric in the form

$$ds^2 = \left(1 - \frac{2m_s}{r}\right) c^2 dt^2 - \left(1 - \frac{2m_s}{r}\right)^{-1} dr^2 - r^2(d\theta^2 + \sin^2\theta d\varphi^2) \quad (3)$$

where is $r = 2m_s = r_s$ the Schwarzschild radius, $r_s = \frac{2Gm}{c^2}$.

This solution to Einstein's equations was found by Schwarzschild. It completely determines the gravitational field in a vacuum, created by any centrally symmetric mass distribution. We emphasize that this solution is valid not only for masses at rest but also for masses in motion, provided that the motion also possesses the necessary

symmetry (for example, centrally symmetric pulsations). Note that the metric depends only on the total mass of the gravitating body, as in the analogous problem of Newtonian theory. When the body's mass reaches the geometric mass, matter collapses. The black hole model under consideration is called the Schwarzschild model. This model is considered statistical and cannot emit gravitational waves in principle.

There is also a model of an electrically charged Black Hole with the following metric:

$$ds^2 = -\left(1 - \frac{2M}{r} + \frac{Q^2}{r^2}\right) dt^2 + \left(1 - \frac{2M}{r} + \frac{Q^2}{r^2}\right)^{-1} dr^2 + r^2 d\Omega^2, \quad (4)$$

This black hole is called the Neistner-Nordstrom black hole. By choosing a spherically symmetric metric, the stress-energy tensor for the electric field

There is also a model of a rotating Black Hole with the following metric:

$$ds^2 = -\left(1 - \frac{2Mr}{\rho^2}\right) dt^2 - \frac{4Mar \sin^2 \theta}{\rho^2} dt d\phi + \frac{\Sigma}{\rho^2} \sin^2 \theta d\phi^2 + \frac{\rho^2}{\Delta} dr^2 + \rho^2 d\theta^2 \quad (5)$$

Where,

$$\rho^2 = r^2 + a^2 \cos^2 \theta, \quad \Delta = r^2 - 2Mr + a^2,$$

$$\Sigma = (r^2 + a^2)^2 - a^2 \Delta \sin^2 \theta,$$

is named after Kerr (1963). It should be noted that it is apparently impossible to directly observe a black hole for a simple reason. The effects that a black hole reveals to us are easily observed .

In 1965 at Cambridge, Penrose showed that singularities similar to those in black holes could be formed during the gravitational collapse of dying large stars .

The 2020 Nobel Prize in Physics was awarded to Roger Penrose for his discovery that the formation of a black hole is a reliable prediction of general relativity.

German-American astrophysicist Reinhard Genzel and American scientist Andrea Ghez were awarded the prize "For the discovery of a supermassive compact object at the center of our galaxy" (a giant black hole is believed to reside at the center of the Milky Way). The Hubble Space Telescope team, as well as several ground-based astrophysical stations and laboratories, have made significant contributions to shaping our understanding of black holes.

2. Results and Discussion

Let's briefly review the astrophysical observations that led to the discovery of new types of black holes. We present the first astrophysical image of a black hole, officially released by the Astrophysical Society.

Among the black hole families, the so-called intermediate-mass black holes are perhaps the most prominent. These are black holes with masses significantly greater than those of stellar black holes (from 10 to several tens of solar masses), but much smaller than those of supermassive black holes (from a million to hundreds of millions of solar masses). It was previously assumed that this type of black hole was significantly rarer than the other two classes, but a recent discovery has refuted this assumption.

In 2018, scientists discovered the most common location for such objects. For reasons that remain unexplained, intermediate-mass black holes are most often found in the centers of small galaxies. Once scientists discovered this, this rare type of black hole ceased to be rare.

Moreover, this discovery may help solve another mystery related to black holes. One of the most pressing questions in modern astronomy is the nature of supermassive black holes. Scientists are unable to understand how some of the supermassive black holes discovered in relatively compact galaxies have grown so rapidly in size since the Big Bang.

Those very same intermediate-mass black holes may point to the correct answer. According to one hypothesis, supermassive black holes may have grown from intermediate-mass black holes; according to another, they were born that way from the start. Scientists can't yet provide a definitive answer, but they appear to be moving in the right direction. Sagittarius A* is a supermassive black hole located at the center of our galaxy. In the early 2000s, scientists discovered two mysterious objects near it. Dubbed G-class objects, they were initially mistaken for gas and dust clouds. The mystery began when these objects approached the black hole. Instead of being torn apart by the powerful gravity of the supermassive black hole, the objects G1 and G2 somehow managed to survive.

In 2018, scientists discovered three more G-class objects (G3, G4, and G5) near Sagittarius A*. Analysis of data collected over 12 years has not provided a definitive answer for astronomers. The objects attract attention due to their unusual properties. All five G-class objects have the characteristic visual signatures of gas clouds, yet behave like stars with enormous masses. Based on this, scientists hypothesized that they have encountered a very rare type of star, uncharacteristic of our galaxy. Scientists explain the appearance of these objects by the unique conditions in the vicinity of a supermassive black hole: here, under the influence of powerful gravity, binary stars

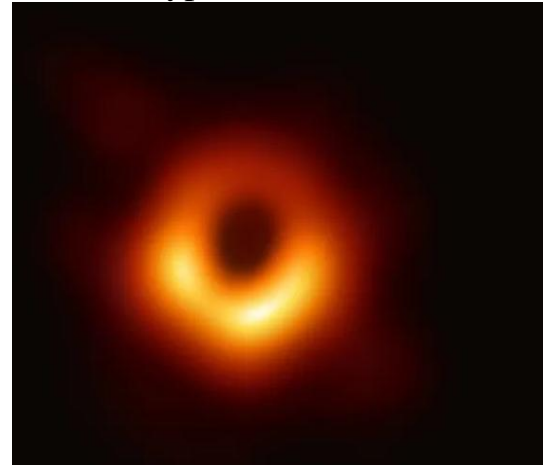


Fig. 1. Image of a Black Hole.

can collapse to form a single, large object shrouded in thick gas and dust shells. However, the scientists note that not all objects have similar orbits around the black hole.

In 2018, scientists discovered the "hungriest" black hole in the known Universe. Every second of every day, it consumes a mass equivalent to our Sun, causing it to expand rapidly. Fortunately for us, it's very far away. If this monster were at the center of the Milky Way, the X-ray radiation it produces would sterilize Earth of all life.

When scientists detected the first light from quasar J2157-3602, associated with this black hole, its age was estimated at 12 billion years. Once scientists confirmed that the quasar was indeed home to a black hole, its mass was already estimated to be approximately 20 billion solar masses. Astronomers are currently unable to explain the black hole's rapid growth. All that is known about this object is that its heat heats the surrounding gas and dust to such a degree that their brightness easily outshines the light of virtually all the stars in the sky.

Another mystery for scientists is so-called binaries, or pairs of black holes orbiting each other. Scientists have observed cases of black hole collisions in the past. Two were detected in 2015, and another in 2017. Remarkably, the latter event provided the first direct witnesses of an equally rare phenomenon. The signal received from the collision of two black holes showed signs of gravitational ripples in spacetime—changes in the gravitational field propagating like waves. The two black holes were not destroyed, but instead merged into a single entity—a supermassive black hole, even larger in size than its progenitors. Scientists have two theories regarding the origin of binary black hole systems. According to one, binary black holes are formed when binary stellar systems collapse. According to the second, black holes are formed independently of each other and then, drifting in space, are attracted to each other under the influence of gravitational forces.

A single galaxy cluster can contain hundreds or even thousands of galaxies. These clusters are considered by scientists to be among the largest objects in the Universe. You might think such a colossus couldn't be hidden by a single cosmic object. A single quasar has proven otherwise.

The discovered object, named PKS1353-341, was initially thought to be a separate galaxy with an incredibly bright central region. However, in 2018, astronomers at the Massachusetts Institute of Technology revealed the truth, which had been hidden for several decades since its discovery. It turned out that the object is not a galaxy, but a single quasar (a region of hot gas surrounding a supermassive black hole), located at the center of an entire galaxy cluster located 2.4 billion light-years from Earth.

The quasar was so bright that it literally outshone the surrounding space, which contained hundreds of galaxies. MIT scientists calculated its brightness and found it to be 46 billion times brighter than the Sun. The researchers believe this extreme

brightness is due to the central supermassive black hole consuming a large amount of surrounding material.

According to the author Chernyu, holes play a decisive role in the formation of galaxies and the Universe.

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