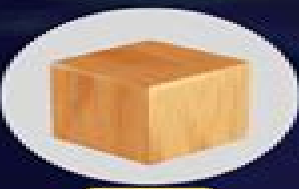


FUNDAMENTAL PARTICLES



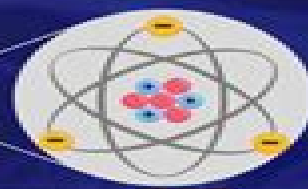
Matter

(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

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**.



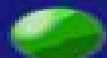
Photons

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



Gluons

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)**.



Higgs Boson

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

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**.

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Three Generations of Matter (Fermions)

Force Carriers (Bosons)

Quarks

up u	charm c	top t
down d	strange s	bottom b

Leptons

electron e	muon μ	tau τ
electron neutrino ν _e	muon neutrino ν _μ	tau neutrino ν _τ

Gauge Bosons

photon γ	gluon g	Z Boson Z	W Boson W
-------------	------------	--------------	--------------

Scalar Bosons

Higgs Boson H

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FERMIONS

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



Leptons

Electron

- **Leptons** are fundamental particles that do not feel the **strong nuclear force**.
- **Electrons**, commonly found in atoms, are the most **well-known leptons**.
- There are six types of leptons:



Muon



Electron



Tau



Electron Neutrino



Muon Neutrino



Tau Neutrino



Neutrinos

- **Neutrinos** are tiny, neutral particles with nearly undetectable mass.
- They are the **most abundant massive particles in the universe**.
- Produced during nuclear reactions in stars, reactors, and particle accelerators.
- **Bananas emit neutrinos due to their natural radioactivity.**



Gluon

Quarks



Neutron

Proton

- **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

Fundamental Particles And Their Interactions

Sebastian Brünink



Fundamental Particles And Their Interactions:

Elementary Particles and Their Interactions Quang Ho-Kim,Xuan-Yem Pham,1998-09-08 The first part of this two part work is intended as an introduction to the fundamentals while the second part discusses applications from the point of view of the researcher Lively illustrations and informative tables an overview at the beginning of each chapter and exercises with solutions make this book a valuable resource

The Fundamental Particles and Their Interactions William B. Rolnick,Joey Huston,1994 An accessible introduction to high energy physics presenting concepts of particle physics including some of the experimental evidence of their discovery and verification It also covers topics such as group theory quantum chromodynamics and the electroweak theory

Elementary Particles and Their Interactions Stephen P. Martin,James D. Wells,2022 The Standard Model of elementary particle physics was tentatively outlined in the early 1970s The concepts of quarks leptons neutrinos gauge symmetries chiral interactions Higgs boson strong force weak force and electromagnetism were all put together to form a unifying theory of elementary particles Furthermore the model was developed within the context of relativistic quantum field theory making it compatible with all of the laws of Einstein s Special Relativity The successes of the Standard Model over the years have been tremendous and enduring leading up to the recent discovery and continuing study of the Higgs boson This book is a comprehensive and technical introduction to Standard Model physics Martin and Wells provide readers who have no prior knowledge of quantum field theory or particle physics a firm foundation into the fundamentals of both The emphasis is on obtaining practical knowledge of how to calculate cross sections and decay rates There is no better way to understand the necessary abstract knowledge and solidify its meaning than to learn how to apply it to the computation of observables that can be measured in a laboratory Beginning graduate students both experimental and theoretical and advanced undergraduate students interested in particle physics will find this to be an ideal one semester textbook to begin their technical learning of elementary particle physics

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 matters 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

Nano-Structures for Optics and Photonics
 Baldassare Di Bartolo, John Collins, Luciano Silvestri, 2014-10-06 The contributions in this volume were presented at a NATO Advanced Study Institute held in Erice Italy 4-19 July 2013 Many aspects of important research into nanophotonics plasmonics semiconductor materials and devices instrumentation for bio sensing to name just a few are covered in depth in this volume The growing connection between optics and electronics due to the increasing important role played by semiconductor materials and devices find their expression in the term photonics which also reflects the importance of the photon aspect of light in the description of the performance of several optical systems Nano structures have unique capabilities that allow the enhanced performance of processes of interest in optical and photonic devices In particular these structures permit the nanoscale manipulation of photons electrons and atoms they represent a very hot topic of research and are relevant to many devices and applications The various subjects bridge over the disciplines of physics biology and chemistry making this volume of interest to people working in these fields The emphasis is on the principles behind each technique and on examining the full potential of each technique

The Nobel collection, Volume 2 Idan Segev, Robert Knight, 2023-10-12 This second Volume of our unique Nobel Collection brings you more articles by Nobel Prize winners called Laureates written specifically for young minds These amazing research leaders explain their ground breaking discoveries and how they achieved them and also share their thoughts on making a career path in science with advice for becoming a successful researcher and having a happy life Like everything Frontiers for Young Minds publishes these articles have been reviewed and approved by kids like you What are the Nobel Prizes Humans are highly curious we are eager to understand ourselves and the world around us A scientific understanding is critical for finding solutions to all our global challenges from diseases like Covid to climate change Scientists and researchers devote their lives to exploring and understanding the laws of nature and life itself Every researcher's results contribute to our body of human knowledge Occasionally new discoveries totally transform the way we understand the universe and ourselves for example Albert Einstein's famous breakthroughs in theoretical physics or the pioneering work of Marie Skłodowska-Curie which led to the discovery of new elements and advanced treatments using X-rays and curing cancer Each year these transformative discoveries are celebrated with Nobel Prizes founded by Alfred Nobel in his will and awarded since 1901 to represent the highest level of recognition for research In our journal we feature the winners of prizes in Chemistry Physics Physiology or Medicine and Economics Did you know that you as a Young Minds reader share an important trait with our Nobel Prize winners This is curiosity The scientific journeys of Nobel laureates are fueled by an intense life-long search for answers the same curiosity that motivates you to read these articles As Nobel Laureate May-Britt Moser told us As a scientist I feel privileged to be able to ask questions that I

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Technical Highlights of the National Bureau of Standards United States. National Bureau of Standards,1955

Handbook of Physics Walter Benenson,John W. Harris,Horst Stöcker,Holger Lutz,2006-01-13 Handbook of Physics is a veritable toolbox for rapid access to a wealth of physics information for everyday use in problem solving homework and examinations This complete reference includes not only the fundamental formulas of physics but also experimental methods used in practice

Understanding the World: Unraveling the Mysteries of Physics Pasquale De Marco,2025-05-18 In Understanding the World Unraveling the Mysteries of Physics embark on an exhilarating journey through the captivating world of physics where you'll uncover the secrets of the cosmos from the vastness of galaxies to the intricate workings of atoms Written with clarity and passion this book demystifies complex concepts and presents them in an engaging and accessible manner making physics approachable for readers of all backgrounds With its comprehensive coverage of fundamental principles real world applications and cutting edge research this book is an invaluable resource for students educators and anyone seeking a deeper understanding of the physical world Explore the fundamental building blocks of matter delve into the realm of forces and motion and unravel the mysteries of energy and waves Witness the interplay of electricity and magnetism and uncover the secrets of quantum physics where particles behave in ways that defy classical intuition Through captivating explanations and vivid illustrations this book brings to life the wonders of the universe from the grandeur of celestial bodies to the intricacies of subatomic particles It ignites curiosity sparks imagination and inspires a sense of awe and wonder at the beauty and complexity of the physical world With its comprehensive coverage of essential topics and its engaging writing style Understanding the World Unraveling the

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precise top quark pair production cross section measurement to date The most precise measurements of the top quark mass obtain the top quark mass parameter Monte Carlo mass used in simulations which are partially based on heuristic models Its interpretation in terms of mass parameters used in theoretical calculations e g a running or a pole mass has been a long standing open problem with far reaching implications beyond particle physics even affecting conclusions on the stability of the vacuum state of our universe In this thesis this problem is solved experimentally in three steps using data obtained with the compact muon solenoid CMS detector The most precise top quark pair production cross section measurements to date are performed The Monte Carlo mass is determined and a new method for extracting the top quark mass from theoretical calculations is presented Lastly the top quark production cross sections are obtained for the first time without residual dependence on the top quark mass are interpreted using theoretical calculations to determine the top quark running and pole mass with unprecedented precision and are fully consistently compared with the simultaneously obtained top quark Monte Carlo mass

AEC Authorizing Legislation United States. Congress. Joint Committee on Atomic Energy,1960

AEC Authorizing Legislation Fiscal Year 1961 United States. Congress. Joint Committee on Atomic Energy. Subcommittee on Legislation,1960

APPLIED PHYSICS FOR ENGINEERS MEHTA, NEERAJ ,2011-07-30 This book is intended as a textbook for the first year undergraduate engineering students of all disciplines The text written in a student friendly manner covers a wide range of topics of engineering interest both from the domains of applied and modern physics It is meticulously tailored to cover the syllabi needs of almost all the Indian universities and institutes With its exhaustive treatment of different topics in one volume it relieves the engineering students of the arduous task of referring to several books Besides engineering students this book will be equally useful to the BSc Physics students of different universities **KEY FEATURES** Simple and clear diagrams throughout the book help students in understanding the concepts clearly Numerous in chapter solved problems chapter end unsolved problems with answers and review questions assist students in assimilating the theory comprehensively A large number of objective type questions at the end of each chapter help students in testing their knowledge of the theory

Secrets of the Aether David W. Thomson III,2004-10-06 Author David Thomson and Jim Bourassa have founded the Quantum AetherDynamics Institute an organization dedicated to understanding the Aether For the first time in human history the Aether is fully quantified based upon empirical data Through a very simple observation noted nearly 200 years ago by Charles Coulomb the electromagnetic units have been corrected of an error that has led physics astray for so long Now electrodynamics expresses in simple dimensional equations the neurosciences unite with quantum and classical physics and we can precisely model the geometry of subatomic particles

Unified Field Mechanics: Natural Science Beyond The Veil Of Spacetime - Proceedings Of The Ix Symposium Honoring Noted French Mathematical Physicist Jean-pierre Vigier Richard L Amoroso,Louis H Kauffman,Peter Rowlands,2015-09-08

Unified Field Mechanics the topic of the 9th international symposium honoring noted French mathematical physicist Jean

Pierre Vigier cannot be considered highly speculative as a myopic critic might surmise The 8th Vigier Symposium proceedings The Physics of Reality should in fact be touted as a companion volume because of its dramatic theoretical Field Mechanics in additional dimensionality Many still consider the Planck scale zero point field stochastic quantum foam as the basement of reality This could only be considered true under the limitations of the Copenhagen interpretation of quantum theory As we enter the next regime of Unified Field Mechanics we now know that the energy dependent Einstein Minkowski manifold called spacetime has a finite radius beyond which a large scale multiverse beckons So far a battery of 14 experiments has been designed to falsify the model When the 1st is successfully performed a revolution in Natural Science will occur This volume strengthens and expands the theoretical and experimental basis for that immanent new age

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