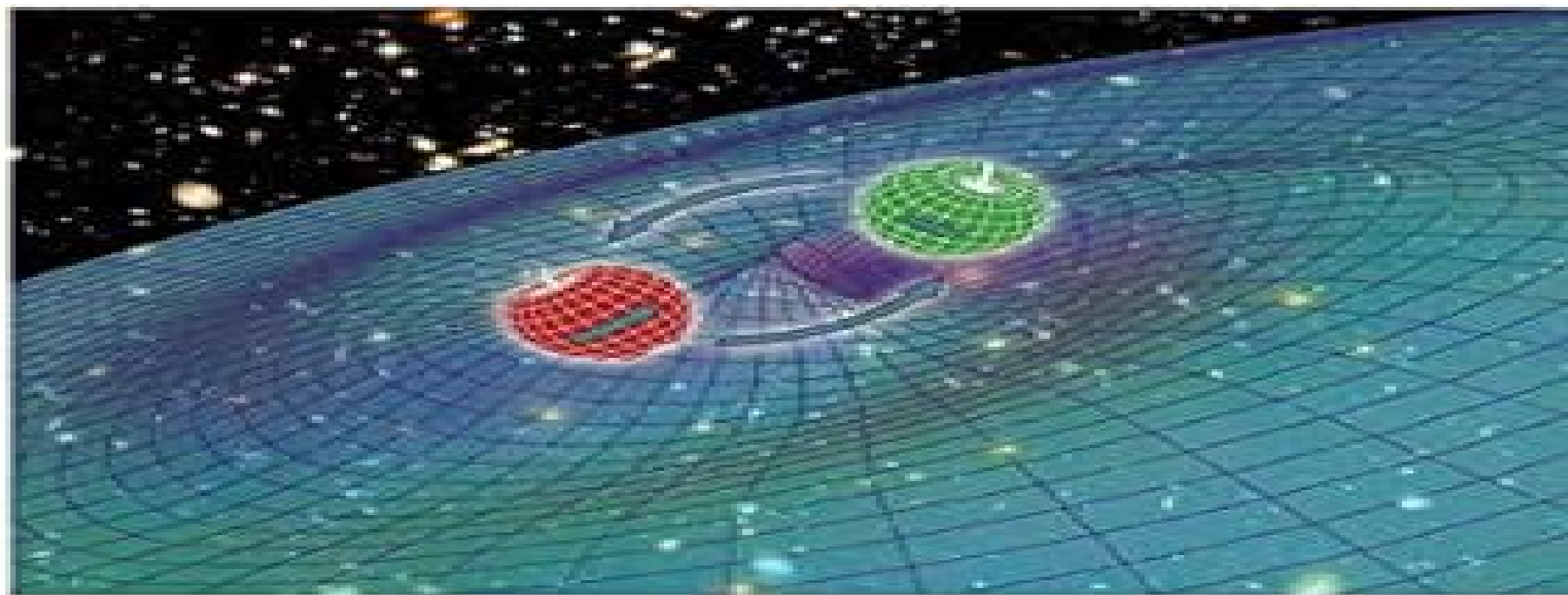


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# Gravitational-Wave Physics and Astronomy

An Introduction to Theory, Experiment and Data Analysis



# Gravitational Wave Physics And Astronomy An

**Joseph Weber**



## **Gravitational Wave Physics And Astronomy An:**

Gravitational-Wave Physics and Astronomy Jolien D. E. Creighton, Warren G. Anderson, 2012-01-09 This most up to date one stop reference combines coverage of both theory and observational techniques with introductory sections to bring all readers up to the same level Written by outstanding researchers directly involved with the scientific program of the Laser Interferometer Gravitational Wave Observatory LIGO the book begins with a brief review of general relativity before going on to describe the physics of gravitational waves and the astrophysical sources of gravitational radiation Further sections cover gravitational wave detectors data analysis and the outlook of gravitational wave astronomy and astrophysics

**Gravitational-Wave Astronomy** Nils Andersson, 2019-11-28 This book is an introduction to gravitational waves and related astrophysics It provides a bridge across the range of astronomy physics and cosmology that comes into play when trying to understand the gravitational wave sky Starting with Einstein s theory of gravity chapters develop the key ideas step by step leading up to the technology that finally caught these faint whispers from the distant universe The second part of the book makes a direct connection with current research introducing the relevant language and making the involved concepts less mysterious The book is intended to work as a platform low enough that anyone with an elementary understanding of gravitational waves can scramble onto it but at the same time high enough to connect readers with active research and the many exciting discoveries that are happening right now The first part of the book introduces the key ideas following a general overview chapter and including a brief reminder of Einstein s theory This part can be taught as a self contained one semester course The second part of the book is written to work as a collection of set pieces with core material that can be adapted to specific lectures and additional material that provide context and depth A range of readers may find this book useful including graduate students astronomers looking for basic understanding of the gravitational wave window to the universe researchers analysing data from gravitational wave detectors and nuclear and particle physicists Nanohertz Gravitational Wave Astronomy Stephen R. Taylor, 2021-11-23 Nanohertz Gravitational Wave Astronomy explores the exciting hunt for low frequency gravitational waves by using the extraordinary timing precision of pulsars The book takes the reader on a tour across the expansive gravitational wave landscape from LIGO detections to the search for polarization patterns in the Cosmic Microwave Background then hones in on the band of nanohertz frequencies that Pulsar Timing Arrays PTAs are sensitive to Within this band may lie many pairs of the most massive black holes in the entire Universe all radiating in chorus to produce a background of gravitational waves The book shows how such extra Galactic gravitational waves can alter the arrival times of radio pulses emanating from monitored Galactic pulsars and how we can use the pattern of correlated timing deviations from many pulsars to tease out the elusive signal The book takes a pragmatic approach to data analysis explaining how it is performed in practice within classical and Bayesian statistics as well as the numerous strategies one can use to optimize numerical Bayesian searches in PTA analyses It closes with a complete discussion of the data model for nanohertz

gravitational wave searches and an overview of the past achievements present efforts and future prospects for PTAs The book is accessible to upper division undergraduate students and graduate students of astronomy and also serves as a useful desk reference for experts in the field Key features Contains a complete derivation of the pulsar timing response to gravitational waves and the overlap reduction function for PTAs Presents a comprehensive overview of source astrophysics and the dynamical influences that shape the gravitational wave signals that PTAs are sensitive to Serves as a detailed primer on gravitational wave data analysis and numerical Bayesian techniques for PTAs

**Gravitational Waves in Physics and Astrophysics** M. Coleman Miller,Nicolas Yunes,2022-03-15 The direct detection of gravitational waves in 2015 has initiated a new era of gravitational wave astronomy which has already paid remarkable dividends in our understanding of astrophysics and gravitational physics Aimed at advanced undergraduates and graduate students this book introduces gravitational waves and its many applications to cosmology nuclear physics astrophysics and theoretical physics The material is presented in a pedagogical way through Fermi estimates and detailed explanations and discussions The student will not only learn what gravitational waves are and how they are produced but also how they can be used to learn about astrophysical phenomena and cosmological observations to investigate the interior of neutron stars and to test general relativity when black holes and neutron stars collide Key Features Provides a concise yet comprehensive treatment of gravitational wave physics Emphasises fundamental physical principles Provides a coherent integration of astrophysical and general relativistic intuition Includes carefully chosen problems designed to improve student intuition Written by experts in the field

Gravitational Wave Astrophysics Carlos F. Sopuerta,2014-12-15 This book offers review chapters written by invited speakers of the 3rd Session of the Sant Cugat Forum on Astrophysics Gravitational Waves Astrophysics All chapters have been peer reviewed The book goes beyond normal conference proceedings in that it provides a wide panorama of the astrophysics of gravitational waves and serves as a reference work for researchers in the field

**Understanding Gravitational Waves** C. R.

Kitchin,2021-09-23 The birth of a completely new branch of observational astronomy is a rare and exciting occurrence For a long time our theories about gravitational waves proposed by Albert Einstein and others more than a hundred years ago could never be fully proven since we lacked the proper technology to do it That all changed when on September 14 2015 instruments at the LIGO Observatory detected gravitational waves for the first time This book explores the nature of gravitational waves what they are where they come from why they are so significant and why nobody could prove they existed before now Written in plain language and interspersed with additional explanatory tutorials it will appeal to lay readers science enthusiasts physical science students amateur astronomers and to professional scientists and astronomers

Gravitational Waves Ajit Kembhavi,Pushpa Khare,2020-08-06 Gravitational waves were first predicted by Albert Einstein in 1916 a year after the development of his new theory of gravitation known as the general theory of relativity This theory established gravitation as the curvature of space time produced by matter and energy To be discernible even to the most

sensitive instruments on Earth the waves have to be produced by immensely massive objects like black holes and neutron stars which are rotating around each other or in the extreme situations which prevail in the very early ages of the Universe This book presents the story of the prediction of gravitational waves by Albert Einstein the early attempts to detect the waves the development of the LIGO detector the first detection in 2016 the subsequent detections and their implications All concepts are described in some detail without the use of any mathematics and advanced physics which are needed for a full understanding of the subject The book also contains description of electromagnetism Einstein's special theory and general theory of relativity white dwarfs neutron stars and black holes and other concepts which are needed for understanding gravitational waves and their effects Also described are the LIGO detectors and the cutting edge technology that goes into building them and the extremely accurate measurements that are needed to detect gravitational waves The book covers these ideas in a simple and lucid fashion which should be accessible to all interested readers The first detection of gravitational waves was given a lot of space in the print and electronic media So the curiosity of the non technical audience has been aroused about what gravitational waves really are and why they are so important This book seeks to answer such questions

*General Relativity and Gravitational Waves* Sanjeev Dhurandhar, Sanjit Mitra, 2022-02-16 This book serves as a textbook for senior undergraduate students who are learning the subject of general relativity and gravitational waves for the first time Both authors have been teaching the course in various forms for a few decades and have designed the book as a one stop book at basic level including derivations and exercises A spectacular prediction of general relativity is gravitational waves Gravitational waves were first detected by the LIGO detectors in 2015 hundred years after their prediction Both authors are part of the LIGO Science Collaboration and were authors on the discovery paper Therefore a strong motivation for this book is to provide the essential concepts of general relativity theory and gravitational waves with their modern applications to students and to researchers who are new to the multi disciplinary field of gravitational wave astronomy One of the advanced topics covered in this book is the fundamentals of gravitational wave data analysis filling a gap in textbooks on general relativity The topic blends smoothly with other chapters in the book not only because of the common area of research but it uses similar differential geometric and algebraic tools that are used in general relativity

*LISA and the Future of Gravitational Wave Physics and Astronomy*, 2003 Gravitational waves offer views of the universe which complement those in electromagnetic waves and neutrinos Just as different frequencies of the electromagnetic spectrum highlight different astrophysical phenomena different frequencies of gravitational radiation will highlight different kinds of objects The NASA ESA Laser Interferometer Space Antenna LISA planned for launch in 2010 will detect and measure gravitational radiation from astronomical sources at frequencies 0.0001 Hz to 0.1 Hz vs 10-1000 Hz for ground based detectors like LIGO LISA will detect continuous signals from thousands of exotic binary stars in the Milky Way merging supermassive black holes in the nuclei of merging galaxies at redshifts from 0 to 100 and compact stars scattered into

supermassive black holes The latter will provide precision tests of strong field predictions of relativity such as the No Hair Theorem and energy extraction from rotating black holes We will conclude with an outline of some of the limitations of and remarkable possibilities for the future of gravitational wave physics and astronomy Report of the Ad Hoc Committee on Gravitation Physics and Astronomy United States. National Aeronautics and Space Administration. Ad Hoc Committee on Gravitation Physics and Astronomy,1990 *Gravitational Waves* Hartmut Grote,2020 The historic detection of gravitational waves on September 14 2015 prompted by the highly energetic fusion of two black holes has made events in the universe audible for the first time This expansion of the scientific sensorium has opened a new chapter in astronomy and already led to among others fascinating new insights about the abundance of black holes the collision of neutron stars and the origin of heavy chemical elements The history of this event which is epochal for physics is reconstructed in this book along with a walk through of the main principles of how the detectors operate and a discussion of how the search for gravitational waves is conducted The book concludes with an update of the latest detections and developments to date and a brief look into the future of this exciting research field This book is accessible to non specialist readers from a general audience and is also an excellent introduction to the topic for undergraduates in physics Features Provides an introduction to the historic discovery of gravitational waves Explains the inner workings of the detectors and the search to find the waves hidden in the data Authored by a renowned specialist involved in the ground breaking discovery Hartmut Grote is a Professor of physics at Cardiff University UK His main expertise is in experimental gravitational wave physics and he has worked on building and improving gravitational wave detectors for over 20 years From 2009 to 2017 he was the scientific leader of the British German gravitational wave detector GEO600 **Gravity from the Ground Up** Bernard Schutz,2003-12-04 This book invites the reader to understand our Universe not just marvel at it From the clock like motions of the planets to the catastrophic collapse of a star into a black hole gravity controls the Universe Gravity is central to modern physics helping to answer the deepest questions about the nature of time the origin of the Universe and the unification of the forces of nature Linking key experiments and observations through careful physical reasoning the author builds the reader's insight step by step from simple but profound facts about gravity on Earth to the frontiers of research Topics covered include the nature of stars and galaxies the mysteries of dark matter and dark energy black holes gravitational waves inflation and the Big Bang Suitable for general readers and for undergraduate courses the treatment uses only high school level mathematics supplemented by optional computer programs to explain the laws of physics governing gravity Einstein Was Right Jed Z. Buchwald,2020-10-13 An authoritative interdisciplinary account of the historic discovery of gravitational waves In 1915 Albert Einstein predicted the existence of gravitational waves ripples in the fabric of spacetime caused by the movement of large masses as part of the theory of general relativity A century later researchers with the Laser Interferometer Gravitational Wave Observatory LIGO confirmed Einstein's prediction detecting gravitational waves generated by the

collision of two black holes Shedding new light on the hundred year history of this momentous achievement Einstein Was Right brings together essays by two of the physicists who won the Nobel Prize for their instrumental roles in the discovery along with contributions by leading scholars who offer unparalleled insights into one of the most significant scientific breakthroughs of our time This illuminating book features an introduction by Tilman Sauer and invaluable firsthand perspectives on the history and significance of the LIGO consortium by physicists Barry Barish and Kip Thorne Theoretical physicist Alessandra Buonanno discusses the new possibilities opened by gravitational wave astronomy and sociologist of science Harry Collins and historians of science Diana Kormos Buchwald Daniel Kennefick and Jürgen Renn provide further insights into the history of relativity and LIGO The book closes with a reflection by philosopher Don Howard on the significance of Einstein's theory for the philosophy of science Edited by Jed Buchwald Einstein Was Right is a compelling and thought provoking account of one of the most thrilling scientific discoveries of the modern age

**General Relativity and Gravitational Waves** Joseph Weber, 1961 Gravitational Waves: A New Window to the Universe Rosalba Perna, Bruno Giacomazzo, 2021-07-02 Gravitational Waves Michele Maggiore, 2007-10-05 The aim of this book is to become a major reference text for gravitational wave physics covering in detail both the experimental and the theoretical aspects It is the only existing book on gravitational waves to date and it will likely remain unique for its broadness and scope It brings the reader to the forefront of present day research both theoretical and experimental assuming no previous knowledge of gravitational wave physics Part I of Volume 1 is devoted to the theory of gravitational waves Here we have re derived in a coherent way most of the results that we present clarifying or streamlining existing derivations Part II of Volume 1 is devoted to a description of experimental gravitational wave physics We discuss in great detail existing and planned experiments as well as data analysis techniques Overview Of Gravitational Waves, An: Theory, Sources And Detection Gerard Auger, Eric Plagnol, 2017-02-15 This book describes detection techniques used to search for and analyze gravitational waves GW It covers the whole domain of GW science starting from the theory and ending with the experimental techniques both present and future used to detect them The theoretical sections of the book address the theory of general relativity and of GW followed by the theory of GW detection The various sources of GW are described as well as the methods used to analyse them and to extract their physical parameters It includes an analysis of the consequences of GW observations in terms of astrophysics as well as a description of the different detectors that exist and that are planned for the future With the recent announcement of GW detection and the first results from LISA Pathfinder this book will allow non specialists to understand the present status of the field and the future of gravitational wave science

**Gravity!** Pierre Binétruy, 2018-04-23 What force do the Big Bang the expansion of the Universe dark matter and dark energy black holes and gravitational waves all have in common This book uncovers gravity as a key to understanding these fascinating phenomena that have so captivated public interest in recent years Readers will discover the latest findings on how this familiar force in our everyday lives

powers the most colossal changes in the Universe Written by the widely recognized French public scientist and leading astrophysicist Pierre Bin try the book also explains the recent experimental confirmation of the existence of gravitational waves

**Gravitational Waves and Cosmology** Eugenio Cocchia, Joe Silk, Nicola Vittorio, 2020-08-15 The past twenty years have seen a number of breakthroughs in astrophysics and cosmology some of which have been awarded Nobel prizes These physics triumphs highlight the fact that while students need a solid grounding in the fundamentals of astrophysics and cosmology sight of the basics of the fundamental interactions in physics must not be lost This book presents papers based on lectures given at the 200th Course of the International School of Physics Enrico Fermi on Gravitation and Cosmology held in Varenna Italy from 3-12 July 2017 The aim of the school was to expose students to state of the art research in the field of gravitational waves and cosmology from both a theoretical and experimental point of view Lectures were organized in such a way as to foster interaction between the two communities and a wide range of topics was addressed In the gravitational waves section topics covered include experimental issues connected with gravitational wave detection and the new field of multi messenger astronomy as well as more astrophysical aspects In the section on cosmology there are contributions on the early universe on the cosmic microwave background CMB and on redshift surveys Other areas covered include a review of inflationary scenarios the non Gaussian features of primordial density fluctuations and the physical mechanisms responsible for the spectral distortions of the blackbody spectrum of the CMB The book provides an overview of important research developments and will be of interest to all students of gravitation and cosmology

**General Relativity and Gravitational Waves** Joseph Weber, 2004-01-01 An internationally famous physicist and electrical engineer the author of this text was a pioneer in the investigation of gravitational waves Joseph Weber's General Relativity and Gravitational Waves offers a classic treatment of the subject Appropriate for upper level undergraduates and graduate students this text remains ever relevant Brief but thorough in its introduction to the foundations of general relativity it also examines the elements of Riemannian geometry and tensor calculus applicable to this field Approximately a quarter of the contents explores theoretical and experimental aspects of gravitational radiation The final chapter focuses on selected topics related to general relativity including the equations of motion unified field theories Friedman's solution of the cosmological problem and the Hamiltonian formulation of general relativity Exercises Index



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