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Einstein's Monsters: The Life and Times of Black Holes
Black Holes, White Dwarfs, and Neutron Stars

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KENDRA JACKSON

Cosmological and Black Hole Apparent Horizons Pan Macmillan These lecture notes are dedicated to the most recent theoretical applications of Black Hole solutions in high-energy physics. The main motivation of this volume is to present the latest black hole backgrounds that are relevant for gauge/gravity correspondence. Leading scientists in the field explain effective techniques for finding singular and cosmological solutions embedded in gauged supergravity, shedding light on underlying properties and symmetries. Starting from a basic level, the mathematical structures underlying black holes and cosmologies are revealed, helping the reader grasp the connection between theoretical approaches and physical observations with insights into possible future developments from both a theoretical and experimental point of view. The topics covered in this volume are based on lectures delivered during the “Theoretical Frontiers in Black Holes and Cosmology” school, held in Natal in June 2015. Exploring Black Holes Springer Nature

A self-contained introduction to the mathematical theory of black holes.

Big Bang Black Holes No Math Springer Science & Business Media

Einstein's General Theory of Relativity leads to two remarkable predictions: first, that the ultimate destiny of many massive stars is to undergo gravitational collapse and to disappear from view, leaving behind a 'black hole' in space; and secondly, that there will exist singularities in space-time itself. These singularities are places where space-time begins or ends, and the presently known laws of physics break down. They will occur inside black holes, and in the past are what might be construed as the beginning of the universe. To show how these predictions arise, the authors discuss the General Theory of Relativity in the large. Starting with a precise formulation of the theory and an account of the necessary background of differential geometry, the significance of space-time curvature is discussed and the global properties of a number of exact solutions of Einstein's field equations are examined. The theory of the causal structure of a general space-time is developed, and is used to study black holes and to prove a number of theorems establishing the inevitability of singualarities under certain conditions. A discussion of the Cauchy problem for General Relativity is also included in this 1973 book.

A Relativist's Toolkit

Imperial College Press Teachers continue to look for ways to make math meaningful by providing students with problems and examples demonstrating its applications in everyday life. Space Mathematics offers math applications through one of the strongest motivators-Space. Technology makes it possible for students to experience the value of math, instead of just reading about it. Technology is essential to mathematics and science for such purposes as "access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information." Black Hole Math is designed to be used as a supplement for teaching mathematical topics. The problems can be used to enhance understanding of the mathematical concept, or as a good assessment of student mastery. This collection of activities is based on a weekly series of space science problems distributed to thousands of teachers during the 2004-2008 school years. They were intended as supplementary problems for students looking for additional challenges in the math and physical science curriculum in grades 10 through 12. The problems are designed to be 'one-pagers' consisting of a Student Page, and Teacher's Answer Key. This compact form was deemed very popular by participating teachers. The topic for this

collection is Black Holes, which is a very popular, and mysterious subject among students hearing about astronomy. Students have endless questions about these exciting and exotic objects as many of you may realize! Amazingly enough, many aspects of black holes can be understood by using simple algebra and pre-algebra mathematical skills. This booklet fills the gap by presenting black hole concepts in their simplest mathematical form. General Approach: The activities are organized according to progressive difficulty in mathematics. Students need to be familiar with scientific notation, and it is assumed that they can perform simple algebraic computations involving exponentiation, square-roots, and have some facility with calculators. The assumed level is that of Grade 10-12 Algebra II, although some problems can be worked by Algebra I students. Some of the issues of energy, force, space and time may be appropriate for students taking high school Physics.

Black Hole Math W. W. Norton & Company

This thesis presents a systematic study of the orbital evolution, gravitational wave radiation, and merger remnant of the black hole–neutron star binary merger in full general relativity for the first time. Numerical-relativity simulations are performed using an adaptive mesh refinement code, SimulAtor for Compact objects in Relativistic Astrophysics (SACRA),

which adopts a wide variety of zero-temperature equations of state for the neutron star matter. Gravitational waves provide us with quantitative information on the neutron star compactness and equation of state via the cutoff frequency in the spectra, if tidal disruption of the neutron star occurs before the binary merges. The cutoff frequency will be observed by next-generation laser interferometric ground-based gravitational wave detectors, such as Advanced LIGO, Advanced VIRGO, and KAGRA. The author has also determined that the mass of remnant disks are sufficient for the remnant black hole accretion disk to become a progenitor of short-hard gamma ray bursts accompanied by tidal disruptions and suggests that overspinning black holes may not be formed after the merger of even an extremely spinning black hole and an irrotational neutron star.

The Mathematical Theory of Black Holes

Cambridge University Press

Now in paperback, this book by Nobel prizewinner S. Chandrasekhar, is devoted to the mathematical theory of the space-times surrounding the black holes of nature. Since the general theory of relativity provides a single unique family of solutions (the Kerr family) for black holes, the subject is mathematically a very well defined one. Besides, the analysis discloses a richness rarely encountered in

mathematical physics. A preliminary chapter provides the basic mathematical tools. The principal chapters deal with the Schwarzchild solution describing static spherically symmetric black holes. The geometry of these space-times is analysed in terms of their geodesics. A particular feature of the book is the collection of illustrations exhibiting the various classes of geodesics.

A Random Walk in Physics Yale University Press

As a result of significant research over the past 20 years, black holes are now linked to some of the most spectacular and exciting phenomena in the Universe, ranging in size from those that have the same mass as stars to the super-massive objects that lie at the heart of most galaxies, including our own Milky Way. This book first introduces the properties of simple isolated holes, then adds in complications like rotation, accretion, radiation, and magnetic fields, finally arriving at a basic understanding of how these immense engines work. Black Hole Astrophysics • reviews our current knowledge of cosmic black holes and how they generate the most powerful observed pheonomena in the Universe; • highlights the latest, most up-to-date theories and discoveries in this very active area of astrophysical research; • demonstrates why we believe that black holes are responsible for important phenomena such as quasars, microquasars and gammaray bursts; •

explains to the reader the nature of the violent and spectacular outfl ows (winds and jets) generated by black hole accretion.

Black Hole Physics John Wiley & Sons

This book overviews the extensive literature on apparent cosmological and black hole horizons. In theoretical gravity, dynamical situations such as gravitational collapse, black hole evaporation, and black holes interacting with non-trivial environments, as well as the attempts to model gravitational waves occurring in highly dynamical astrophysical processes, require that the concept of event horizon be generalized. Inequivalent notions of horizon abound in the technical literature and are discussed in this manuscript. The book begins with a quick review of basic material in the first one and a half chapters, establishing a unified notation. Chapter 2 reminds the reader of the basic tools used in the analysis of horizons and reviews the various definitions of horizons appearing in the literature. Cosmological horizons are the playground in which one should take baby steps in understanding horizon physics. Chapter 3 analyzes cosmological horizons, their proposed thermodynamics, and several coordinate systems. The remaining chapters discuss analytical solutions of the field equations of General Relativity, scalar-tensor, and f(R) gravity which exhibit time-varying apparent horizons and

horizons which appear and/or disappear in pairs. An extensive bibliography enriches the volume. The intended audience is master and PhD level students and researchers in theoretical physics with knowledge of standard gravity.

Internal Structure of Black Holes and Spacetime Singularities Cambridge University Press

In 1965 Penrose introduced the fundamental concept of a trapped surface, on the basis of which he proved a theorem which asserts that a spacetime containing such a surface must come to an end. The presence of a trapped surface implies, moreover, that there is a region of spacetime, the black hole, which is inaccessible to observation from infinity. Since that time a major challenge has been to find out how trapped surfaces actually form, by analyzing the dynamics of gravitational collapse. The present monograph achieves this aim by establishing the formation of trapped surfaces in pure general relativity through the focusing of gravitational waves. The theorems proved in this monograph constitute the first foray into the long-time dynamics of general relativity in the large, that is, when the initial data are no longer confined to a suitable neighborhood of trivial data. The main new method, the short pulse method, applies to general systems of Euler-Lagrange equations of hyperbolic type and provides the means to tackle problems which have hitherto seemed

unapproachable. This monograph will be of interest to people working in general relativity, geometric analysis, and partial differential equations.

General Relativity

Springer

A pedagogical introduction to the physics of black holes. The membrane paradigm represents the four-dimensional spacetime of the black hole's "event horizon" as a two-dimensional membrane in three-dimensional space, allowing the reader to understand and compute the behavior of black holes in complex astrophysical environments.

The Mathematical Theory of Black Holes

Springer Science & Business Media

Our esteemed colleague C. V. Vishveshwara, popularly known as Vishu, turned sixty on 6th March 1998. His colleagues and well wishers felt that it would be appropriate to celebrate the occasion by bringing out a volume in his honour. Those of us who have had the good fortune to know Vishu, know that he is unique, in a class by himself. Having been given the privilege to be the volume's editors, we felt that we should attempt something different in this endeavour. Vishu is one of the well known relativists from India whose pioneer ing contributions to the studies of black holes is universally recognised. He was a student of Charles Misner. His Ph. D. thesis on the stability of the Schwarzschild black hole, coordinate invariant characterisation of the sta

tionary limit and event horizon for Kerr black holes and subsequent seminal work on quasi-normal modes of black holes have passed on to become the starting points for detailed mathematical investigations on the nature of black holes. He later worked on other aspects related to black holes and compact objects. Many of these topics have matured over the last thirty years. New facets have also developed and become current areas of vigorous research interest. No longer are black holes, ultracompact objects or event horizons mere idealisations of mathematical physicists but concrete entities that astrophysicists detect, measure and look for. Astrophysical evidence is mounting up steadily for black holes.

Theoretical Frontiers in Black Holes and Cosmology Springer

Richly illustrated with the images from observatories on the ground and in space, and computer simulations, this book shows how black holes were discovered, and discusses our current understanding of their role in cosmic evolution. This second edition covers new discoveries made in the past decade, including definitive proof of a black hole at the center of the Milky Way, evidence that the expansion of the Universe is accelerating, and the new appreciation of the connection between black holes and galaxy formation. There are entirely new chapters on gamma-ray bursts and cosmic feedback.

Begelman and Rees blend theoretical arguments with observational results to demonstrate how both approaches contributed to this subject. Clear illustrations and photographs reveal the strange and amazing workings of our universe. The engaging style makes this book suitable for introductory undergraduate courses, amateur astronomers, and all readers interested in astronomy and physics. **Foundations of General Relativity** Cambridge University Press

Black holes have turned out to be the cornerstone of both physics and popular belief. But what if we were to realize that exact black holes cannot exist, even though their existence is apparently suggested by exact general relativistic solutions, and Roger Penrose won the 2020 Nobel Prize in Physics ‘for the discovery that black hole formation is a robust prediction of the general theory of relativity’? While it might seem far-fetched to claim so, it will be worth remembering that

the finest theoretical physicists like Albert Einstein and Paul Dirac did not believe in black holes, and Stephen Hawking finally thought that there are no exact black holes. While the black hole paradigm has become commonplace in popular consciousness, in the last decade, noise has consistently grown about the many physical effects which can inhibit the formation of exact mathematical black holes. In The Rise and Fall of the Black Hole Paradigm, Abhas Mitra shows us

how, much before these developments, he had proven why the so-called black holes must only be black hole pretenders. He identified these black hole candidates to be Magnetospheric Eternally Collapsing Objects (MECOs) and, along with Darryl J. Leiter and Stanley L. Robertson, generalized them. Recent evidence for the existence of strong magnetic fields around so-called black holes may provide confirmations of his claim.

The Formation of Black Holes in General Relativity Springer Science & Business Media What happens when something is sucked into a black hole? Does it disappear? Three decades ago, a young physicist named Stephen Hawking claimed it did-and in doing so put at risk everything we know about physics and the fundamental laws of the universe. Most scientists didn't recognize the import of Hawking's claims, but Leonard Susskind and Gerard t'Hooft realized the threat, and responded with a counterattack that changed the course of physics. THE BLACK HOLE WAR is the thrilling story of their united effort to reconcile Hawking's revolutionary theories of black holes with their own sense of reality-effort that would eventually result in Hawking admitting he was wrong, paying up, and Susskind and t'Hooft realizing that our world is a hologram projected from the outer boundaries of space. A brilliant book about modern physics, quantum mechanics, the fate of stars and the deep

mysteries of black holes, Leonard Susskind's account of the Black Hole War is mind-bending and exhilarating reading.

The Mathematical Theory of Black Holes

Springer

Dive into a mind-bending exploration of the physics of black holes Black holes, predicted by Albert Einstein’s general theory of relativity more than a century ago, have long intrigued scientists and the public with their bizarre and fantastical properties. Although Einstein understood that black holes were mathematical solutions to his equations, he never accepted their physical reality—a viewpoint many shared. This all changed in the 1960s and 1970s, when a deeper conceptual understanding of black holes developed just as new observations revealed the existence of quasars and X-ray binary star systems, whose mysterious properties could be explained by the presence of black holes. Black holes have since been the subject of intense research—and the physics governing how they behave and affect their surroundings is stranger and more mind-bending than any fiction. After introducing the basics of the special and general theories of relativity, this book describes black holes both as astrophysical objects and theoretical “laboratories” in which physicists can test their understanding of gravitational, quantum, and thermal physics. From Schwarzschild black holes to rotating and colliding black holes, and

from gravitational radiation to Hawking radiation and information loss, Steven Gubser and Frans Pretorius use creative thought experiments and analogies to explain their subject accessibly. They also describe the decades-long quest to observe the universe in gravitational waves, which recently resulted in the LIGO observatories' detection of the distinctive gravitational wave "chirp" of two colliding black holes—the first direct observation of black holes' existence. The Little Book of Black Holes takes readers deep into the mysterious heart of the subject, offering rare clarity of insight into the physics that makes black holes simple yet destructive manifestations of geometric destiny.

Gravity Oxford University Press, USA

Readership: Upper level undergraduates, graduate students, lecturers and researchers in theoretical, mathematical and quantum physics.

Black Hole The Mathematical Theory of Black Holes

This is a fascinating and enjoyable popular science book on gravity and black holes. It offers an absorbing account on the history of research on the universe and gravity from Aristotle via Copernicus via Newton to Einstein. The author possesses high literary qualities and is celebrated relativist. The physics of black holes constitutes one of the most fascinating chapters in modern science. At the same time, there is a fanciful quality associated

with this strange and beautiful entity. The black hole story is undoubtedly an adventure through physics, philosophy, history, fiction and fantasy. This book is an attempt to blend all these elements together.

The Little Book of Black Holes Springer

In this masterfully written and brilliantly informed work, Dr. Rhorne, the Feynman Professor of Theoretical Physics at Caltech, leads readers through an elegant, always human, tapestry of interlocking themes, answering the great question: what principles control our universe and why do physicists think they know what they know? Features an introduction by Stephen Hawking.

Dynamics of Extremal Black Holes Cambridge University Press

This self-contained textbook brings together many different branches of physics--e.g. nuclear physics, solid state physics, particle physics, hydrodynamics, relativity--to analyze compact objects. The latest astronomical data is assessed. Over 250 exercises.

The Black Hole War Twenty-First Century Books

"The theory of black holes is the most simple consequence of Einstein's relativity theory. Dealing with relativity theory, this book details one of the most beautiful areas of mathematical physics; the theory of black holes. It represents a personal testament to the work of the author, who spent several years working-out the subject matter."--

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