

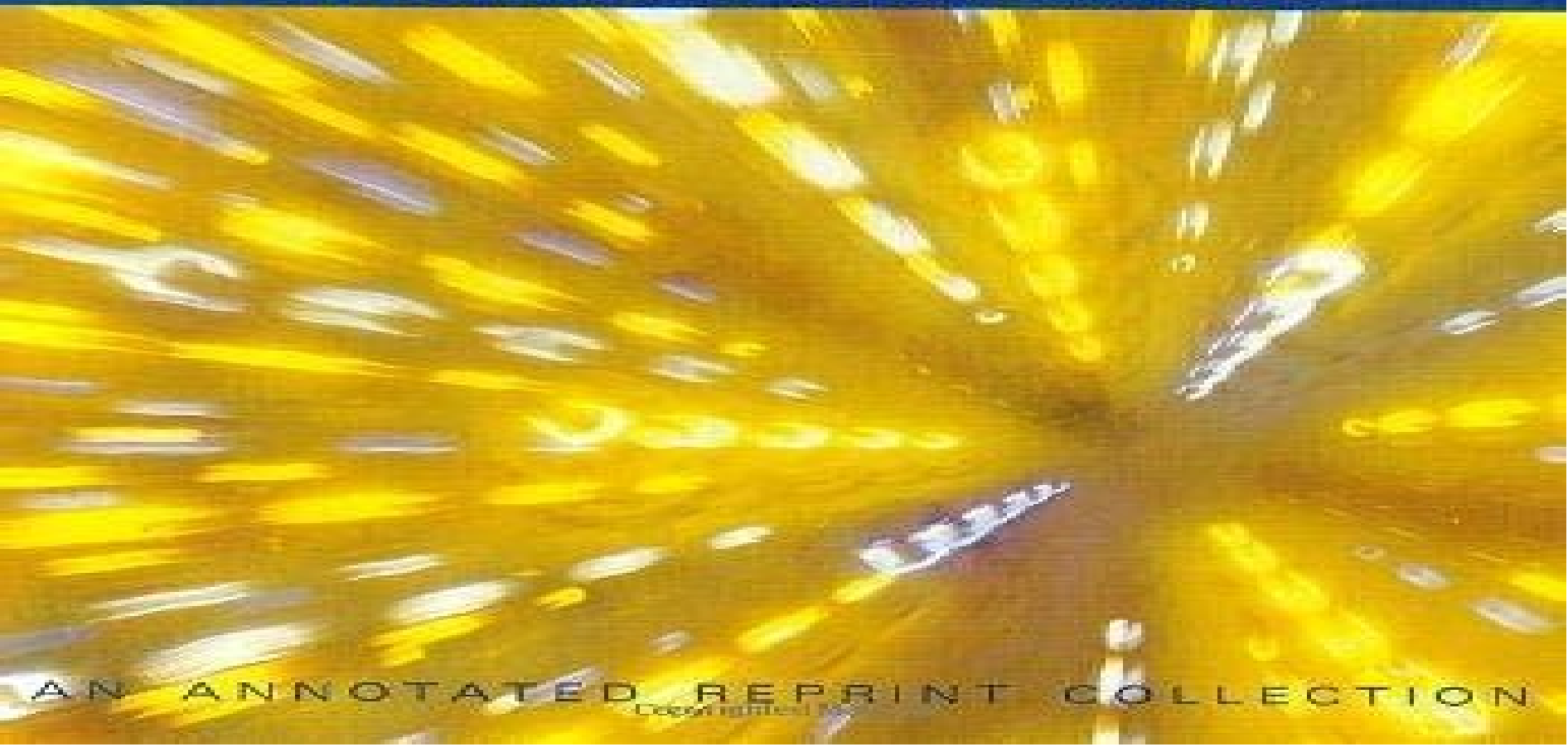


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# QUARK-GLUON PLASMA

## THEORETICAL FOUNDATIONS



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# Quark Gluon Plasma Theoretical Foundations An Annotated Reprint Collection

**Wanda Maria Alberico, Maria-paola  
Lombardo, Marzia Nardi**



## **Quark Gluon Plasma Theoretical Foundations An Annotated Reprint Collection:**

Quark-Gluon Plasma: Theoretical Foundations J. Kapusta, B. Müller, J. Rafelski, 2003-11-25 The purpose of this volume is to trace the development of the theoretical understanding of quark gluon plasma both in terms of the equation of state and thermal correlation functions and in terms of its manifestation in high energy nuclear collisions Who among us has not wondered how tall a mountain is on a neutron star what happens when matter is heated and compressed to higher and higher densities what happens when an object falls into a black hole or what happened eons ago in the early universe The study of quark gluon plasma is related in one way or another to these and other thought provoking questions Oftentimes the most eloquent exposition is given in the original papers To this end a selection is made of what are the most important pioneering papers in this field The early 1950s was an era when high energy multiparticle production in cosmic ray interactions attracted the attention of some of the brightest minds in physics and so it should be no surprise that the first reprinted papers deal with the introduction of statistical models of particle production The quark model arose in the 1960s while QCD as such was recognized as the theory of the strong interactions in the 1970s The behavior of matter at high temperatures and supranuclear densities became of wide interest in the nuclear and particle physics communities starting in the 1970s which is when the concept of quark gluon plasma became established The history of the field has been traced up to the early 1990s There are three reasons for stopping at that point in time First most of the key theoretical concepts and formalisms arose before 1993 although many of them continue to be developed today and hopefully well into the future Second papers written after 1992 are much more readily available than those written before due to the advent of the World Wide Web and its electronic preprint databases and journals Finally in making this collection of reprints available as hardcopy one is limited in the number of pages and some papers in the present selection should have been deleted in order to make room for post 1993 papers For the same reason the subject focus must of necessity be limited which means that in this reprint collection two wide subject areas are not addressed the behavior of nuclear matter under extreme conditions is not reported nor is quark matter in neutron stars The broad categories into which the material has been placed reflect the diverse studies of quark gluon plasma and its manifestation They are phase space models of particle production perturbative QCD plasma lattice gauge theory fluid dynamics and flow strangeness heavy flavor charm electromagnetic signals parton cascade and minijets parton energy loss and jet quenching Hanbury Brown Twiss HBT interferometry disoriented chiral condensates phase transition dynamics and cosmology and color superconductivity Each chapter is prefaced by an introduction which contains a list of significant papers which is more complete than the reprinted papers though by no means exhaustive It also contains citations to most relevant papers published up to the date of completion of this volume fall 2002 It is hoped that the short reviews will help bring the reader up to date on the latest developments The selection of papers cited in each chapter and in particular the ones selected for reprinting is solely the responsibility of the Editors It is based on their

best judgement and experience in this field dating back to the mid 1970s In order to be reprinted a paper must have been pioneering in the sense of originality and impact on the field Generally they have been cited over a hundred times by other papers published in refereed journals The final selection was reviewed and discussed among the Editors repeatedly Just because a paper is not included does not mean they do not know of it or do not have a high regard for it All of the papers cited or reprinted are original research contributions There are three other types of publications listed The first is a compilation of books The second is a list of reviews many of which contain a significant amount of original material The third is a list of the proceedings of the series of Quark Matter meetings the primary series of international conferences in this field that is attended by both theorists and experimentalists

**Quark-Gluon Plasma** Kohsuke Yagi, Tetsuo Hatsuda, Yasuo Miake, 2005-12-15 Quark Gluon Plasma introduces the primordial matter composed of two types of elementary particles created at the time of the Big Bang During the evolution of the universe Quark Gluon Plasma QGP undergoes a transition to hadronic matter governed by quantum chromodynamics the law of strong interactions After an introduction to gauge theories various aspects of quantum chromodynamic phase transitions are illustrated in a self contained manner The cosmological approach and renormalization group are discussed as well as the cosmological and astrophysical implications of QGP on the basis of Einstein's equations Recent developments towards the formation of QGP in ultrarelativistic heavy ion collisions are also presented in detail This text is suitable as an introduction for graduate students as well as providing a valuable reference for researchers already working in this and related fields It includes eight appendices and over a hundred exercises

**Melting Hadrons, Boiling Quarks - From Hagedorn Temperature to Ultra-Relativistic Heavy-Ion Collisions at CERN** Johann Rafelski, 2015-10-21 This book shows how the study of multi hadron production phenomena in the years after the founding of CERN culminated in Hagedorn's pioneering idea of limiting temperature leading on to the discovery of the quark gluon plasma announced in February 2000 at CERN Following the foreword by Herwig Schopper the Director General 1981-1988 of CERN at the key historical juncture the first part is a tribute to Rolf Hagedorn 1919-2003 and includes contributions by contemporary friends and colleagues and those who were most touched by Hagedorn Tam's Bir Igor Dremin Torleif Ericson Marek Gdazicki Mark Gorenstein Hans Gutbrod Maurice Jacob Istvan Montvay Berndt Mller Grazyna Odyniec Emanuele Quercigh Krzysztof Redlich Helmut Satz Luigi Sertorio Ludwik Turko and Gabriele Veneziano The second and third parts retrace 20 years of developments that after discovery of the Hagedorn temperature in 1964 led to its recognition as the melting point of hadrons into boiling quarks and to the rise of the experimental relativistic heavy ion collision program These parts contain previously unpublished material authored by Hagedorn and Rafelski conference retrospectives research notes workshop reports in some instances abbreviated to avoid duplication of material and rounded off with the editor's explanatory notes About the editor Johann Rafelski is a theoretical physicist working at The University of Arizona in Tucson USA Born in 1950 in Krakow Poland he received his Ph.D. with Walter Greiner in Frankfurt Germany in

1973 Rafelski arrived at CERN in 1977 where in a joint effort with Hagedorn he contributed greatly to the establishment of the relativistic heavy ion collision and quark gluon plasma research fields Moving on with stops in Frankfurt and Cape Town to Arizona he invented and developed the strangeness quark flavor as the signature of quark gluon plasma

*Quark Confinement and the Hadron Spectrum VI* Nora Brambilla, Umberto D'Alesio, Alberto Devoto, Khin Maung, Giovanni Maria Prosperi, Sergio Serçi, 2005-04-28 This book provides an update on our understanding of strong interactions with theoretical and experimental highlights included It is divided into five sections The first section is devoted to the investigations into the QCD Vacuum and the latest results on the mechanism of quark confinement The second and third sections focus respectively on light and heavy quarks effective field theories Schwinger Dyson approach and lattice QCD results The fourth section deals with the deconfinement mechanism and quark gluon plasma formation signals The last section presents highlights of experiments new physics beyond QCD and nonperturbative approaches in other theories strings and SUSY that may be useful in QCD

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**American Book Publishing Record**, 2004

The British National Bibliography Arthur James Wells, 2004

*Forthcoming Books* Rose Arny, 1996

**Quark-gluon Plasma 4** Rudolph C Hwa, Xin-nian Wang, 2010-02-09 This is a review volume containing articles written by experts on current theoretical topics in the subject of Quark Gluon Plasma created in heavy ion collisions at high energy It is the fourth volume in the series with the same title sequenced numerically The articles are written in a pedagogical style so that they can be helpful to a wide range of researchers from graduate students to mature physicists who have not worked previously on the subject A reader should be able to learn from the reviews without having extensive knowledge of the background literature

Quark-gluon Plasma, 1990

**Quark-gluon Plasma 2** Rudolph C Hwa, 1995-11-16 This is a sequel to the review volume Quark Gluon Plasma There are 13 articles contributed by leading investigators in the field covering a wide range of topics about the theoretical approach to the subject These contributions are timely reviews of nearly all the actively pursued problems written in a pedagogical style suitable for beginners as well as experienced researchers

Quark-gluon Plasma 3 Rudolph C Hwa, Xin-nian Wang, 2004-01-20 This is a review monograph on quark gluon plasma QGP Different theoretical and experimental aspects of the program to produce QGP in relativistic heavy ion collisions are covered by experts in the field This is the third volume in a series on the subject and the first such monograph to focus on the

implications of the experimental results from RHIC the relativistic heavy ion collider at the National Brookhaven Laboratory The review articles will be useful to experienced researchers as well as to graduate students entering the field

Quark-gluon Plasma 5 Xin-nian Wang,2016-01-21 This is the fifth volume in the series on the subject of quark gluon plasma a unique phase created in heavy ion collisions at high energy It contains review articles by the world experts on various aspects of quark gluon plasma taking into account the advances driven by the latest experimental data collected at both the Relativistic Heavy Ion Collider RHIC and the Large Hadron Collider LHC The articles are pedagogical and comprehensive which can be helpful for both new researchers entering the field as well as the experienced physicists working on the subject

**Quark-gluon Plasma 6** Xin-nian Wang,2025-02-27 This book the sixth volume in a series on Quark Gluon Plasma QGP research offers updated reviews on theoretical developments and phenomenological understanding of the hot and dense matter formed in high energy heavy ion collisions Authored by leading experts in the field it delves into how these advancements help shed light on the recent data emerging from the experiments conducted at the Relativistic Heavy Ion Collider RHIC and the Large Hadron Collider LHC Despite setbacks caused by the COVID 19 pandemic the book explores a multitude of recent progresses including insights into jet measurements study of hydrodynamization in QGP flow measurements in large and small systems spin polarization and chiral magnetic effect in relativistic heavy ion collisions Additionally the book features a timely review of the QCD phase diagram in light of the new data collected at the Beam Energy Scan program at RHIC Furthermore it includes a chapter on the growing role of machine learning in analyzing and interpreting complex data Written carefully with detailed analyses and expert reviews Quark Gluon Plasma 6 stands as an invaluable reference for individuals engaged in the field

Quark-gluon Plasma Five ,2016 This is the fifth volume in the series on the subject of quark gluon plasma a unique phase created in heavy ion collisions at high energy It contains review articles by the world experts on various aspects of quark gluon plasma taking into account the advances driven by the latest experimental data collected at both the Relativistic Heavy Ion Collider RHIC and the Large Hadron Collider LHC The articles are pedagogical and comprehensive which can be helpful for both new researchers entering the field as well as the experienced physicists working on the subject

*Study of Quark Gluon Plasma By Particle Correlations in Heavy Ion Collisions* Li Yi,2016-08-25 This thesis covers several important topics relevant to our understanding of quark gluon plasma It describes measurement of the third order harmonic flow using two particle correlations and isolation of flow and non flow contributions to particle correlations in gold gold collisions The work also investigates long range longitudinal correlations in small systems of deuteron gold collisions The former is related to the hydrodynamic transport properties of the quark gluon plasma created in gold gold collisions The latter pertains to the question whether hydrodynamics is applicable to small systems such as deuteron gold collisions and whether the quark gluon plasma can be formed in those small system collisions The work presented in this thesis was conducted with the STAR experiment at the Relativistic Heavy Ion Collider at

Brookhaven National Laboratory where the center of mass energy of both collision systems was a factor of 100 larger than the rest mass of the colliding nuclei The results contained in this thesis are highly relevant to our quest for deeper understanding of quantum chromodynamics The results obtained challenge the interpretation of previous works from several other experiments on small systems and provoke a fresh look at the physics of hydrodynamics and particle correlations pertinent to high energy nuclear collisions

### **Hadrons and Quark-Gluon Plasma** Jean Letessier, Johann

Rafelski, 2002-05-30 Before matter as we know it emerged the universe was filled with the primordial state of hadronic matter called quark gluon plasma This hot soup of quarks and gluons is effectively an inescapable consequence of our current knowledge about the fundamental hadronic interactions quantum chromodynamics This book covers the ongoing search to verify the prediction experimentally and discusses the physical properties of this novel form of matter It begins with an overview of the subject followed by discussion of experimental methods and results The second half of the book covers hadronic matter in confined and deconfined form and strangeness as a signature of the quark gluon phase Covering the basics as well as more advanced material it is ideal as an introduction for graduate students as well as providing a valuable reference for researchers already working in this and related fields

### The Physics of the Quark-Gluon Plasma

Sourav Sarkar, Helmut Satz, Bikash Sinha, 2009-11-25 The aim of this book is to offer to the next generation of young researchers a broad and largely self contained introduction to the physics of heavy ion collisions and the quark gluon plasma providing material beyond that normally found in the available textbooks For each of the main aspects QCD thermodynamics and global features of the QGP collision hydrodynamics electromagnetic probes jet and quarkonium production color glass condensate and the gravity connection the present volume provides extensive and pedagogical lectures surveying the present status of both theory and experiment A particular feature of this volume is that all lectures have been written with the active assistance of selected students present at the course in order to ensure the adequate level and coverage for the intended readership

### **Two Theoretical Treatments of the Quark-gluon Plasma** Margaret Elise Carrington, 1989

Quark-gluon Plasma And Heavy Ion Collisions: Procs Of A Meeting Held In The Framework Of The Activities Of Giselda, The Italian Working Group On Strong Interactions Wanda Maria Alberico, Maria-paola Lombardo, Marzia Nardi, 2002-09-23

This book offers the unique possibility of tackling the problem of hadronic deconfinement from different perspectives After general introductions to the physical issues from both the theoretical and the experimental point of view the book presents the most recent expertise on field theory approaches to the QCD phase diagram many body techniques and applications the dynamics of phase transitions and phenomenological analysis of relativistic heavy ion collisions One of the major goals of this book is to promote interchange among those fields of research which have traditionally been cultivated by different communities of physicists The contributions in the book help in obtaining deep comprehension of this new state of matter a system of deconfined quarks and gluons At the same time the book offers a few examples of how the seeds of the deconfined

state are looked for in the phenomenological analysis of the observables measured in relativistic heavy ion collisions The main topics are dealt with in a pedagogical style suitable for beginners as well as experienced researchers



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