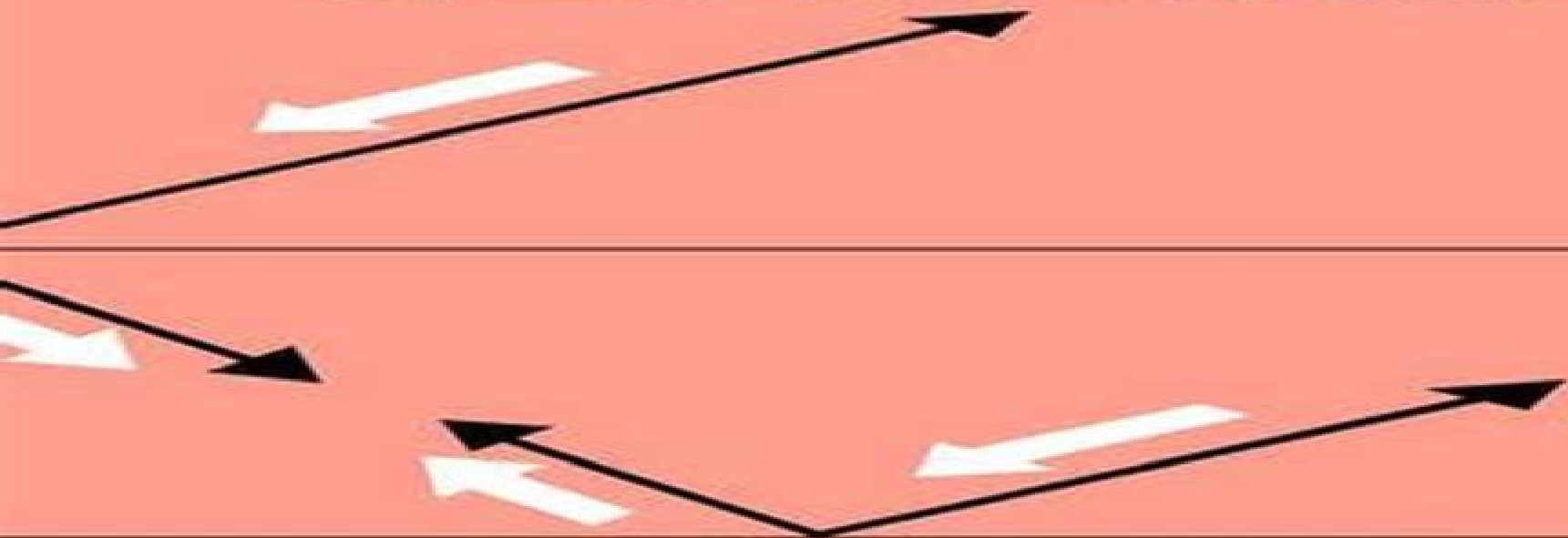


PHYSICS OF MASSIVE NEUTRINOS



FELIX BOEHM & PETR VOGEL

SECOND EDITION

Physics Of Massive Neutrinos

**Orrin Fackler, Gérard Fontaine, J. Thanh
Van Tran**

Physics Of Massive Neutrinos:

Physics of Massive Neutrinos Felix Boehm, Petr Vogel, 1992-06-26 Neutrinos play a decisive part in nuclear and elementary particle physics as well as in astrophysics and cosmology Some of their most basic properties such as their mass and charge conjugation symmetry are largely unknown This book focuses on what we know and may hope to know about the mass of the neutrino and its particle antiparticle symmetry Topics include neutrino mixing neutrino decay neutrino oscillations double beta decay solar neutrinos supernova neutrinos and related issues The authors stress the physical concepts and discuss both theoretical and experimental techniques This updated second edition differs from the first in that it contains an expanded coverage of experimental results and theoretical advances Since publication of the first edition many issues that were at that time unresolved such as tritium beta decay and reactor neutrino oscillations have been clarified and are discussed here Also included is an expanded coverage of solar and supernova neutrinos This book deals with one of the most intriguing issues in modern physics and will be of value to researchers graduate students and advanced undergraduates specializing in experimental and theoretical particle physics and nuclear physics

Massive Neutrinos in Physics and Astrophysics Rabindra Nath Mohapatra, Palash B. Pal, 1991 Summarizes the theoretical phenomenological and astrophysical aspects relevant to research on the possibility of a massive neutrino Designed as an introduction to the subject for readers familiar with field theory group theory and the basic concepts in particle physics and as a quick reference for old hands in the field Annotation copyrighted by Book News Inc Portland OR

The Physics of Massive Neutrinos Boris Kayser, Françoise Gibrat-Debu, 1989 This book explains the physics and phenomenology of massive neutrinos The authors argue that neutrino mass is not unlikely and consider briefly the search for evidence of this mass in decay processes before they examine the physics and phenomenology of neutrino oscillation The physics of Majorana neutrinos neutrinos which are their own antiparticles is then discussed This volume requires of the reader only a knowledge of quantum mechanics and of very elementary quantum field theory

Introduction to the Physics of Massive and Mixed Neutrinos Samoil Bilenky, 2018-04-02 Small neutrino masses are the first signs of new physics beyond the Standard Model of particle physics Since the first edition of this textbook appeared in 2010 the Nobel Prize has been awarded for the discovery of neutrino oscillations which shows that neutrinos have mass The measurement of the small neutrino mixing angle θ_{13} in 2012 launched the precision stage of the investigation of neutrino oscillations This measurement now allows such fundamental problems as the three neutrino mass spectrum is it normal or inverted and the CP violation in the lepton sector to be tackled In order to understand the origin of small neutrino masses it remains crucial to reveal the nature of neutrinos with definite masses are they Dirac neutrinos possessing a conserved lepton number which distinguishes neutrinos and antineutrinos or are they Majorana neutrinos with identical neutrinos and antineutrinos Experiments searching for the neutrinoless double beta decay are presently under way to answer this fundamental question The second edition of this book comprehensively discusses all these

important recent developments Based on numerous lectures given by the author a pioneer of modern neutrino physics recipient of the Bruno Pontecorvo Prize 2002 at different institutions and schools it offers a gentle yet detailed introduction to the physics of massive and mixed neutrinos that prepares graduate students and young researchers entering the field for the exciting years ahead in neutrino physics Massive Neutrinos In Physics And Astrophysics (Third Edition) Rabindra N Mohapatra, Palash B Pal, 2004-03-09 The recent groundbreaking discovery of nonzero neutrino masses and oscillations has put the spotlight on massive neutrinos as one of the key windows on physics beyond the standard model as well as into the early universe This third edition of the invaluable book *Massive Neutrinos in Physics and Astrophysics* is an introduction to the various issues related to the theory and phenomenology of massive neutrinos for the nonexpert providing at the same time a complete and up to date discussion on the latest results in the field for the active researcher It is designed not merely to be a guide but also as a self contained tool for research with all the necessary techniques and logics included Specially emphasized are the various implications of neutrino discoveries for the nature of new forces Elementary discussions on topics such as grand unification left right symmetry and supersymmetry are presented The most recent cosmological and astrophysical implications of massive neutrinos are also dealt with **Massive Neutrinos: Flavor Mixing Of Leptons And Neutrino Oscillations** Harald Fritzsch, 2015-08-28 Since the discovery of neutrino oscillations neutrino physics has become an interesting field of research in physics They imply that neutrino must have a small mass and that the neutrinos coupled to the charged leptons are mixtures of the mass eigenstates analogous to the flavor mixing of the quarks The mixing angles for the quarks are small but for the leptons two of the mixing angles are large The masses of the three neutrinos must be very small less than 1 eV but from the oscillation experiments we only know the mass differences the absolute masses are still unknown Also we do not know if the masses of the neutrinos are Dirac masses as the masses of the charged leptons and of the quarks or whether they are Majorana masses In this volume an overview of the present state of research in neutrino physics is given by well known experimentalists and theorists The contents originated from talks and discussions at a recent conference addressing some of the most pressing open questions in neutrino physics range from the oscillation experiments to CP violation for leptons to texture zero mass matrices and to the role of neutrinos in astrophysics and cosmology

Massive Neutrinos in Astrophysics and in Particle Physics J. Thanh Van Tran, 1984 **Confluence of Cosmology, Massive Neutrinos, Elementary Particles, and Gravitation** Behram N. Kursunogammalu, Stephan L. Mintz, Arnold Perlmutter, 2005-12-19 Just before the preliminary program of Orbis Scientiae 1998 went to press the news in physics was suddenly dominated by the discovery that neutrinos are after all massive particles This was predicted by some physicists including Dr Behram Kursunoglu who had a paper published on this subject in 1976 in the *Physical Review* Massive neutrinos do not necessarily simplify the physics of elementary particles but they do give elementary particle physics a new direction If the dark matter content of the universe turns out to consist of neutrinos the fact that they are massive should make an impact

on cosmology Some of the papers in this volume have attempted to provide answers to these questions We have a long way to go before we find the real reasons for nature's creation of neutrinos Another neutrino related event was the passing of their discoverer Fredrick Reines The trustees of the Global Foundation members of the Orbis Scientiae 1998 dedicate this conference to Fredrick Reines of the University of California at Irvine The late Professor Reines was a loyal and active member of these series of conferences on the frontiers of physics and cosmology since 1964 He also served as one of the trustees of the Global Foundation for the past three years Professor Reines discovered the most elusive particle the neutrino in 1954 We are proud to say that we recognized the importance of this discovery by awarding him the J *The Physics Of Massive Neutrinos* F Gibrat-debu, B Kayser, F Perrier, 1989-02-01 This book explains the physics and phenomenology of massive neutrinos The authors argue that neutrino mass is not unlikely and consider briefly the search for evidence of this mass in decay processes before they examine the physics and phenomenology of neutrino oscillation The physics of Majorana neutrinos neutrinos which are their own antiparticles is then discussed This volume requires of the reader only a knowledge of quantum mechanics and of very elementary quantum field theory **Neutrinos in Particle Physics, Astronomy and Cosmology** Zhizhong Xing, Shun Zhou, 2011-06-08 Neutrinos in Particle Physics Astronomy and Cosmology provides a comprehensive and up to date introduction to neutrino physics neutrino astronomy and neutrino cosmology The intrinsic properties and fundamental interactions of neutrinos are described as is the phenomenology of lepton flavor mixing seesaw mechanisms and neutrino oscillations The cosmic neutrino background stellar neutrinos supernova neutrinos and ultrahigh energy cosmic neutrinos together with the cosmological matter antimatter asymmetry and other roles of massive neutrinos in cosmology are discussed in detail This book is intended for researchers and graduate students in the fields of particle physics particle astrophysics and cosmology Dr Zhizhong Xing is a professor at the Institute of High Energy Physics Chinese Academy of Sciences China Dr Shun Zhou is currently a postdoctoral fellow at the Max Planck Institute for Physics Germany

On the Physics of Massive Neutrinos K. Zuber, 1998 *Massive Neutrinos* Orrin Fackler, Gérard Fontaine, J. Thanh Van Tran, 1991 **'86 Massive Neutrinos in Astrophysics and in Particle Physics** Orrin Fackler, J. Thanh Van Tran, 1986

Gauge Theories, Massive Neutrinos and Proton Decay, 2013-12-01 The following proceedings contains most of the contributions given at Orbis Scientiae 1981 As has become customary during the past few years the organizers and moderators have attempted to strike a balance between reviews of the status of experimental and theoretical developments during the preceding year We are very pleased that experimentalists representing the critical developments in new accelerator plans neutrino oscillations proton decay and decay schemes of the upsilon have seen fit to enlighten at first hand their theoretical colleagues We believe that this interaction can be of great benefit to both groups The reports of theorists on many of the key theoretical advances by the practitioners themselves is a particularly satisfying feature of this series of conferences and is a tribute to the care and wisdom of the session moderators Although it has not been a customary editorial

practice we feel that it is particularly appropriate to point out that the 1981 recipient of the J Robert Oppenheimer Memorial Prize was Professor Frederick Reines of University of California Irvine for his pioneering experiments which first experimentally established the existence of the neutrino. The flurry of activity experimental and theoretical generated by recent evidence for massive neutrinos is amply reflected in the contents of this volume. The enthusiasm and skill of Mrs Helga S Billings and Mrs Susan L Maxon in the organization and the running of the conference as well as in the preparation of these proceedings is gratefully acknowledged.

Some Theoretical Issues in Physics of Massive Neutrinos Ville Sipiläinen, 2003

Physics of Neutrinos Masataka Fukugita, Tsutomu Yanagida, 2013-06-29 This book aims to provide a survey of the current state of research in the physics of neutrinos which has undergone dramatic development during the last decade in a form accessible to the nonspecialist and the graduate student. The major issue during the last two decades has been the neutrino mass whereas the interaction of neutrinos was well understood within the framework of the standard theory which was established in the 1970s. In 1994 we published a textbook format review article *Physics 01 Neutrinos in Physics and Astrophysics 01 Neutrinos* in anticipation that the mass of the neutrino would be found in the near future. It was indeed found thanks to the Super Kamiokande experiment four years after that book was written and a flurry of activity followed in the phenomenology of the neutrino mass. From the theoretical point of view the importance of this discovery stems from the fact that it probably indicates the presence of a new energy scale beyond the standard theory. At the same time the formalism for massive neutrinos and the techniques to find the neutrino mass have now realistic importance and have become the subject of standard physics. On the other hand experiment revealed that the pattern of the neutrino mass and mixing among generations appears in a way different from what has been speculated on the basis of existing theoretical models.

Neutrino Mass Guido Altarelli, Klaus Winter, 2003-09-08 Reviews the current state of knowledge of neutrino masses and the related question of neutrino oscillations. After an overview of the theory of neutrino masses and mixings detailed accounts are given of the laboratory limits on neutrino masses, astrophysical and cosmological constraints on those masses, experimental results on neutrino oscillations, the theoretical interpretation of those results and theoretical models of neutrino masses and mixings. The book concludes with an examination of the potential of long baseline experiments. This is an essential reference text for workers in elementary particle physics, nuclear physics and astrophysics.

Massive Neutrinos in Particle Physics and Astrophysics, 1986 The concepts of Majorana and Dirac neutrinos are reviewed from an operational point of view and survey the experimental search for neutrino mass. Also reviewed are the work of Mikheyev and Smirnov on the enhancement of neutrino oscillations via the mechanism of Wolfenstein, matter oscillations. Results of an extensive computation of MSW effects in the sun are described. 41 refs. 6 figs.

Measurements of Neutrino Mass Fernando Ferroni, Francesco Vissani, Chiara Brofferio, 2009 This volume offers a valuable insight into various aspects of the ongoing work directed at measuring neutrino mass. It took twenty years to refute the assertions of Bethe and Peierls that neutrinos

were not observable but it has since been realised that much can be learnt from these particles The moral is as Fiorini argues here that the study of neutrinos was and remains demanding but rewarding Subjects addressed in this volume include clarifying the meaning of the Klapdor Kleingrothaus results probing the Majorana nature of neutrinos observing lepton number violating effects for the first time studying the end point of the spectrum in the search for neutrino masses and speculating whether it is possible to measure neutrino masses in cosmology Lectures are enriched with rich historical overviews and valuable introductory material Attention is also given to theoretical topics such as the evolution of the concept of mass in particle physics a status report on neutrino oscillations and current discussion on neutrino masses The reader is further reminded that neutrino masses may also have some bearing on the very origin of the matter among us and have many deep links with other important lines of current physics research Book Jacket **Neutrino Cosmology** Julien

Lesgourgues, Gianpiero Mangano, Gennaro Miele, Sergio Pastor, 2013-02-21 The role that neutrinos have played in the evolution of the Universe is the focus of one of the most fascinating research areas that has stemmed from the interplay between cosmology astrophysics and particle physics In this self contained book the authors bring together all aspects of the role of neutrinos in cosmology spanning from leptogenesis to primordial nucleosynthesis their role in CMB and structure formation to the problem of their direct detection The book starts by guiding the reader through aspects of fundamental neutrino physics such as the standard cosmological model and the statistical mechanics in the expanding Universe before discussing the history of neutrinos in chronological order from the very early stages until today This timely book will interest graduate students and researchers in astrophysics cosmology and particle physics who work with either a theoretical or experimental focus

Physics Of Mabive Neutrinos: Bestsellers in 2023 The year 2023 has witnessed a noteworthy surge in literary brilliance, with numerous compelling novels captivating the hearts of readers worldwide. Lets delve into the realm of top-selling books, exploring the engaging narratives that have charmed audiences this year. Physics Of Mabive Neutrinos : Colleen Hoover "It Ends with Us" This poignant tale of love, loss, and resilience has gripped readers with its raw and emotional exploration of domestic abuse. Hoover masterfully weaves a story of hope and healing, reminding us that even in the darkest of times, the human spirit can prevail. Uncover the Best : Taylor Jenkins Reids "The Seven Husbands of Evelyn Hugo" This spellbinding historical fiction novel unravels the life of Evelyn Hugo, a Hollywood icon who defies expectations and societal norms to pursue her dreams. Reids captivating storytelling and compelling characters transport readers to a bygone era, immersing them in a world of glamour, ambition, and self-discovery. Discover the Magic : Delia Owens "Where the Crawdads Sing" This mesmerizing coming-of-age story follows Kya Clark, a young woman who grows up alone in the marshes of North Carolina. Owens weaves a tale of resilience, survival, and the transformative power of nature, captivating readers with its evocative prose and mesmerizing setting. These bestselling novels represent just a fraction of the literary treasures that have emerged in 2023. Whether you seek tales of romance, adventure, or personal growth, the world of literature offers an abundance of captivating stories waiting to be discovered. The novel begins with Richard Papen, a bright but troubled young man, arriving at Hampden College. Richard is immediately drawn to the group of students who call themselves the Classics Club. The club is led by Henry Winter, a brilliant and charismatic young man. Henry is obsessed with Greek mythology and philosophy, and he quickly draws Richard into his world. The other members of the Classics Club are equally as fascinating. Bunny Corcoran is a wealthy and spoiled young man who is always looking for a good time. Charles Tavis is a quiet and reserved young man who is deeply in love with Henry. Camilla Macaulay is a beautiful and intelligent young woman who is drawn to the power and danger of the Classics Club. The students are all deeply in love with Morrow, and they are willing to do anything to please him. Morrow is a complex and mysterious figure, and he seems to be manipulating the students for his own purposes. As the students become more involved with Morrow, they begin to commit increasingly dangerous acts. The Secret History is a brilliant and suspenseful novel that will keep you guessing until the very end. The novel is a warning tale about the dangers of obsession and the power of evil.

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