Qeios PEER-APPROVED

v1: 18 April 2025

Research Article

A Hollow Black Hole

Peer-approved: 18 April 2025

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Qeios, Vol. 7 (2025)
ISSN: 2632-3834

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A black hole is a singularity that exists hidden beyond the event horizon. Here we describe a massive black hole (MBH) structure that consists of black holes in a shell with a void within that supports normal dynamics as in the Schwarzschild or black hole cosmology. In an MBH, the hollow will support an expanding system in which objects far from the center will be accelerated to the shell. This view of the black hole from the outside complements the inside-out view of black hole cosmology.

Introduction

In standard cosmology, there should be no preferred rotational direction. But in a recently published analysis of the images from JWST's Advanced Deep Extragalactic Survey (JADES), it has been found that two-thirds of the 263 galaxies examined rotated clockwise, and a third rotated counterclockwise[1].

One explanation for this anomaly is that the universe was born rotating, which agrees with theories such as black hole or Schwarzschild cosmology that postulates the entire observable universe as the interior of a black hole[2][3][4]. A related cosmology sees the universe as the interior of a black hole, excepting that the leading edge of the Big Bang explosion is a shockwave arbitrarily far beyond the Hubble length in the Friedmann–Robertson–Walker (FRW) spacetime[5]. However, these cosmological models cannot explain either the acceleration of the expansion of the universe or the Hubble tension, both of which are readily explained by the information-theoretic *e*-dimensionality cosmology[6][7][8].

Every large galaxy has a supermassive black hole at its center[9], which is typically greater than $10^5\ M_\odot$. Such a black hole at the center of the Milky Way galaxy corresponds to the radio source Sagittarius A* with an estimated mass of 8.54×10^{36} kg, which is $4.297\times10^6\ M_\odot$.

In physics, we consider the search for mathematical bases for the observed phenomena, and the structure of the theory may be abstract or geometric. In some ways, these two have parallels with epistemology and ontology, where in the epistemic view, one is speaking of the knowledge obtained from the experiment without going into the ultimate nature of reality, whereas in the ontic view, one is describing reality as a particular assemblage of objects, together with their mutual relationships and evolution in time[10]. The abstract is information-theoretic, whereas the geometric is structural, and while starting from different points, they do come together in the final framework that must incorporate aspects of both.

Ideas of black hole thermodynamics[11][12][13] or the holographic principle[14] are based on observed information, whereas Lambda-CDM cosmology[15][16] is the "standard model" for understanding the structure of the universe and its inferred evolution. The evolution of dimensionality at the basis of information-theoretic cosmology provides the desirable properties of self-similarity and scaling in the universe and ties up with the corresponding self-similarity in the biological world; therefore, it can form a bridge to connect seemingly disparate frameworks from entirely different application domains.

The event horizon of the black hole (BH) separates its inside from where nothing can leave its outside, to which it is invisible. Any event inside a BH cannot influence a spacetime region outside the BH, and so it is meaningless to speak of any structure to the BH, even though it does interact with the outside world[17]. Philosophically, the cutting off or separation of the BH from the world is problematic, for quantum mechanics is reversible in time, whereas when an object falls into a BH, its information is not available any more to the outside world. This leads to difficulties such as the information paradox, and so investigating the question of the structure is helpful in advancing the understanding of spacetime.

For a star of mass *M* and radius *R*, let the object of mass *m* be tossed from the surface with a velocity *v*. The total energy of the object is $E = \frac{1}{2}mv^2 - \frac{GMm}{R}$. The escape velocity is achieved when it is large enough to overcome the gravitational potential. Thus $v_{es}{}^2 = \frac{2GM}{R}$. If $v_{es} = c$, the speed of light, we obtain the Schwarzschild radius *R,* which is the radius of the event horizon $R_s = \frac{2GM}{c^2}$. If the radius of the star is less than R_s, no object or light can escape.

To the observer, the main light source from a BH is the accretion disk[18]. A stellar-mass BH paired with a star may pull gas from it, and a supermassive black hole (SBH) does the same from nearby stars. The gas settles into a hot, bright, rapidly spinning disk, and matter gradually moves from the outer part of the disk to its inner edge, where it falls into the event horizon. Isolated black holes that have consumed the matter surrounding them do not possess an accretion disk and are difficult to spot.

In this paper, we present a black hole structure, viewing it from the outside in a manner that complements black hole cosmology, which is a view from inside out. Other structures may likewise be proposed, although they will be taken up here. The paper is consistent with information-theoretic cosmology based on the evolution of dimensions, according to which spiral galaxies arose very early in the universe[19], and there is self-similarity across scales.

Hollow black holes

Consider a hollow sphere of inner radius *r* and outer radius *R*, so that the shell thickness is $R - r$ (Figure 1). The total volume of the outer sphere is $\frac{4}{3}\pi R^3$, and the hollow inner sphere is $\frac{4}{3}\pi r^3$. Thus, the volume of the shell is $\frac{4}{3}\pi(R^3 - r^3)$.

doi.org/10.32388/IJ74VB.2

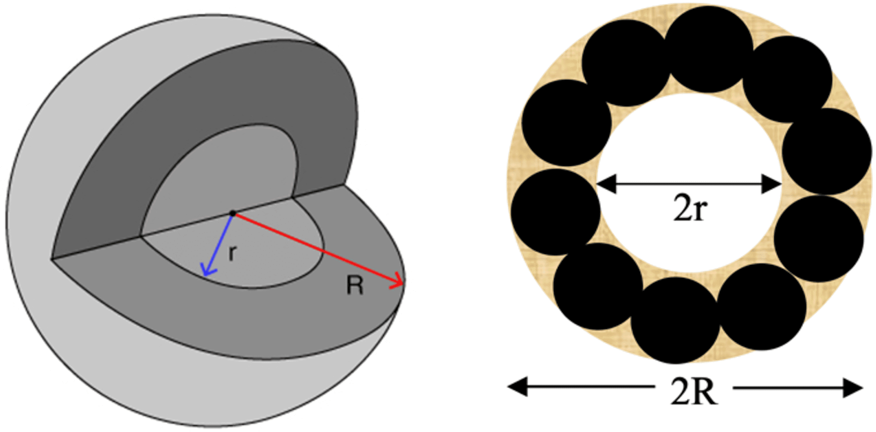

Figure 1. A hollow sphere with outer diameter of 2R

Now imagine little spheres lining up the shell, where the radius of each ball is $k = (R - r)/2$. Since the surface area of the inner sphere is $4\pi r^2$, and the thickness of the shell is $(R - r)$, the volume of the shell can also be approximately written as $4\pi R^2(R - r)$.

Let the BHs, each of radius $k = \frac{R-r}{2}$ in the shell have a mass so that each one of them is a BH. So, $k = \frac{2GM}{c^2}$.

To the outside world, the outer shell of BHs, lined up together, constitutes a larger, massive MBH, and to be viewed as a singularity.

The number, *n*, of BHs in the shell of the hollow sphere will be approximately given by the number of cubes of volume $8k^3$the shell can be divided into, for the side of the cube will be twice the value of radius k.

$$n \approx \frac{\frac{4}{3}\pi(R^3 - r^3).}{8k^3} \tag{4}$$

Let $\frac{R}{r} = z$. Then one can write $n \approx \frac{\frac{4}{3}\pi(z^2+z+1).}{(z-1)^2}$.

Therefore, the total mass of the larger BH will be *nM*.

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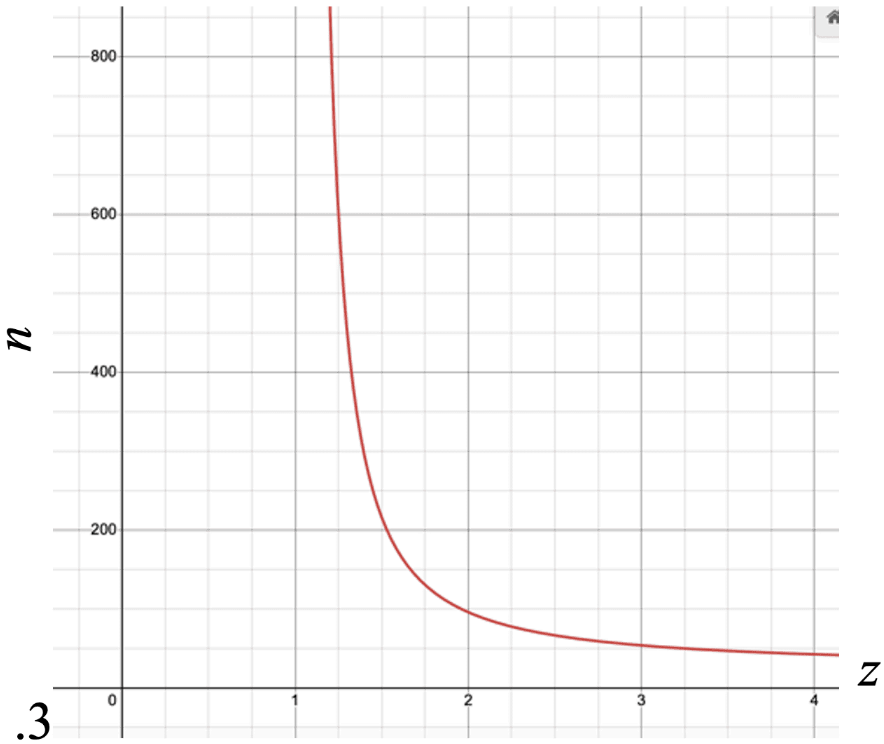

Figure 2. Number of small BHs in the MBH

Since the radius of the event horizon of each small BH is $\frac{R-r}{2}$, the radius of the event horizon of the MBH will be $\frac{n(R-r)}{2} = 2GnM/c^2$. The radius of the void inside the MBH is *r*.

According to the current understanding of the origin of cosmic microwave background radiation, and the comoving distance to the edge of the observable universe, the radius of the observable universe is estimated to be about 46.5 billion light-years, and the total mass of ordinary matter in the universe has been calculated to be about 1.5×10^{53} kg. If this represents our observable universe, we may assume that there are other similar universes within the supermassive black holes at the center of galaxies.

A resolution of the information paradox would then be that while information is lost to the observer who sees an object fall into a black hole, the information is merely transferred to another universe within the black hole. One could then assert that the total universe within the super universe of all the black hole universes remains unchanged.

Discussion

The radius of the event horizon of the MBH may be used to estimate the size of the void. From inside out, it should equal the distance at which objects are receding from us at the speed of light due to the expansion of the universe, but from the perspective of outside in, it is smaller than the radius of the outside event horizon. In the MBH, the hollow will support an expanding system in which objects far from the center will be accelerated to the shell.

Other structured hollow black holes, such as those with several shells, may also be proposed. An important question to ask about such black holes is whether their structure could be inferred by suitable interaction with it that goes beyond observing its evaporating radiation.

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Declarations

Funding: No specific funding was received for this work.
Potential competing interests: No potential competing interests to declare.