We are IntechOpen,
the world's leading publisher of
Open Access books
Built by scientists, for scientists

6,900
Open access books available

186,000
International authors and editors

200M
Downloads

Our authors are among the

154
Countries delivered to

TOP 1%
most cited scientists

12.2%
Contributors from top 500 universities

CLARIVATE ANALYTICS
BOOK CITATION INDEX
INDEXED

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

Introductory Chapter: Black Holes, The Singularity Problem, and The Universe

Eugene Terry Tatum

1. Black holes

Black holes are arguably the most fascinating and mysterious objects in the known universe. Our fascination is heightened by the recent imaging, for the first time, of the event horizon of a galactic supermassive black hole. This was a monumental feat of ingenuity and engineering on the part of contemporary astronomers, mathematicians, computer programmers, and physicists. And it was, equally, a monumental achievement of the human mind, dating back to the work of Albert Einstein in the early days of the twentieth century.

As first recognized by German physicist Karl Schwarzschild in 1916, Einstein's general theory of relativity predicts the existence of a particularly strange phenomenon occurring inside the radius of any celestial object whose mass becomes equal to $rc^2/2G$. It was soon apparent that an object satisfying the Schwarzschild metric should not allow anything, including light, to escape from within this "horizon" radius.

2. Singularity problem

Stranger still, it eventually became apparent that such an object had no obvious means of stabilizing itself at any given radius of gravitational collapse, *no matter how small!* Effectively, an empty black "hole" would be created inside the Schwarzschild radius, with the exception of an infinitely small and infinitely dense "singularity" at the hole's geometric center. This was a strange prediction of general relativity that even Einstein could not accept. After all, what could "infinitely small" and "infinitely dense" even mean?!

Infinity may be an acceptable concept to a mathematician, but physicists tend to abhor the idea of real objects with infinite properties. Accordingly, we would prefer to invoke real or imagined principles of quantum physics in order to avoid the conundrum presented by an infinite singularity. This has become the primary inspiration for developing theories of quantum gravity collectively known as loop quantum gravity. It is also a primary motivation for the intrinsically beautiful, although somewhat abstract, hyperdimensional and mathematically complex collection of string theories. Unfortunately, there is not, as of yet, a fully coherent and provable theory of quantum gravity upon which we can hope to understand the inner workings of a black hole, to say nothing of the gravitational conditions at the inception of the universe. This singularity problem is just one of the many puzzling things about black holes and the very early universe, some of which are addressed in this book.

3. Universe

In the 1960s, English mathematical physicists Roger Penrose and Stephen Hawking cleverly extended the black hole singularity problem to our expanding universe. They proved that a backward time extrapolation of the expansion should inevitably lead to the same problem implied at the geometric center of a Schwarzschild black hole. Thus, allowing for the time symmetry of general relativity, the implication of their work [1–3] was that our universe has this feature, *and perhaps others*, in common with a nonrotating, electrically neutral, black hole. Whether the universe could be a time-reversed black hole-like object (sometimes referred to as a "white hole") has been a subject of vigorous debate over the last 50 years [4–11].

When one rearranges the Schwarzschild formula, it is readily apparent that the M/r ratio (the ratio of the gravitational mass to Schwarzschild's horizon radius) of an equilibrated, nonrotating, electrically neutral black hole must equal $c^2/2G$. This ratio (approximately 6.73×10^{26} kg/m in metric units) is effectively a constant of nature incorporating two of the most fundamental constants of nature, Maxwell's speed of light and Newton's gravitational constant. Furthermore, one could make a strong argument that this mathematical relationship is a reliable *signature* of a black hole or black hole-like object.

One of the features surprisingly in common between Schwarzschild black holes and the observable universe has been documented fairly recently and has been a subject of great interest to myself and others. A series of astronomical observations since the early 1990s [12–15] allow one to calculate a reasonably accurate M/r ratio value for the observable universe. If so inclined, the interested reader can skip the foundational references indicated and simply look up the relevant numbers on the Wikipedia link entitled "observable universe." The mass M of the observable universe is now estimated to be 1.5×10^{53} kg, and the radius r of the observable universe is now estimated to be 4.4×10^{26} m. One can readily see that this implies a current M/r ratio value for the observable universe of approximately 3.4×10^{26} kg/m. Consequently, *the M/r ratio values for an equilibrated Schwarzschild black hole and the expanding observable universe are of the same order of magnitude*. One should let that sink in.

4. A useful model

The above calculation made from recently published observations was unavailable to an earlier generation of physicists. This new result, in combination with the time-symmetric properties of general relativity enshrined within Hawking's singularity theorem, provides an excellent starting point for exploring the heuristic cosmology model of the universe I present in this book. It is believed to be the first cosmology model of its kind, namely, that which solely incorporates in its assumptions reasonable speculations about black hole time reversal. Thus, Hawking's singularity theorem is the founding principle of this model which I call flat space cosmology.

So far, this model appears to be quite accurate with respect to correlations between its embedded predictions at any particular point in cosmic time and a variety of astronomical observations. It is my hope that the reader will begin with this chapter and be inspired to study the model further. The competing "concordance model" incorporating inflationary cosmology may not be the last word after all!

5. A sense of wonder

As the reader delves further into this book, it is also my hope that he or she will have a sense of wonder for how far we have come in understanding black holes and

the rules governing the expansion of our universe. That so much of our universe is actually comprehensible was a wonder to even Albert Einstein. However, as the new ideas presented in this book clearly show, there are still many creative avenues for further exploration.

Author details

Eugene Terry Tatum
Independent Researcher, Bowling Green, Kentucky, USA

*Address all correspondence to: ett@twc.com

IntechOpen

References

[1] Penrose R. Gravitational collapse and space-time singularities. Physical Review Letters. 1965;**14**(3):57-59

[2] Hawking S. Properties of expanding universes [PhD.5437]. Cambridge University Library; 1966. Available from: https://cudl.lib.cam.ac.uk/view/MS-PHD-05437/134

[3] Hawking S, Penrose R. The singularities of gravitational collapse and cosmology. Proceedings of the Royal Society of London A. 1970;**314**:529-548

[4] Pathria RK. The universe as a black hole. Nature. 1972;**240**(5379):298299

[5] Poplawski N. Radial motion into an Einstein-Rosen bridge. Physics Letters B. 2010;**687**(2-3):110-113. DOI: 10.1016/j.physletb.2010.03.029

[6] Seshavatharam UVS. Physics of rotating and expanding black hole universe. Progress in Physics. 2010;**2**:7-14

[7] Cowen R. Quantum bounce could make black holes explode. Interview with Carlo Rovelli. 2014. Available from: www.nature.com/1.15573

[8] Tatum ET. Could our universe have features of a giant black hole? Journal of Cosmology. 2015;**25**:13061-13080

[9] Tatum ET. How a black hole universe theory might resolve some cosmological conundrums. Journal of Cosmology. 2015;**25**:13081-13111

[10] Haggard HM, Rovelli C. Quantum-gravity effects outside the horizon spark black to white hole tunneling. Physical Review D. 2015;**92**:104020

[11] Laguipo A. Black holes may be possible portals to another universe: Stephen Hawking. Interview article.

2016. Available from: www.techtimes.com/articles/153308

[12] Bars I, Terning J. Extra Dimensions In Space And Time. Springer; 2009. p. 27. ISBN 978-0-387-77637-8

[13] Planck Collaboration. Planck 2015 results. XIII. Cosmological parameters. Astronomy & Astrophysics. 2016;**594**:A13. arXiv:1502.01589. DOI: 10.1051/0004-6361/201525830

[14] Lineweaver C, Davis TM. Misconceptions about the big bang. Scientific American. 2005;**292**(3):36-45. DOI: 10.1038/scientificamerican0305-36

[15] Bennett CL et al. Seven-year Wilkinson microwave anisotropy probe (WMAP) observations: Are there cosmic microwave background anomalies? Astrophysical Journal Supplement. 2011;**192**(2):17. arXiv:1001.4758. DOI: 10.1088/0067-0049/192/2/17