

# **BLACK HOLES**

## **THE MEMBRANE PARADIGM**



edited by

KIP S. THORNE, RICHARD H. PRICE, and DOUGLAS A. MACDONALD

# Black Holes The Membrane Paradigm

**Edwin Thomas, Derek J Raine**



## **Black Holes The Membrane Paradigm:**

**Black Holes** Kip S. Thorne, Kirk S. Thorne, Richard H. Price, Douglas A. MacDonald, 1986-01-01 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 *Black Holes* Kip S. Thorne, Richard H. Price, Douglas A. MacDonald, 1986 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

**High Energy Radiation from Black Holes** Charles D. Dermer, Govind Menon, 2009-09-21 Bright gamma ray flares observed from sources far beyond our Milky Way Galaxy are best explained if enormous amounts of energy are liberated by black holes The highest energy particles in nature the ultra high energy cosmic rays cannot be confined by the Milky Way s magnetic field and must originate from sources outside our Galaxy Understanding these energetic radiations requires an extensive theoretical framework involving the radiation physics and strong field gravity of black holes In High Energy Radiation from Black Holes Charles Dermer and Govind Menon present a systematic exposition of black hole astrophysics and general relativity in order to understand how gamma rays cosmic rays and neutrinos are produced by black holes Beginning with Einstein s special and general theories of relativity the authors give a detailed mathematical description of fundamental astrophysical radiation processes including Compton scattering of electrons and photons synchrotron radiation of particles in magnetic fields photohadronic interactions of cosmic rays with photons gamma ray attenuation Fermi acceleration and the Blandford Znajek mechanism for energy extraction from rotating black holes The book provides a basis for graduate students and researchers in the field to interpret the latest results from high energy observatories and helps resolve whether energy released by rotating black holes powers the highest energy radiations in nature The wide range of detail will make High Energy Radiation from Black Holes a standard reference for black hole research The membrane paradigm for black holes

**Physics of Black Holes** Eleftherios Papantonopoulos, 2009-01-28 Black Holes are still considered to be among the most mysterious and fascinating objects in our universe Awaiting the era of gravitational astronomy much progress in theoretical modeling and understanding of classical and quantum black holes has already been achieved The present volume serves as a tutorial high level guided tour through the black hole landscape information paradox and blackhole thermodynamics numerical simulations of black hole formation and collisions braneworld scenarios and stability of black holes with respect to perturbations are treated in great detail as is their possible occurrence at the LHC An outgrowth of a topical and tutorial summer school this extensive set of carefully edited notes has been set up with the aim of constituting an advanced level multi authored textbook which meets the needs

of both postgraduate students and young researchers in the fields of modern cosmology astrophysics and quantum field theory

**Black Holes** Derek J. Raine, Edwin George Thomas, 2010 This introduction to the fascinating subject of black holes fills a significant gap in the literature which exists between popular non mathematical expositions and advanced textbooks at the research level It is designed for advanced undergraduates and first year postgraduates as a useful stepping stone to the advanced literature The book provides an accessible introduction to the exact solutions of Einstein's vacuum field equations describing spherical and axisymmetric rotating black holes The geometry and physical properties of these spacetimes are explored through the motion of particles and light The use of different coordinate systems maximal extensions and Penrose diagrams is explained The association of the surface area of a black hole with its entropy is discussed and it is shown that with the introduction of quantum mechanics black holes cease to be black and can radiate This result allows black holes to satisfy the laws of thermodynamics and thus be consistent with the rest of physics In this new edition the problems in each chapter have been revised and solutions are provided The text has been expanded to include new material on wormholes and clarify various other issues

**Astronomy and Astrophysics Abstracts** S. Böhme, U. Esser, H. Hefele, I. Heinrich, W. Hofmann, D. Krahn, V. R. Matas, L. D. Schmadel, G. Zech, 2013-12-14 From the reviews Astronomy and Astrophysics Abstracts has appeared in semi annual volumes since 1969 and it has already become one of the fundamental publications in the fields of astronomy astrophysics and neighbouring sciences It is the most important English language abstracting journal in the mentioned branches The abstracts are classified under more than hundred subject categories thus permitting a quick survey of the whole extended material The AAA is a valuable and important publication for all students and scientists working in the fields of astronomy and related sciences As such it represents a necessary ingredient of any astronomical library all over the world Space Science Reviews 1 Dividing the whole field plus related subjects into 108 categories each work is numbered and most are accompanied by brief abstracts Fairly comprehensive cross referencing links relevant papers to more than one category and exhaustive author and subject indices are to be found at the back making the catalogues easy to use The series appears to be so complete in its coverage and always less than a year out of date that I shall certainly have to make a little more space on those shelves for future volumes The Observatory Magazine 1

**Introduction to Black Hole Astrophysics** Gustavo E. Romero, Gabriela S. Vila, 2013-09-14 This book is based on the lecture notes of a one semester course on black hole astrophysics given by the author and is aimed at advanced undergraduate and graduate students with an interest in astrophysics The material included goes beyond that found in classic textbooks and presents details on astrophysical manifestations of black holes In particular jet physics and detailed accounts of objects like microquasars active galactic nuclei gamma ray bursts and ultra luminous X ray sources are covered as well as advanced topics like black holes in alternative theories of gravity The author avoids unnecessary technicalities and to some degree the book is self contained The reader will find some basic general relativity tools in Chapter 1 The appendices

provide some additional mathematical details that will be useful for further study and a guide to the bibliography on the subject

*Black Holes in Higher Dimensions* Gary T. Horowitz, 2012-04-19 The first book devoted to black holes in more than four dimensions for graduate students and researchers

**Black Holes: A Student Text (3rd Edition)** Edwin Thomas, Derek J Raine, 2014-09-30 This book provides an accessible introduction to the fascinating and topical subject of black holes It bridges the gap between popular non mathematical expositions and advanced research texts using simple undergraduate level calculations and the most basic knowledge of relativity to explain current research This means the theory can be understood by a wide audience of physicists including those who are not necessarily interested in learning higher level mathematical techniques The third edition links more of the current research trends to fundamental aspects of the physics of black holes Additionally This new edition introduces a chapter dedicated to a selection of recent results Existing chapters have been updated and new explanatory material has been added to aid in the understanding of the physics This book is recommended reading for advanced undergraduate students and first year postgraduates who will find it a useful stepping stone to the advanced literature

**Black Hole Physics** V. Frolov, I. Novikov, 2012-12-06 It is not an exaggeration to say that one of the most exciting predictions of Einstein's theory of gravitation is that there may exist black holes putative objects whose gravitational fields are so strong that no physical bodies or signals can break free of their pull and escape The proof that black holes do exist and an analysis of their properties would have a significance going far beyond astrophysics Indeed what is involved is not just the discovery of yet another even if extremely remarkable astrophysical object but a test of the correctness of our understanding of the properties of space and time in extremely strong gravitational fields Theoretical research into the properties of black holes and into the possible corollaries of the hypothesis that they exist has been carried out with special vigor since the beginning of the 1970s In addition to those specific features of black holes that are important for the interpretation of their possible astrophysical manifestations the theory has revealed a number of unexpected characteristics of physical interactions involving black holes By the middle of the 1980s a fairly detailed understanding had been achieved of the properties of the black holes their possible astrophysical manifestations and the specifics of the various physical processes involved Even though a completely reliable detection of a black hole had not yet been made at that time several objects among those scrutinized by astrophysicists were considered as strong candidates to be confirmed as being black holes

**International Conference on Theoretical Physics** Daniel Iagolnitzer, Vincent Rivasseau, Jean Zinn-Justin, 2012-12-06 The International Conference on Theoretical Physics TH 2002 took place in Paris from July 22 to 27 in the Conference Center of the UNESCO the United Nations Educational Scientific and Cultural Organization under aegis of the IUPAP the International Union of Pure and Applied Physics and of the French and European Physical Societies with a large support of several French European and international Institutions International and crossdisciplinary TH 2002 welcomed around 1200 participants representing all domains of modern theoretical physics The conference offered

a high level scientific program including 18 plenary lectures 45 general lectures in thematic sessions and 140 more specialized lectures partly invited and partly selected among proposals received from participants Around 500 contributions were also presented as posters Plenary lectures as well as general thematic lectures were addressed to a general audience of theoreticians not only to specialists According to our commitments towards UNESCO and other sponsoring institutions TH 2002 attributed more than 200 fellowships mostly to scientists from developing countries and Eastern Europe covering registration fees and for more than half of them stay expenses with student type accommodation Special highlights of the conference included the opening ceremony on July 22 with the participation of Mrs Claudie Haignere French Minister of Research and M Walter Erdelen General Ad joint Director for Sciences at UNESCO Their opening addresses were especially appreciated and are reproduced below This ceremony preceded the first lecture by Professor Cohen Tannoudji Physics Nobel prize winner

Gravitation Charles W. Misner, Kip S. Thorne, John Archibald Wheeler, 2017-10-24 Spacetime physics Physics in flat spacetime The mathematics of curved spacetime Einstein's geometric theory of gravity Relativistic stars The universe Gravitational collapse and black holes Gravitational waves Experimental tests of general relativity Frontiers

**Black Hole Physics** V. de Sabbata, Zhenjiu Zhang, 2012-12-06 In these last years Black hole Physics has developed rapidly both from theoretical and observational aspects especially as regards quantum aspects many things must be clarified as for instance the processes occurring near mini black holes with spontaneous creation of particles that eventually lead to the evaporation of black hole In these last stages probably a connection with string theory will appear This field of research was subject of the NATO Advanced study Institute on Black Hole Physics which was held at the Ettore Majorana Center for Scientific Culture in Erice Sicily th Italy from May 12th through May 22 1991 It was at the same time the 12th Course of the International School of Cosmology and Gravitation During this 12th Course after recalling the starting point that is the concept of black hole in Newton theory the lectures are gone through classical quantum cosmological and astrophysical aspects Of course in order to understand fully the behaviour of these objects one is faced with a large number of broad areas related to different branches of physics In fact have been widely treated not only classical aspects thermodynamics entropy internal dynamics cosmology inflation and astrophysics but quantum behaviour involving creation of particles Hawking radiation until the modern theory of strings and superstrings that claims the unification of all interactions So the physics involved and discussed in the various lectures goes from cosmology and very early universe to that of elementary particles including neutrino physics

*Black Holes* Lawrence A. Jameson, 2002

**High Energy Astrophysics** Malcolm S. Longair, 2011-02-03 Providing students with an in depth account of the astrophysics of high energy phenomena in the Universe the third edition of this well established textbook is ideal for advanced undergraduate and beginning graduate courses in high energy astrophysics Building on the concepts and techniques taught in standard undergraduate courses this textbook provides the astronomical and astrophysical background for students to explore more advanced topics Special emphasis is given to the

underlying physical principles of high energy astrophysics helping students understand the essential physics The third edition has been completely rewritten consolidating the previous editions into one volume It covers the most recent discoveries in areas such as gamma ray bursts ultra high energy cosmic rays and ultra high energy gamma rays The topics have been rearranged and streamlined to make them more applicable to a wide range of different astrophysical problems

*The Tenth Marcel Grossmann Meeting* M. Novello, Santiago E. Perez Bergliaffa, Remo Ruffini, 2005 The Marcel Grossmann meetings were conceived to promote theoretical understanding in the fields of physics mathematics astronomy and astrophysics and to direct future technological observational and experimental efforts They review recent developments in gravitation and general relativity with major emphasis on mathematical foundations and physical predictions Their main objective is to bring together scientists from diverse backgrounds and their range of topics is broad from more abstract classical theory and quantum gravity and strings to more concrete relativistic astrophysics observations and modeling This Tenth Marcel Grossmann Meeting was organized by an international committee composed of D Blair Y Choquet Bruhat D Christodoulou T Damour J Ehlers F Everitt Fang Li Zhi S Hawking Y Ne eman R Ruffini chair H Sato R Sunyaev and S Weinberg and backed by an international coordinating committee of about 135 members from scientific institutions representing 54 countries The scientific program included 29 morning plenary talks during 6 days and 57 parallel sessions over five afternoons during which roughly 500 papers were presented These three volumes of the proceedings of MG10 give a broad view of all aspects of gravitation from mathematical issues to recent observations and experiments

**Tenth Marcel Grossmann Meeting, The: On Recent Developments In Theoretical & Experimental General Relativity, Gravitation, & Relativistic Field Theories (In 3 Vols) - Procs Of The Mgio Meeting Held At Brazilian Ctr For Res In Phys (Cbpf)** Mario Novello, Santiago Perez Bergliaffa, Remo Ruffini, 2006-02-17 The Marcel Grossmann meetings were conceived to promote theoretical understanding in the fields of physics mathematics astronomy and astrophysics and to direct future technological observational and experimental efforts They review recent developments in gravitation and general relativity with major emphasis on mathematical foundations and physical predictions Their main objective is to bring together scientists from diverse backgrounds and their range of topics is broad from more abstract classical theory and quantum gravity and strings to more concrete relativistic astrophysics observations and modeling This Tenth Marcel Grossmann Meeting was organized by an international committee composed of D Blair Y Choquet Bruhat D Christodoulou T Damour J Ehlers F Everitt Fang Li Zhi S Hawking Y Ne eman R Ruffini chair H Sato R Sunyaev and S Weinberg and backed by an international coordinating committee of about 135 members from scientific institutions representing 54 countries The scientific program included 29 morning plenary talks during 6 days and 57 parallel sessions over five afternoons during which roughly 500 papers were presented These three volumes of the proceedings of MG10 give a broad view of all aspects of gravitation from mathematical issues to recent observations and experiments

**The Black Hole at the Center of Our**

**Galaxy** Fulvio Melia, 2003 With this superbly illustrated elegantly written nontechnical account of the most enigmatic astronomical object yet observed Melia captures all the excitement of the growing realization that humans are on the verge of actually seeing this exotic black hole object within the next few years 39 illustrations

**Lectures on Quantum Gravity** Andres Gomberoff, Donald Marolf, 2006-05-30 The 2002 Pan American Advanced Studies Institute School on Quantum Gravity was held at the Centro de Estudios Cientificos CECS Valdivia Chile January 4-14 2002 The school featured lectures by ten speakers and was attended by nearly 70 students from over 14 countries A primary goal was to foster interaction and communication between participants from different cultures both in the layman's sense of the term and in terms of approaches to quantum gravity We hope that the links formed by students and the school will persist throughout their professional lives continuing to promote interaction and the essential exchange of ideas that drives research forward This volume contains improved and updated versions of the lectures given at the School It has been prepared both as a reminder for the participants and so that these pedagogical introductions can be made available to others who were unable to attend We expect them to serve students of all ages well



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