

FUNDAMENTAL PARTICLES

P



Matter

(All things are composed of atoms)



Molecule

(Matter is composed of molecules, which are groups of two or more atoms bonded together)



Atom

(Electrons orbit the positively charged nucleus of an atom)



Nucleus

Fundamental particles are classified into "Bosons" and "Fermions" based on their spin.

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BOSONS

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Particles with **whole number spins** (0, 1, 2, etc.). They are energy and force carriers throughout the universe. They include **photons** (light), **gluons** (particles that act as force carriers in the nucleus), the **Higgs boson**, and the **W and Z bosons**.



Photons



Gluons



Higgs Boson



W and Z Bosons

Photons are massless, **charge-less** particles of light that travel at the speed of light.

Gluons are **charge-less** particles that mediate the **strong nuclear force**, holding quarks together in protons and neutrons. They have **color charges** (red, green, blue) and are studied in high-energy environments like the **Relativistic Heavy Ion Collider (RHIC)**.

The Higgs boson, linked to the Higgs field, gives **mass to particles like electrons and quarks**. Mass determines a particle's resistance to force. Photons, which carry the electromagnetic force, have **no mass**.

W and Z bosons are **elementary particles with spin 0 or 1**, discovered in 1983. They mediate the **weak force**, which is weaker than the **strong force**. There are two W bosons (W⁺ and its antiparticle W⁻), while Z bosons are their own antiparticles.

Quarks

up	charm	top
d	s	b
down	strange	bottom

Leptons

electron	muon	tau
e ⁻	μ^-	τ^-
electron neutrino	muon neutrino	tau neutrino

Gauge Bosons

photon	gluon	Z Boson	W Boson
γ	g	Z	W

Scalar Bosons

Higgs Boson
H

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Three Generations of Matter (Fermions)

P

Force Carriers (Bosons)

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FERMIONS

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Particles with **half-number spins** (1/2, 3/2, etc.). They include protons, neutrons, electrons, neutrinos, and quarks.



Leptons



Electron
Muon



Electron
Neutrino



Tau
Electron
Neutrino



Muon
Neutrino



Tau
Neutrino



Neutrinos



Gluon



Quarks



Proton



Neutron



Quarks

- Quarks are the building blocks of protons and neutrons. They combine to form protons and neutrons.
- Protons and neutrons are **not** fundamental particles because they are composed of smaller particles called **quarks**.
- There are **six types (Flavors)** of quarks:



Up



Down



Charm



Strange



Top



Bottom

Particle Physics And The Universe

New Scientist Staff

Particle Physics And The Universe:

Particles in the Dark Universe Yann Mambrini,2024-10-21 This second edition of Particles in the Dark Universe has been substantially enhanced with several new chapters that delve into crucial aspects of particle physics in the Universe These additions encompass the role of primordial black holes in the early universe tracing their formation to decay unification theories a comprehensive historical overview of cosmological models an extensive examination of the physics of the graviton and an educational exploration of gravitational phenomena such as Unruh type or Hawking radiation Additionally this edition incorporates 30 new exercises and provides a comprehensive presentation of inflationary models along with a pedagogical insight into the mechanism of baryogenesis Structured in a logical sequence this book offers a thorough and instructional exploration of particle physics within the early universe It initiates by elucidating the thermal history of the universe delving into pivotal concepts like Big Bang nucleosynthesis the cosmic microwave background CMB and inflation Subsequently it meticulously addresses both direct and indirect detection methods of dark matter followed by an in depth analysis of neutrino physics The book further scrutinizes potential candidates for dark matter and their interactions Designed for theoretical physicists engaged in particle physics within the universe dark matter detection astrophysical constraints and those interested in models of inflation or reheating this book also caters to astrophysicists involved in quantum field theory computations It encompasses all essential elements required for computing various physical processes providing mathematical tables necessary thermodynamic functions for the early universe and Feynman rules Consequently this book serves as an intersecting point between astrophysics particle physics and cosmology

Understanding the Universe Don Lincoln,2012 This book explains the fascinating world of quarks and leptons and the forces that govern their behavior Told from an experimental physicist s perspective it forgoes mathematical complexity using instead particularly accessible figures and apt analogies In addition to the story of quarks and leptons which are regarded as well accepted fact the author who is a leading researcher at one of the world s highest energy particle physics laboratories also discusses mysteries at both the experimental and theoretical frontiers before tying it all together with the exciting field of cosmology and indeed the birth of the universe itself

Why the Universe Exists New Scientist,2017-09-21 As you read this billions of neutrinos from the sun are passing through your body antimatter is sprouting from your dinner and the core of your being is a chaotic mess of particles known only as quarks and gluons If the recent discovery of the Higgs boson piqued your interest then Why The Universe Exists will take you deeper into the world of particle physics with leading physicists and New Scientist exploring how the universe functions at the smallest scales Find out about hunt for dark matter and why there is something rather than nothing Discover how accelerators such as the Large Hadron Collider in Switzerland are rewinding time to the first moments after the big bang and how ghostly neutrino particles may hold the answers to the greatest mysteries of the universe

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Why the Universe Exists New Scientist Staff,2017-09-21 As you read this billions of neutrinos from the sun are passing through your body antimatter is sprouting from your dinner and the core of your being is a chaotic mess of particles known only as quarks and gluons If the recent discovery of the Higgs boson piqued your interest then Why The Universe Exists will take you deeper into the world of particle physics with leading physicists and New Scientist exploring how the universe functions at the smallest scales Find out about hunt for dark matter and why there is something rather than nothing Discover how accelerators such as the Large Hadron Collider in Switzerland are rewinding time to the first moments after the big bang and how ghostly neutrino particles may hold the answers to the greatest mysteries of the universe **ABOUT THE SERIES** New Scientist Instant Expert books are definitive and accessible entry points to the most important subjects in science subjects that challenge attract debate invite controversy and engage the most enquiring minds Designed for curious readers who want to know how things work and why the Instant Expert series explores the topics that really matter and their impact on individuals society and the planet translating the scientific complexities around us into language that s open to everyone and putting new ideas and discoveries into perspective and context [From the Universe to the Elementary Particles](#) Ulrich Ellwanger,2012-01-05 In this book the author leads the reader step by step and without any advanced mathematics to a clear understanding of the foundations of modern elementary particle physics and cosmology He also addresses current and controversial questions on topics such as string theory The book contains gentle introductions to the theories of special and

general relativity and also classical and quantum field theory The essential aspects of these concepts are understood with the help of simple calculations for example the force of gravity as a consequence of the curvature of the space time Also treated are the Big Bang dark matter and dark energy as well as the presently known interactions of elementary particles electrodynamics the strong and the weak interactions including the Higgs boson Finally the book sketches as yet speculative theories Grand Unification theories supersymmetry string theory and the idea of additional dimensions of space time Since no higher mathematical or physics expertise is required the book is also suitable for college and university students at the beginning of their studies Hobby astronomers and other science enthusiasts seeking a deeper insight than can be found in popular treatments will also appreciate this unique book **Explaining The Universe** John M Charap, *Introduction to Particle and Astroparticle Physics* Alessandro De Angelis,Mário João Martins Pimenta,2015-09-05 This book written by researchers who had been professionals in accelerator physics before becoming leaders of groups in astroparticle physics introduces both fields in a balanced and elementary way requiring only a basic knowledge of quantum mechanics on the part of the reader The new profile of scientists in fundamental physics ideally involves the merging of knowledge in astroparticle and particle physics but the duration of modern experiments is such that people cannot simultaneously be practitioners in both Introduction to Particle and Astroparticle Physics is designed to bridge the gap between the fields It can be used as a self training book a consultation book or a textbook providing a modern approach to particles and fundamental interactions

Particles in the Dark Universe Yann Mambrini,2021 This book provides a comprehensive and instructive coverage of particle physics in the early universe in a logical way It starts from the thermal history of the universe by investigating some of the main arguments such as Big Bang nucleosynthesis the cosmic microwave background CMB and the inflation before treating in details the direct and indirect detection of dark matter and then some aspects of the physics of neutrino Following it describes possible candidates for dark matter and its interactions The book is targeted at theoretical physicists who deal with particle physics in the universe dark matter detection and astrophysical constraints and at particle physicists who are interested in models of inflation or reheating This book offers also material for astrophysicists who work with quantum field theory computations All that is useful to compute any physical process is included mathematical tables all the needed functions for the thermodynamics of early universe and Feynman rules In light of this this book acts as a crossroad between astrophysics particle physics and cosmology **Astroparticle Physics** Claus Grupen,2005-12-06 Describes the branch of astronomy in which processes in the universe are investigated with experimental methods employed in particle physics experiments After a historical introduction the basics of elementary particles Explains particle interactions and the relevant detection techniques while modern aspects of astroparticle physics are described in a chapter on cosmology Provides an orientation in the field of astroparticle physics that many beginners might seek and appreciate because the underlying physics fundamentals are presented with little mathematics and the results are illustrated by many diagrams Readers have a

chance to enter this field of astronomy with a book that closes the gap between expert and popular level **Particles and the Universe** Stephan Narison,2015-11-27 This book aims to present the history and developments of particle physics from the introduction of the notion of particles by the Ionian school until the discovery of the Higgs boson at LHC in 2012 Neutrino experiments and particle accelerators where different particles have been discovered are reviewed In particular details about the CERN accelerators are presented This book also discusses the future developments of the field and the work to popularize high energy physics A short presentation of some features of astrophysics and its connection to particle physics is also included At the end of the book some useful tools in the research of particle physics are given for the advanced readers

Introduction to Particle and Astroparticle Physics Alessandro De Angelis,Mário João Martins Pimenta,2015-11-17 This book written by researchers who had been professionals in accelerator physics before becoming leaders of groups in astroparticle physics introduces both fields in a balanced and elementary way requiring only a basic knowledge of quantum mechanics on the part of the reader The early history of particle physics cannot be distinguished from the history of cosmic rays With the advent of accelerators however the importance of cosmic rays in particle physics was lost This situation persisted until the 1990s when novel techniques allowed breakthrough discoveries and exploration of new physics scales now requires returning to cosmic rays The new profile of scientists in fundamental physics ideally involves the merging of knowledge in astroparticle and particle physics but the duration of modern experiments is such that people cannot simultaneously be practitioners in both *Introduction to Particle and Astroparticle Physics* is designed to bridge the gap between the fields It can be used as a self training book a consultation book or a textbook providing a modern approach to particles and fundamental interactions **Particles and the Universe** Kyle Kirkland,2007 Discusses the advances in physics since Newton s observations including nuclear physics particle physics quantum mechanics and cosmology

Cracking the Quantum Code of the Universe John Moffat,2014-02 Questions preconceived ideas about the nature of matter in light of the hunt for the Higgs particle and the success of the Large Hadron Collider **Knocking on Heaven's Door** Lisa Randall,2011-09-20 From one of Time magazine s 100 most influential people in the world a rousing defense of the role of science in our lives The latest developments in physics have the potential to radically revise our understanding of the world its makeup its evolution and the fundamental forces that drive its operation Knocking on Heaven s Door is an exhilarating and accessible overview of these developments and an impassioned argument for the significance of science There could be no better guide than Lisa Randall The bestselling author of Warped Passages is an expert in both particle physics the study of the smallest objects we know of and cosmology the study of the largest In Knocking on Heaven s Door she explores how we decide which scientific questions to study and how we go about answering them She examines the role of risk creativity uncertainty beauty and truth in scientific thinking through provocative conversations with leading figures in other fields such as the chef David Chang the forecaster Nate Silver and the screenwriter Scott Derrickson and she explains

with wit and clarity the latest ideas in physics and cosmology Randall describes the nature and goals of the largest machine ever built the Large Hadron Collider the enormous particle accelerator below the border of France and Switzerland as well as recent ideas underlying cosmology and current dark matter experiments The most sweeping and exciting science book in years Knocking on Heaven s Door makes clear the biggest scientific questions we face and reveals how answering them could ultimately tell us who we are and where we came from

Understanding The Universe: From Quarks To Cosmos

(Revised Edition) Donald Lincoln,2012-03-20 The Big Bang the birth of the universe was a singular event All of the matter of the universe was concentrated at a single point with temperatures so high that even the familiar protons and neutrons of atoms did not yet exist but rather were replaced by a swirling maelstrom of energy matter and antimatter Exotic quarks and leptons flickered briefly into existence before merging back into the energy sea This book explains the fascinating world of quarks and leptons and the forces that govern their behavior Told from an experimental physicist s perspective it forgoes mathematical complexity using instead particularly accessible figures and apt analogies In addition to the story of quarks and leptons which are regarded as well accepted fact the author who is a leading researcher at one of the world s highest energy particle physics laboratories also discusses mysteries at both the experimental and theoretical frontiers before tying it all together with the exciting field of cosmology and indeed the birth of the universe itself The text spans the tiny world of the quark to the depths of the universe with breathtaking clarity The casual student of science will appreciate the careful distinction between what is known quarks leptons and antimatter what is suspected Higgs bosons neutrino oscillations and the reason why the universe has so little antimatter and what is merely dreamed supersymmetry superstrings and extra dimensions Included is an unprecedented chapter explaining the accelerators and detectors of modern particle physics experiments The chapter discussing the hunt for the Higgs boson currently consuming the efforts of nearly 6000 physicists reveals drama that only big stakes science can give Understanding the Universe leaves the reader with a deep appreciation of the fascinating particle realm and reverence for just how much it determines the rich beauty of our universe Since the release of the first edition the landscape has changed The venerable Fermilab Tevatron has ceased operations after a quarter century of extraordinary performance to be replaced by the CERN Large Hadron Collider an accelerator with a design energy of seven times greater than the Tevatron and a collision rate of nearly a billion collisions per second The next few years promise to be very exciting as scientists explore this new realm This revised edition of Understanding the Universe will leave the reader with a deep appreciation of just why physicists are so excited

The Quantum Universe Brian Cox,Jeff Forshaw,2012-01-31

International bestselling authors Brian Cox and Jeff Forshaw s fascinating entertaining and clear introduction to quantum mechanics In The Quantum Universe Brian Cox and Jeff Forshaw approach the world of quantum mechanics in the same way they did in Why Does E mc2 and make fundamental scientific principles accessible and fascinating to everyone The subatomic realm has a reputation for weirdness spawning any number of profound

misunderstandings journeys into Eastern mysticism and woolly pronouncements on the interconnectedness of all things Cox and Forshaw's contention There is no need for quantum mechanics to be viewed this way There is a lot of mileage in the weirdness of the quantum world and it often leads to confusion and frankly bad science The Quantum Universe cuts through the Wu Li and asks what observations of the natural world made it necessary how it was constructed and why we are confident that for all its apparent strangeness it is a good theory The quantum mechanics of The Quantum Universe provide a concrete model of nature that is comparable in its essence to Newton's laws of motion Maxwell's theory of electricity and magnetism and Einstein's theory of relativity *Particle Physics and the Universe* Josip Trampetic, Julius Wess, 2004-10-06

The Adriatic Meetings have traditionally been conferences on the most vanced status of science They are one of the very few conferences in physics aiming at a very broad participation of young and experienced researchers with different backgrounds in particle physics Particle physics has grown into a highly multi faceted discipline over the sixty years of its existence mainly because of two reasons Particle physics as an experimental science is in need of large scale laboratory set ups involving typically collaborations of several hundreds or even thousands of researchers and technicians with the most diverse expertise This forces particle physics being one of the most fundamental disciplines of physics to maintain a constant interchange and contact with other disciplines notably solid state physics and laser physics cosmology and astrophysics mathematical physics and mathematics Since the expertise necessary in doing research in particle physics has become tremendously demanding in the last years the field tends to organize purely expert conferences meetings and summer schools such as for detector development for astroparticle physics or for string theory The Adriatic Meeting throughout its entire history has been a place for establishing exchange between theory and experiment The 9th Adriatic Meeting successfully continued this tradition and even intensified the cross discipline communication by establishing new contacts between the community of cosmologists and of particle physicists The exchange between theorists and experimentalists was impressively intensive and will certainly have a lasting effect on several research projects of the European and world wide physics community *Fundamentals of Cosmic Particle Physics* Maxim Khlopov, 2012-03-14

This current updated and expanded text reflects the large number of scientific advances both theoretically and experimentally within the discipline of cosmoparticle physics in the last 10 years Some of the topics that have been added updated include but are not limited to HND or CMD HND scenarios being implemented into sterile neutrino scenarios the ramifications of extending the forms of dark matter with respect to our view of neutrinos the origin of baryon matter and the need for non baryonic matter in current theories problems the existence of dark matter raises with respect to cosmoparticle physics and the relationship with meta stable super weakly interacting particles predicted by the extension of the standard model restrictions on baryon and lepton photons as well as problems associated with cosmological expansion just to name a few These and many other topics are readdressed in light of recent both experimental and theoretical developments Other areas of that will be of interest to the reader include the puzzles presented

by direct and indirect effects of dark matter e g results of experiments such as DAMA NaI DAMA LIBRA and PAMELA may lead to nontrivial new solutions for the problem of its nature like the existence of new stable families of quarks and leptons and composite dark matter scenario The present work will be of interest to any researcher interested in this fascinating field dealing with fundamental interactions of the micro and macroworld

Elementary Particles and the Early Universe

Eitan Abraham,Andrés J. Kreiner,2022-12-21 The birth of the Universe and its subsequent evolution is an exciting blend of Cosmology Particle Physics and Thermodynamics This book with its synoptic approach provides an accessible introduction to these fascinating topics It begins in Part I with an overview of cosmology and is followed by a discussion on the present understanding about the birth of the universe detailing the Planck Era Inflation and the Big Bang It speculates the possibility of multiple universes Before moving on to explore the essentials of the Standard Model of Particle Physics in Part II with particular stress on the electroweak force the first example of acquisition of mass by gauge bosons via the Higgs mechanism The book finishes in Part III with the thermal history of the Universe This will also lead to understanding baryonic matter and baryogenesis as well as nucleosynthesis This book is suitable for those taking courses on particle physics general relativity and cosmology Readers mathematically inclined who wish to enhance their basic knowledge about the early Universe will also find this book suitable to move up to the next level Features Authored by experienced lecturers in Particle Physics Quantum Field Theory Nuclear Physics and General Relativity Provides an accessible introduction to Particle Physics and Cosmology

Embracing the Melody of Phrase: An Emotional Symphony within **Particle Physics And The Universe**

In a world taken by displays and the ceaseless chatter of instantaneous connection, the melodic splendor and emotional symphony produced by the published term usually diminish into the back ground, eclipsed by the constant noise and disruptions that permeate our lives. However, situated within the pages of **Particle Physics And The Universe** a charming fictional prize filled with natural emotions, lies an immersive symphony waiting to be embraced. Constructed by an elegant musician of language, that charming masterpiece conducts visitors on an emotional trip, well unraveling the concealed tunes and profound influence resonating within each cautiously crafted phrase. Within the depths of the touching examination, we shall examine the book's central harmonies, analyze its enthralling writing model, and submit ourselves to the profound resonance that echoes in the depths of readers souls.

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