Why We Should Be Skeptical of Black Holes*

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Abstract

Black holes were long predicted by general relativity, they have been observed in collapsed stars and galactic centers, and are universally accepted as real. But the orthodox GR equations were derived and tested for weak gravitational fields, and the extrapolations to large fields may not be valid. While the general evidence for compact gravitational objects is clear, the precision of the observations of these objects is quite low. In particular, there is virtually no evidence for event horizons, the central feature of the orthodox theory. Some recent observations of black holes that have been widely promoted may reflect confirmation bias on noisy signals, rather than independent data analysis.

Introduction

Everyone believes in black holes. They were predicted a century ago from Einstein's gravitational field equations, and are an established component of modern astrophysics. A large number of collapsed massive stars in our galaxy have been identified as black holes, and supermassive black holes are believed to be present in the centers of most galaxies. A radio image of a black hole was recently reported, and others reported mergers of two black holes by their gravitational radiation signature. Further, black holes and even more exotic structures such as wormholes have become well established within the science fiction universe.

On the contrary, I hold the opposite viewpoint, that black holes are purely fictional, and do not exist in the real world. The theory of black holes depends on extrapolation of equations many orders of magnitude beyond their demonstrated range of validity, into an unexplored regime of strong gravitational fields. The astronomical observations indicate the presence of compact massive objects, but they do not have the accuracy to say anything about theoretical black holes.

The most recent observations come from large consortia of many researchers, and report complex fitting to very noisy data. The results validate exactly what was predicted, and serve to justify very expensive investments into facilities and personnel. Given the natural tendency toward confirmation bias, these results should be viewed with suspicion by properly skeptical scientists.

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Event Horizons and Divergences

The key parameter in gravitational theory is the normalized potential, $\phi = -GM/Rc^2$ a distance R from a large mass M. At the surface of the sun, $\phi = -2 \times 10^{-6}$. The most accurate tests of GR are for ϕ on this order or less. The primary predictions of GR correspond to time dilation and length contraction by a factor $(1+2\phi)^{-0.5}$. Note that since ϕ is always negative, this factor diverges for $|\phi| = 0.5$ and becomes imaginary for $|\phi| > 0.5$, which is 5 orders of magnitude beyond standard precision tests of GR. But this corresponds to the event horizon of a black hole, at the Schwarzschild radius $Rs = 2GM/c^2$.

To lowest order in ϕ, the GR factor becomes $(1-\phi)$, which is always >1 for all ϕ. If one extrapolates this factor to large fields, this completely avoids event horizons and other singularities. Taking this alternative model seriously [1] leads to a compact object (a "dim star") that traps most but not all light, even for $|\phi| >> 1$. This is a regime that would be completely inaccessible for orthodox GR. There is no reason to assume that this is the proper extrapolation, but it provides a useful alternative limit for evaluation.

There may be physical reasons to question the existence of a divergence at an event horizon. Infinity is a mathematical concept, which does not normally exist in the real world. However, it would be better to attempt precision observations in regions of large ϕ, for example by examining gravitational lensing near where one would expect an event horizon. But that would require accurate measurement of the mass M of a compact object and resolution on the scale of Rs, which would be 30 km for a star of 10 solar masses. That spatial resolution seems difficult, unless the star would be unusually close. For a supermassive black hole of a million solar masses or more, such as in the center of galaxies, Rs would be larger than a million km, which might be possible to resolve using telescope systems with very large baselines. Without such quantitative measurements, the existence and structure of a black hole is speculation, rather than real science.

Gravitational Wave Detection of Black Hole Mergers

Gravitational radiation is a standard prediction of GR, but would also be expected for any theory whereby changes in gravitational fields travel at the speed of light. However, this radiation is so weak, that it is very difficult to detect. The first indirect evidence of gravitational radiation was observed in the gradual decay of the rotation rate of binary pulsars, associated with radiational energy loss. However, direct detection of gravitational radiation would be preferred, and large laser interferometers have been developed for this purpose. The *Laser Interferometric Gravitational Wave Observatory* (LIGO) consists of two such interferometers in the U.S.

An ordinary event such as a rotating pulsar would be far too weak to show up on these interferometers. Only a much stronger transient event, such as two black holes in their final stages of catastrophic merging, would be expected to do so. And indeed, such an event was detected soon after an upgrade in the sensitivity of LIGO in 2015, and announced in 2016 after the data from both interferometers were carefully analyzed for several months [2]. This was modeled as the merger of two black holes, each of about 30 solar masses, spiraling together in a distant galaxy 1.3 billion light years away. Several other similar events were subsequently reported by LIGO.

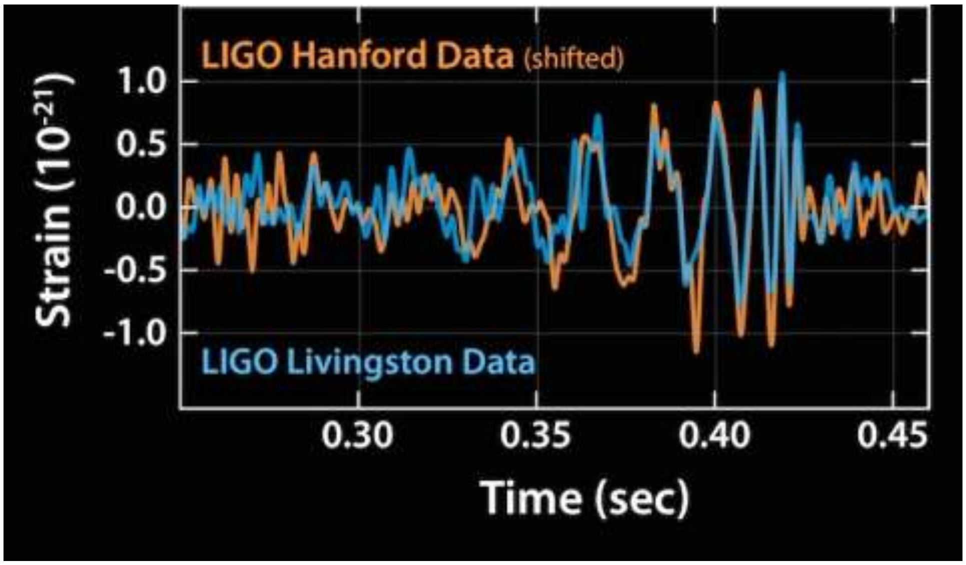

Fig. 1. Digitally processed signals of merging black holes from two LIGO interferometers.

These LIGO observations were universally acclaimed as major scientific achievements, and the very next year, in 2017, three scientists were awarded the Nobel Prize in Physics specifically for LIGO and these observations [3]. Note that Einstein was awarded the Nobel Prize in Physics in 1922, not for the verification of GR in 1919 (which was still controversial), but rather for his explanation of the photoelectric effect, which dated to 1905.

But the congratulations for LIGO were not completely unanimous. One research group, led by Dr. Andrew Jackson of the Niels Bohr Institute in Copenhagen, argued that the reported black hole events were probably just noise in the detectors [4-6]. This criticism is controversial, but essentially argues that these were not separate events in the two detectors, but rather extensive signal processing of the data from both detectors taken together, with a digital filter designed to look for exactly the type of signal that was detected. This group concluded one of their papers [6] with the statement

> *We remain convinced that data must be analyzed and a best common signal determined without a priori biases and preconceptions before theoretical models are invoked. It is a truism that, if gravitational waves are all you look for, gravitational waves are all you will ever find.*

I agree. While I am sure that gravitational waves exist, I am not convinced that the LIGO events are real, or even if they are, that they are due to colliding black holes.

Radio Image of Supermassive Black Hole

Another major breakthrough involving black holes was announced in 2019, a radio image of a supermassive black hole in M87, an elliptical galaxy 50 million light years away [7]. This black hole is believed to have a mass of 7 billion solar masses, and a Schwarzschild radius of 2 billion km. The image shows a black center and a white halo around it, what one might expect from a black hole, with gravitational lensing of light from behind.

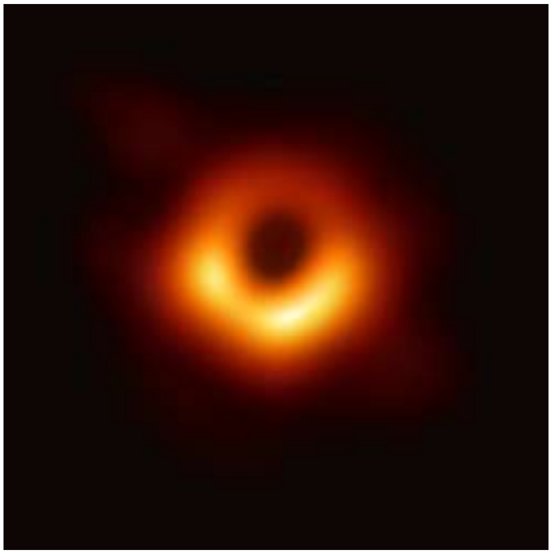

Fig. 2. Radio image of M87 supermassive black hole, from Event Horizon Telescope collaboration.

But this is not a simple photograph. This image was digitally generated by the *Event Horizon Telescope*, a large consortium of 8 radio telescopes across the globe, needed to obtain the required spatial resolution. This consortium was created specifically to image black holes, and M87 was identified in advance. The data was quite noisy, and the analysis required two years by a team of computer scientists to obtain the final image. This image was widely viewed as a great success, and the EHT Collaboration was recently rewarded with a large ($13M) grant to develop time-lapse images that can be processed into black hole movies [8].

If this image does indeed represent an accurate distribution of electromagnetic radiation near the event horizon of a supermassive black hole, this could provide important information that is not otherwise available. However, when complex digital data processing creates exactly the expected image, I would be suspicious that the analysis may unintentionally reflect confirmation bias. I am skeptical that this image contains significant independent information on the structure or existence of black holes or other massive gravitational objects.

Conclusions

There are good reasons to question whether the theory of black holes is correct, particularly with regard to the structure of the event horizon. The observations of black holes appear to assume that the theory is correct, and look for supporting information, which inevitably agrees with the orthodox theory. I remain skeptical whether any of this is valid. A proper application of the scientific method requires developing approaches that can disprove an orthodox theory or distinguish it from an alternative theory. Until that happens, black holes will remain objects of science fiction, not science fact.

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