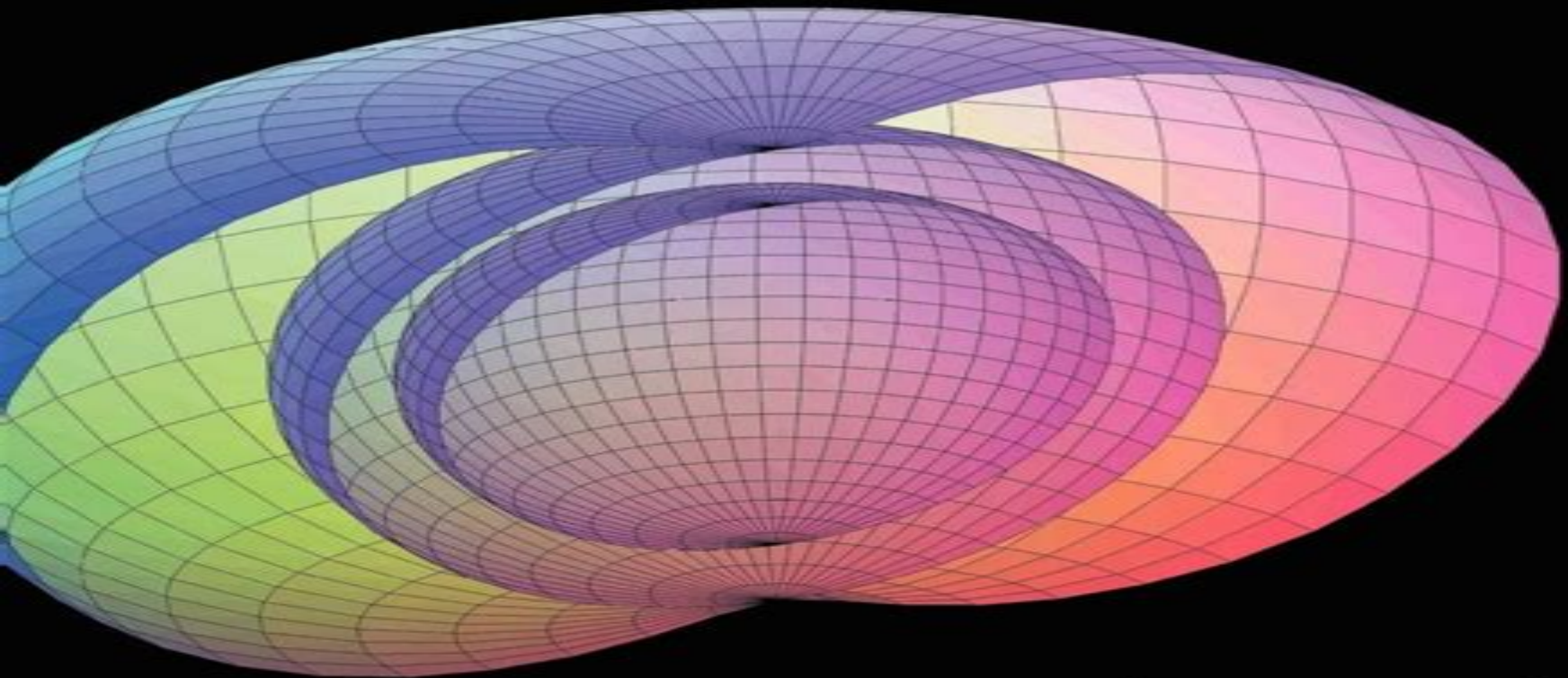


A Relativist's Toolkit

The Mathematics of Black-Hole Mechanics

Eric Poisson



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A Relativists Toolkit The Mathematics Of Black Hole Mechanics

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A Relativists Toolkit The Mathematics Of Black Hole Mechanics:

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 congruencies 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

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 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

Introduction to Black Hole Physics Valeri P. Frolov, Andrei Zelnikov, 2011-09-22 What is a black hole How many of them are in our Universe Can black holes be created in a laboratory or in particle colliders Can objects similar to black holes be used for space and time travel This book discusses these and many other questions providing the reader with the tools required to explore the Black Hole Land independently

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 Black holes present one of the most fascinating predictions of Einstein's general relativity with strong evidence of their existence through observations of many means 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

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

An Introduction to Mathematical Relativity José

Natário,2021-03-24 This concise textbook introduces the reader to advanced mathematical aspects of general relativity covering topics like Penrose diagrams causality theory singularity theorems the Cauchy problem for the Einstein equations the positive mass theorem and the laws of black hole thermodynamics It emerged from lecture notes originally conceived for a one semester course in Mathematical Relativity which has been taught at the Instituto Superior Técnico University of Lisbon Portugal since 2010 to Masters and Doctorate students in Mathematics and Physics Mostly self contained and mathematically rigorous this book can be appealing to graduate students in Mathematics or Physics seeking specialization in general relativity geometry or partial differential equations Prerequisites include proficiency in differential geometry and the basic principles of relativity Readers who are familiar with special relativity and have taken a course either in Riemannian geometry for students of Mathematics or in general relativity for those in Physics can benefit from this book 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 p **Foundations of General Relativity** Klaas

Landsman,2021-10-08 This book dedicated to Roger Penrose is a second mathematically oriented course in general relativity It contains extensive references and occasional excursions in the history and philosophy of gravity including a relatively lengthy historical introduction The book is intended for all students of general relativity of any age and orientation who have a background including at least first courses in special and general relativity differential geometry and topology The material is developed in such a way that through the last two chapters the reader may acquire a taste of the modern mathematical study of black holes initiated by Penrose Hawking and others as further influenced by the initial value or PDE approach to general relativity Successful readers might be able to begin reading research papers on black holes especially in mathematical physics and in the philosophy of physics The chapters are Historical introduction General differential geometry Metric differential geometry Curvature Geodesics and causal structure The singularity theorems of Hawking and Penrose The Einstein equations The 3+1 split of space time Black holes I Exact solutions and Black holes II General theory These are followed by two appendices containing background on Lie groups Lie algebras constant curvature and on Formal PDE theory

The Black Hole-Neutron Star Binary Merger in Full General Relativity Koutarou Kyutoku,2013-01-11 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 SimulAstor 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 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 important reference resource for researchers in the field

Effects of Non-locality in Gravity and Quantum Theory Jens Boos, 2021-10-28 This thesis is devoted to the systematic study of non local theories that respect Lorentz invariance and are devoid of new unphysical degrees of freedom Such theories are attractive for phenomenological applications since they are mostly unconstrained by current experiments Non locality has played an increasingly important role in the physics of the last decades appearing in effective actions in quantum field theory and arising naturally in string theory and non commutative geometry It may even be a necessary ingredient for quantum theories of gravity It is a feature of quantum entanglement and may even solve the long standing black hole information loss problem Non locality is a broad concept with many promising and fruitful applications in theoretical and mathematical physics After a historical and pedagogical introduction into the concept of non locality the author develops the notion of non local Green functions to study various non local weak field problems in quantum mechanics quantum field theory gravity and quantum field theory in curved spacetime This thesis fills a gap in the literature by providing a self contained exploration of weak field effects in non local theories thereby establishing a non local intuition which may serve as a stepping stone for studies of the full non linear problem of non locality **New Frontiers in**

Gravitational Collapse and Spacetime Singularities Daniele Malafarina, Pankaj S. Joshi, 2024-05-02 The book collects a series of articles to review the advances that have been made in the field of gravitational collapse in general relativity and alternative theories of gravity in the past few years Many approaches to black hole and singularity formation in general

relativity and beyond have been proposed over the last few decades The importance of collapse models is that they provide natural thought experiments where to test the behavior and properties of a variety of approaches to general relativity and its implications for ultra compact objects in the universe Numerical Relativity: Starting from Scratch Thomas W.

Baumgarte, Stuart L. Shapiro, 2021-04-08 A pedagogical and accessible introduction to numerical relativity the key tool to model gravitational waves and black hole mergers Asymptotic Analysis in General Relativity Thierry Daudé, Dietrich

Häfner, Jean-Philippe Nicolas, 2018-01-11 Introduction to modern methods for classical and quantum fields in general relativity Thierry Daud Dietrich H fner and Jean Philippe Nicolas Geometry of black hole spacetimes Lars Andersson Thomas B Ackdahl and Pieter Blue An introduction to Quantum Field Theory on curved space times Christian Gerard A minicourse on microlocal analysis for wave propagation Andras Vasy An introduction to conformal geometry and tractor calculus with a view to applications in general relativity Sean N Curry and A Rod Gover **Sixteenth Marcel Grossmann Meeting, The:**

On Recent Developments In Theoretical And Experimental General Relativity, Astrophysics, And Relativistic Field Theories - Proceedings Of The Mg16 Meeting On General Relativity (In 4 Volumes) Remo Ruffini, Gregory

Vereshchagin, 2022-12-15 The proceedings of MG16 give a broad view of all aspects of gravitational physics and astrophysics from mathematical issues to recent observations and experiments The scientific program of the meeting included 46 plenary presentations 3 public lectures 5 round tables and 81 parallel sessions arranged during the intense six day online meeting All talks were recorded and are available on the ICRANet YouTube channel at the following link www.icranet.org/video_mg16

These proceedings are a representative sample of the very many contributions made at the meeting They contain 383 papers among which 14 come from the plenary sessions The material represented in these proceedings cover the following topics accretion active galactic nuclei alternative theories of gravity black holes theory observations and experiments binaries boson stars cosmic microwave background cosmic strings dark energy and large scale structure dark matter education exact solutions early universe fundamental interactions and stellar evolution fast transients gravitational waves high energy physics history of relativity neutron stars precision tests quantum gravity strong fields and white dwarf all of them represented by a large number of contributions The online e proceedings are published in an open access format

Instabilities in Field Theory Adrià Delhom, Alejandro Jiménez Cano, Francisco José Maldonado Torralba, 2023-09-16 This book presents the most common types of instabilities arising in classical field theories namely tachyonic Laplacian ghost like or strong coupling instabilities also commenting on their quantum implications The authors provide a detailed account on the Ostrogradski theorem and its implications for higher order time derivative field theories After presenting the general concepts and formalism they dive into its applications to particular field theories using mainly modified gravity theories as examples The book is intended for advanced undergraduate graduate students but can also be useful for researchers for having a unified exposition of general results on instabilities in field theory and examples of their applications **Fifteenth**

Marcel Grossmann Meeting, The: On Recent Developments In Theoretical And Experimental General Relativity, Astrophysics, And Relativistic Field Theories - Proceedings Of The Mg15 Meeting On General Relativity (In 3 Volumes) Elia S Battistelli, Robert T Jantzen, Remo Ruffini, 2022-05-10 The three volumes of the proceedings of MG15 give a broad view of all aspects of gravitational physics and astrophysics from mathematical issues to recent observations and experiments The scientific program of the meeting included 40 morning plenary talks over 6 days 5 evening popular talks and nearly 100 parallel sessions on 71 topics spread over 4 afternoons These proceedings are a representative sample of the very many oral and poster presentations made at the meeting Part A contains plenary and review articles and the contributions from some parallel sessions while Parts B and C consist of those from the remaining parallel sessions The contents range from the mathematical foundations of classical and quantum gravitational theories including recent developments in string theory to precision tests of general relativity including progress towards the detection of gravitational waves and from supernova cosmology to relativistic astrophysics including topics such as gamma ray bursts black hole physics both in our galaxy and in active galactic nuclei in other galaxies and neutron star pulsar and white dwarf astrophysics Parallel sessions touch on dark matter neutrinos X ray sources astrophysical black holes neutron stars white dwarfs binary systems radiative transfer accretion disks quasars gamma ray bursts supernovas alternative gravitational theories perturbations of collapsed objects analog models black hole thermodynamics numerical relativity gravitational lensing large scale structure observational cosmology early universe models and cosmic microwave background anisotropies inhomogeneous cosmology inflation global structure singularities chaos Einstein Maxwell systems wormholes exact solutions of Einstein s equations gravitational waves gravitational wave detectors and data analysis precision gravitational measurements quantum gravity and loop quantum gravity quantum cosmology strings and branes self gravitating systems gamma ray astronomy cosmic rays and the history of general relativity

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