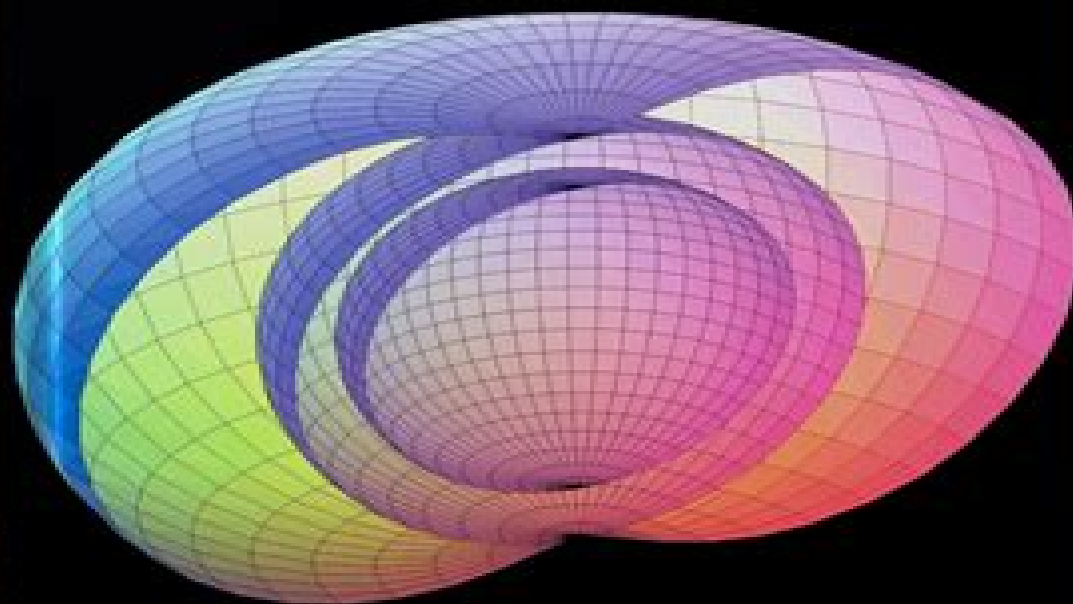




A Relativist's Toolkit

The Mathematics of Black-Hole Mechanics

Eric Poisson



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Kathleen Armour



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A Relativist's Toolkit Eric Poisson, 2004-05-06 This 2004 textbook fills a gap in the literature on general relativity by providing the advanced student with practical tools for the computation of many physically interesting quantities. The context is provided by the mathematical theory of black holes, one of the most elegant, successful, and relevant applications of general relativity. Among the topics discussed are congruences of timelike and null geodesics, the embedding of spacelike, timelike, and null hypersurfaces in spacetime, and the Lagrangian and Hamiltonian formulations of general relativity. Although the book is self-contained, it is not meant to serve as an introduction to general relativity. Instead, it is meant to help the reader acquire advanced skills and become a competent researcher in relativity and gravitational physics. The primary readership consists of graduate students in gravitational physics. It will also be a useful reference for more seasoned researchers working in this field.

Black Holes Sean Alan Hayward, 2013 Black holes, once just fascinating theoretical predictions of how gravity warps space-time according to Einstein's theory, are now generally accepted as astrophysical realities formed by post-supernova collapse or as supermassive black holes mysteriously found at the cores of most galaxies, powering active galactic nuclei, the most powerful objects in the universe. Theoretical understanding has progressed in recent decades with a wider realization that local concepts should characterize black holes rather than the global concepts found in textbooks. In particular, notions such as trapping horizon allow physically meaningful quantities and equations describing how a black hole evolves. This has led to discoveries in fields as diverse as classical and numerical general relativity, differential geometry, thermodynamics, quantum field theory, and quantum gravity. There is heretofore no one volume which covers all the main aspects, so this volume collects together summaries and recent research, each chapter written by an expert or experts in a given field. This is intended for readers at a graduate level upwards who wish to learn about the wide range of research concerning black holes.

Black Hole Physics Daniel Grumiller, Mohammad Mehdi Sheikh-Jabbari, 2022-11-07 This textbook gradually introduces the reader to several topics related to black hole physics with a didactic approach. It starts with the most basic black hole solution, the Schwarzschild metric, and discusses the basic classical properties of black hole solutions as seen by different probes. Then it reviews various theorems about black hole properties as solutions to Einstein gravity coupled to matter fields, conserved charges associated with black holes, and laws of black hole thermodynamics. Next, it elucidates semiclassical and quantum aspects of black holes which are relevant in ongoing and future research. The book is enriched with many exercises and solutions to assist in the learning. The textbook is designed for physics graduate students who want to start their research career in the field of black holes, postdocs who recently changed their research focus towards black holes, and want to get up to date on recent and current research topics, advanced researchers intending to teach or learn basic and advanced aspects of black hole physics, and the associated mathematical tools. Besides general relativity, the reader needs to be familiar with standard undergraduate physics like thermodynamics, quantum mechanics, and

statistical mechanics Moreover familiarity with basic quantum field theory in Minkowski space is assumed The book covers the rest of the needed background material in the main text or the appendices

Geometry of Black Holes Piotr T. Chruściel, 2020-07-31 Black holes present one of the most fascinating predictions of Einstein's general theory of relativity There is strong evidence of their existence through observation of active galactic nuclei including the centre of our galaxy observations of gravitational waves and others There exists a large scientific literature on black holes including many excellent textbooks at various levels However most of these steer clear from the mathematical niceties needed to make the theory of black holes a mathematical theory Those which maintain a high mathematical standard are either focused on specific topics or skip many details The objective of this book is to fill this gap and present a detailed mathematically oriented extended introduction to the subject The book provides a wide background to the current research on all mathematical aspects of the geometry of black hole spacetimes

Cosmological and Black Hole Apparent Horizons Valerio Faraoni, 2015-07-01 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

Introduction to Black Hole Physics Valeri P. Frolov, Andrei Zelnikov, 2011-09-23 This book is about black holes one of the most intriguing objects of modern theoretical physics and astrophysics For many years black holes have been considered as interesting solutions of the Theory of General Relativity with a number of amusing mathematical properties Now after the discovery of astrophysical black holes the Einstein gravity has become an important tool for their study This self contained textbook combines physical mathematical and astrophysical aspects of black hole theory Pedagogically presented it contains standard material on black holes as well as relatively new subjects such as the role of hidden symmetries in black hole physics and black holes in spacetimes with large extra dimensions The book will appeal to students and young scientists interested in the theory of black holes

Introduction to Mathematical Black Holes Awad Elawad, 2024-05-26 This book is a very useful introduction for students

and scholars of black holes through a detailed explanation of the equations and concepts related to astronomical black holes. The importance of the book lies in simplifying mathematical equations without hindrance and making them accessible to understanding away from complexity. The book's sequence also allows students to progress in understanding smoothly and easily.

Black Holes: A Laboratory for Testing Strong Gravity Cosimo Bambi, 2017-06-01 This textbook introduces the current astrophysical observations of black holes and discusses the leading techniques to study the strong gravity region around these objects with electromagnetic radiation. More importantly, it provides the basic tools for writing an astrophysical code and testing the Kerr paradigm. Astrophysical black holes are an ideal laboratory for testing strong gravity. According to general relativity, the spacetime geometry around these objects should be well described by the Kerr solution. The electromagnetic radiation emitted by the gas in the inner part of the accretion disk can probe the metric of the strong gravity region and test the Kerr black hole hypothesis. With exercises and examples in each chapter as well as calculations and analytical details in the appendix, the book is especially useful to the beginners or graduate students who are familiar with general relativity while they do not have any background in astronomy or astrophysics.

Einstein Equations: Physical and Mathematical Aspects of General Relativity Sergio Cacciatori, Batu Güneysu, Stefano Pigola, 2019-11-23 This book is based on lectures given at the first edition of the Domoschool, the International Alpine School in Mathematics and Physics held in Domodossola, Italy, in July 2018. It is divided into two parts. Part I consists of four sets of lecture notes. These are extended versions of lectures given at the Domoschool, written by well-known experts in mathematics and physics related to General Relativity. Part II collects talks by selected participants focusing on research related to General Relativity.

New Frontiers in GRMHD Simulations Cosimo Bambi, Yosuke Mizuno, Swarnim Shashank, Feng Yuan, 2025-03-10 This book offers an updated comprehensive review of the rapidly expanding field of GRMHD simulations. In Part I, it reviews the basic equations for GRMHD simulations and for numerical relativity. Part II describes public codes for GRMHD simulations. Part III is devoted to accretion processes onto compact objects in the non-self-gravitating fluid approximation. Part IV reviews the state of the art of GRMHD simulations with self-gravitating fluids. This book represents both a valuable book for graduate students and an important reference resource for researchers in the field.

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