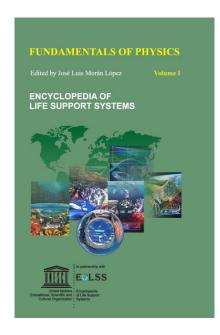
CONTENTS

FUNDAMENTALS OF PHYSICS



Fundamentals of Physics - Volume 1

No. of Pages: 450

ISBN: 978-1-905839-52-0 (eBook) **ISBN**: 978-1-84826-952-1 (Print Volume)

Fundamentals of Physics - Volume 2

No. of Pages: 324

ISBN: 978-1-905839-53-7 (eBook) **ISBN**: 978-1-84826-953-8 (Print Volume)

Fundamentals of Physics - Volume 3

No. of Pages: 284

ISBN: 978-1-84826-223-2 (eBook) **ISBN**: 978-1-84826-673-5 (Print Volume)

For more information on e-book(s) and Print

Volume(s) order, please click here

Or contact: eolssunesco@gmail.com

CONTENTS

VOLUME I

An Introduction to and Overview of Fundamentals of Physics

1

Jose Luis Moran-Lopez, Instituto Potosino de Investigación Científica y Tecnológica, SLP, Mexico Peter Otto Hess, Instituto de Ciencias Nucleares, Universidad Nacional Autonoma de Mexico (UNAM), México

- 1. Introduction
- 2. Review of Different Areas of Physics
 - 2.1. Basic Concepts in Physics
 - 2.2. Physical Systems and Laws
 - 2.3. Particles and Fields
 - 2.4. Quantum Systems
 - 2.5. Order and Disorder in Nature
 - 2.6. Nuclear Processes
 - 2.7. Contemporary Physics
 - 2.8. Future Directions in Physics
- 3. Economical and Social Implications of physics
- 4. Conclusions

Historical Review of Elementary Concepts in Physics

25

Peter Otto Hess, Instituto de Ciencias Nucleares, Universidad Nacional Autonoma de Mexico (UNAM), México

- 1. Introduction
- 2. Newtonian Physics
- 3. Electricity Magnetism and Optics
- 4. Thermodynamics
- 5. Quantum Mechanics
- 6. Theory of Relativity
- 7. Final Remarks

Evolution of Elementary Particle Physics in the 20th Century

42

Jorge Flores, Centro de Ciencias Físicas, Universidad Nacional Autonoma de Mexico (UNAM), México

- 1. Introduction
- 2. Atoms, Nuclei and Radioactivity
- 3. Ultraviolet and Atomic Catastrophes
- 4. Quantum Mechanics
- 5. Quantum Theory of Complex Atoms
- 6. Nuclear Structure
- 7. Relativity and Quantum Mechanics
- 8. The Force Messengers
- 9. The Weak Force
- 10. The Lepton and Baryon Families
- 11. The Quark Model
- 12. The Unified Theory
- 13. Quantum Chromodynamics
- 14. What comes next?

Mechanics of Solids 60

Ramon Peralta Fabi, Facultad de Ciencias, Universidad Nacional Autonoma de Mexico (UNAM), México

- 1. Introduction
- 2. Historical Notes
- 3. General Considerations
- 4. Classical Theory of Elasticity
 - 4.1. Beams and Plates
 - 4.2. Body and Surface Waves
 - 4.3. The Navier Equations
- 5. Fracture
- 6. Finite Elasticity
- 7. Computational Mechanics
- 8. Granular Materials

Electricity and Magnetism

71

Eugenio Ley-Koo, Instituto de Fisica, Universidad Nacional Autonoma de Mexico (UNAM), México

- 1. Introduction
 - 1.1. General Introduction
 - 1.2. Electric Charges at Rest
 - 1.3. Electric charges moving in conductors
 - 1.4. Permanent magnets and electromagnets
 - 1.5. Electromagnetic induction
 - 1.6. Maxwell's electromagnetic field
 - 1.7. Electromagnetic radiation
- 2. Electrostatics
- 3. Electrical Conduction
- 4. Magnetostatics and Electromagnetism
- 5. Electromagnetic Induction
- 6. Maxwell Equations
- 7. Electromagnetic Waves
- 8. Concluding Remarks
- 9. Mathematical Tools

Principles of Optics

106

Daniel Malacara-Hernández, Centro de Investigaciones en Optica, A.C., México

- 1. Geometrical Optics
 - 1.1. Fermat's Principle and Law of Refraction
 - 1.2. First Order Optics
 - 1.3. Aberrations
- 2. Wave Optics
 - 2.1. Diffraction
 - 2.2. Young's Double Slit
 - 2.3. Interferometeres and Coherence of Light Sources
- 3. Photon or Quantum Optics
- 4. Optical Instruments
 - 4.1. Magnifiers
 - 4.2. Ophthalmic Lenses
 - 4.3. Telescopes and Microscopes
 - 4.4. Medical Optical Instruments
 - 4.5. Projectors
- 5. Optical Metrology and Interferometry
 - 5.1. Main Interferometers Used in Metrology
 - 5.2. Newton Rings and Fizeau Interferometer

- 5.3. Twyman-Green Interferometer
- 5.4. Ronchi and Lateral Shear Interferometers
- 6. Holography
 - 6.1. Thin Holograms
 - 6.2. Thick Holograms
 - 6.3. Interferometric Holography
- 7. Lasers
 - 7.1. Laser Principles
 - 7.2. Laser Types
 - 7.3. Laser Applications
- 8. Applications of Optics
 - 8.1. Optics in Astronomy and Physics
 - 8.2. Optics in Medicine and Life Sciences
 - 8.3. Optics in Industry
 - 8.4. Optics in Telecommunications

Principles of Acoustics

150

Andres Porta Contreras, Department of Physics, Universidad Nacional Autonoma de Mexico (UNAM), México

Catalina E. Stern Forgach, Department of Physics, Universidad Nacional Autonoma de Mexico (UNAM), México

- 1. Introduction
- 2. History
- 3. Basic Concepts
 - 3.1. What is Sound?
 - 3.2. Characteristics of a Wave
 - 3.3. Intensity of Sound
 - 3.4. Pitch
 - 3.5. Mathematical Description
 - 3.6. Speed of Sound
 - 3.7. Doppler Effect
 - 3.8. Reflection and Refraction
 - 3.9. Interference and Superposition
 - 3.10. Standing Waves
 - 3.11. Timbre, Modes and Harmonics
 - 3.12. Diffraction
- 4. The Ear
 - 4.1. Outer Ear
 - 4.2. Middle Ear
 - 4.3. Inner Ear
- 5. The Applications
 - 5.1. Ultrasound
 - 5.2. Medicine
 - 5.3. Noise Control
 - 5.4. Meteorology and Seismology
 - 5.5. Harmonic Synthesis
 - 5.6. Architecture and Design
 - 5.7. Speech and Voice
 - 5.8. Recording and Reproduction
 - 5.9. Other

History of Nobel Laureates in Physics

169

Jose M. Moran-Mirabal, Applied and Engineering Physics, Cornell University, USA Kurt Andresen, Applied and Engineering Physics, Cornell University, USA

Jesse D. McMullen, Applied and Engineering Physics, Cornell University, USA

- 1. Introduction
- 2. Atomic and Particle Physics
- 3. Quantum Mechanics
- 4. Condensed Matter
- 5. Astrophysics
- 6. Thermodynamics and Statistical Mechanics
- 7. Development of Experimental Methods and Technology
 - 7.1. On the nature of light and its applications
 - 7.2. On the insight into microscopic and nanoscopic dimensions
 - 7.3. On the study of matter through spectroscopy
 - 7.4. On the study of particles and atoms
 - 7.5. On the study of atomic magnetism
 - 7.6. On the advances of technology and our everyday life

Laws Of Physical Systems

207

Hugo Garcia-Compean, Centro de Investigación y de Estudios Avanzados del IPN, Unidad Monterrey and Centro de Investigación y de Estudios Avanzados, Unidad Zacatenco, México D.F., México. Octavio Obregon, Instituto de Física de la Universidad de Guanajuato, México

- 1. Introduction
- 2. Concepts, Theory and Experiments
- 3. Quantum Mechanics and Quantum Cosmology
- 4. General Relativity
- 5. Loop Quantum Gravity
- 6. String Theory
- 7. M-Theory and Holography
- 8. Emergent Phenomena
- 9. Plasmas
- 10. Thermodynamics and Statistical Physics
- 11. Complex Systems and Chaos

Symmetry Principles and Conservation Laws

230

- J. Lorenzo Diaz-Cruz, Benemerita Universidad Autonoma de Puebla, México
- A. Rosado, Benemerita Universidad Autonoma de Puebla, Mexico
- 1. Introduction
- 2. Symmetries and Conservation Laws; Noether's Theorem
- 3. Internal Symmetries in Physics
- 4. Symmetries and Mathematics
- 5. Discrete Symmetries: P and C
- 6. Isospin and SU(2)
- 7. The Group SU(3) and the quark model
- 8. Gauge Symmetries and Fundamental Interactions
- 9. Symmetry and Observables

Special and General Relativity

246

Jorge Pullin, Department of Physics and Astronomy, Louisiana State University, Baton Rouge LA 70803, USA

- 1. Relativity in Physics
- 2. General Relativity
- 3. Contemporary Developments circa 2004

Quantum Mechanical Laws

255

Bogdan Mielnik, Departamento de Física, Centro de Investigacion y de Estudios Avanzados, Mexico Oscar Rosas-Ortiz, Departamento de Física, Centro de Investigacion y de Estudios Avanzados, Mexico

- 1. Introduction
- 2. Black Body Radiation: The Lateral Problem Becomes Fundamental
- 3. The Discovery of Photons
- 4. Compton's Effect: Collisions Confirm the Existence of Photons
- 5. Atoms: The Contradictions of the Planetary Model
- 6. The Mystery of the Allowed Energy Levels
- 7. Luis de Broglie: Particles or Waves?
- 8. Schrödinger's Wave Mechanics: Wave Vibrations Explain the Energy Levels
- 9. The Statistical Interpretation
 - 9.1. Polarized Photons: Absence of Deterministic Rules?
 - 9.2. Born's Statistical Interpretation
- 10. The Schrödinger's Picture of Quantum Theory
 - 10.1. States, State Superposition, Probabilities
 - 10.2. Quantum Geometry
 - 10.3. Linear Operators: The Spirit of Interference
 - 10.4. Quantum Observable: Old and New Ideas
 - 10.5. Observables as Operators: The Anatomy of the Measurement
 - 10.6. General Formalism; The Extended Born's Hypothesis
 - 10.7. Functions of an Observable
 - 10.8. Transition Probabilities: The Most Elementary Statistical Law
 - 10.9. The Construction of the Traditional Observables
- 11. The Uncertainty Principle: Instrumental and Mathematical Aspects
- 12. Typical States and Spectra
 - 12.1. Harmonic Oscillator: Spectral Ladders, Eigenstates, Coherent States
 - 12.2. The Angular Momentum
 - 12.3. Hydrogen and Hydrogen-like Atoms
 - 12.4. Pauli's Exclusion Principle
 - 12.5. Particle Spin: A Controversial Non-classical Property
 - 12.6. The Spectral Bands
- 13. Unitary Evolution
- 14. Canonical Quantization: Scientific or Magic Algorithm?
- 15. The Mixed States
- 16. Quantum Control: How to Manipulate the Particle?
- 17. Measurement Theory and Its Conceptual Consequences
 - 17.1. State Reduction (Collapse of the Wave Packet)
 - 17.2. The Strong Uncertainty Principle
 - 17.3. The Idea of Complementarity
 - 17.4. "Quantum Logic"
 - 17.5. Quantum Bit (Qubit)
- 18. Interpretational Polemics and Paradoxes
 - 18.1. Quest for Alternative Theories
 - 18.2. The Measurement Problem
 - 18.3. Borderline Doctrine
 - 18.4. The Paradox of the Schrödinger's Cat
 - 18.5. The Doctrine of Decoherence
 - 18.6. The Ensemble Interpretation
 - 18.7. The Realistic View
 - 18.8. Many Worlds Interpretation of Everett
 - 18.9. Quantum Jumps and Quantum Zeno Effect
 - 18.10. The Macroscopic Superposition
- 19. Entangled States
 - 19.1. General Concepts
 - 19.2. Spin-configuration Entanglement
 - 19.3. Many Particle Entangled States

- 20. Dirac's Theory of the Electron as the Square Root of The Klein-Gordon Law
 - 20.1. The Klein-Gordon Equation
 - 20.2. Dirac's Equation
 - 20.3. The Hypothesis of Positron
- 21. Feynman: The Interference of Virtual Histories
- 22. The Locality Problems
 - 22.1. The EPR Paradox
 - 22.2. Hidden Variables and Bell's Inequalities
 - 22.3. "Seeing in the Dark"
 - 22.4. Teleportation
- 23. The Idea of Quantum Computing and Future Perspectives
 - 23.1. Quantum Cryptography
 - 23.2. Quantum Computing
- 24. Open Questions

Thermodynamics, Statistical Physics and Their Laws

327

Fernando del Rio Haza, *Departamento de Física*, *Universidad Autónoma Metropolitana*, *Mexico* Victor Romero-Rochin, *Instituto de Física*, *Universidad Nacional Autónoma de México*, *México*, *DF*, *México*

- 1. Introduction: On the Nature and Importance of Thermodynamic Laws
- 2. Thermodynamic Systems and Their Description
 - 2.1. Thermodynamic Systems
 - 2.2. Thermodynamic Variables
 - 2.3. Equilibrium and Interactions
- 3. The Thermodynamic Laws
 - 3.1. Temperature and the Zeroth Law
 - 3.2. Thermodynamic Processes
 - 3.3. Heat and the First Law
 - 3.4. Entropy and the Second Law
 - 3.5. The Third Law
- 4. The Thermodynamic Potentials
- 5. Statistical Physics A Briefing
 - 5.1. The Principle of Boltzmann-Gibbs
 - 5.2. Averages and the Canonical Distribution
 - 5.3. The Role of Fluctuations
 - 5.4. The Ideal Gas
- 6. Selected Illustrations
 - 6.1. Thermodynamics and Living Organisms
 - 6.2. A World of Engines

Complex Systems and Non-linear Dynamics

356

Jose L. Mateos, Department of Complex Systems, Institute of Physics, National Autonomous University of Mexico, Mexico

- 1. Introduction
- 2. Complex Systems
- 3. Non-Linear Dynamics and Chaos
- 4. Topics Involved
 - 4.1. Hamiltonian Chaos
 - 4.2. Dissipative Chaos
 - 4.3. Non-linear Dynamics and Chaos in Physiology
 - 4.4. Control and Synchronization of Chaos
- 5. Concluding Remarks

Plasmas 371

Julio Javier Martinell, *Plasma Physics Department, Instituto de Ciencias Nucleares, UNAM, Mexico* Rafael Navarro-Gonzalez, *Plasma Physics Department, Instituto de Ciencias Nucleares, UNAM, Mexico* Alejandro Cristian Raga, *Plasma Physics Department, Instituto de Ciencias Nucleares, UNAM, Mexico*

- 1. Introduction
- 2. Astrophysical Plasmas
 - 2.1. Introduction
 - 2.2. Bright and Dark Clouds in the Interstellar Medium
 - 2.3. The Formation of Low Mass Stars and Planets
 - 2.4. The Solar Wind and Coronal Mass Ejections
- 3. Geophysical Plasmas
 - 3.1. Introduction
 - 3.2. Auroras
 - 3.3. Lightning
 - 3.4. Volcanic lightning
- 4. Laboratory Plasmas
 - 4.1. Introduction
 - 4.2. Fusion Plasmas
 - 4.2.1. Magnetic Confinement
 - 4.2.2. Inertial Confinement
 - 4.3. Cold Plasmas
 - 4.4. Laser Plasmas
- 5. Conclusions

Index 389

About EOLSS 397

VOLUME II

Elementary and Fundamental Particles

1

Carlos A. Garcia Canal, Laboratorio de Física Teórica, Departamento de Física, Universidad Nacional de la Plata, Argentina

- 1. Introduction
- 2. Historical, Semantic and Formal Aspects
- 3. Elementary Today
- 4. Interactions and Fundamental Symmetries
- 5. A Bit of Formalism
- 6. Final Remarks

Types of Interactions

17

Guenter Sigl, GReCO, Institu d'Astrophysique de Paris, C.N.R.S., 98bis boulevard Arago, F-75014 Paris, France

- 1. Introduction
- 2. Description of Interactions in Quantum Mechanics and Quantum Field Theory
 - 2.1. The Action Principle
 - 2.2. Symmetries of the Action
 - 2.3. Canonical and Path Integral Quantization
 - 2.4. Space-Time Symmetries and Their Representations
- 3. Gauge Symmetries and Interactions
 - 3.1. Gauge Symmetry of Matter Fields
 - 3.2. Gauge Symmetry of Gauge Fields

3.3. Conformal Invariance

5. Unification of Interactions6. A Theory of Everything?

Molecules, Atoms and Nuclei

3.4. Gauge Symmetries and Quantization
4. The Known Fundamental Interactions of Nature
4.1. The Electromagnetic Interaction
4.2. The Electroweak Interaction
4.3. The Strong Interaction
4.4. The Gravitational Interaction

Jorge G. Hirsch, Instituto de Ciencias Nucleares UNAM, Mexico			
1.	Introduction		
2.			
	2.1. The Quantum Formalism		
	2.2. The Spin		
	2.3. Multielectron Atoms		
	2.4. The Periodic Table		
	2.5. Manipulation of Atoms		
3.	Molecules		
	3.1. Chemical Bonding		
	3.2. Ionic and Covalent Bonds		
	3.3. Molecular Energy Spectra		
4.	Nuclei		
	4.1. Nuclear Masses and Abundances		
	4.2. Nuclear Models		
	4.2.1. The Liquid Drop Model		
	4.2.2. The Shell Model		
	4.3. Radioactivity		
	4.3.1. Alpha, Beta and Gamma Decays		
5.	Final Remarks		
	ctromagnetic Waves 73		
	ctromagnetic Waves 73 é Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain		
Jose	é Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain		
Jose 1.	é Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field		
Jose 1. 2.	é Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations		
Jose 1. 2. 3.	é Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields		
Jose 1. 2. 3. 4.	é Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves		
Jose 1. 2. 3.	é Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum		
Jose 1. 2. 3. 4. 5. 6.	é Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter		
1. 2. 3. 4. 5. 6. 7.	É Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter Standing Waves		
1. 2. 3. 4. 5. 6. 7. 8.	É Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter Standing Waves Energy and Momentum		
1. 2. 3. 4. 5. 6. 7. 8. 9.	É Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter Standing Waves Energy and Momentum Radiation Pressure		
1. 2. 3. 4. 5. 6. 7. 8. 9. 10.	É Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter Standing Waves Energy and Momentum Radiation Pressure Radiation from an Antenna		
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11.	É Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter Standing Waves Energy and Momentum Radiation Pressure Radiation from an Antenna Black Body Radiation		
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.	É Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter Standing Waves Energy and Momentum Radiation Pressure Radiation from an Antenna Black Body Radiation Cosmic Microwave Background		
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13.	É Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter Standing Waves Energy and Momentum Radiation Pressure Radiation from an Antenna Black Body Radiation Cosmic Microwave Background Polarization		
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14.	E Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter Standing Waves Energy and Momentum Radiation Pressure Radiation from an Antenna Black Body Radiation Cosmic Microwave Background Polarization Wave Phenomena: Interference and Diffraction		
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15.	E Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter Standing Waves Energy and Momentum Radiation Pressure Radiation from an Antenna Black Body Radiation Cosmic Microwave Background Polarization Wave Phenomena: Interference and Diffraction The Quantum States of Radiation: Photons		
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16.	E Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter Standing Waves Energy and Momentum Radiation Pressure Radiation from an Antenna Black Body Radiation Cosmic Microwave Background Polarization Wave Phenomena: Interference and Diffraction The Quantum States of Radiation: Photons Atomic Line Spectra		
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16.	E Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter Standing Waves Energy and Momentum Radiation Pressure Radiation from an Antenna Black Body Radiation Cosmic Microwave Background Polarization Wave Phenomena: Interference and Diffraction The Quantum States of Radiation: Photons		
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18.	E Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter Standing Waves Energy and Momentum Radiation Pressure Radiation from an Antenna Black Body Radiation Cosmic Microwave Background Polarization Wave Phenomena: Interference and Diffraction The Quantum States of Radiation: Photons Atomic Line Spectra Energy Levels in Atoms The Laser		
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18.	E Bernabéu, Department of Theoretical Physics and IFIC, University of Valencia and CSIC, Spain Introduction: Physical Reality of the Field Maxwell's Equations The Propagation of Electromagnetic Fields Sinusoidal Electromagnetic Waves The Electromagnetic Spectrum Electromagnetic Waves in Matter Standing Waves Energy and Momentum Radiation Pressure Radiation from an Antenna Black Body Radiation Cosmic Microwave Background Polarization Wave Phenomena: Interference and Diffraction The Quantum States of Radiation: Photons Atomic Line Spectra Energy Levels in Atoms		

50

Quantum Systems 110

Octavio Castanos, *Instituto de Ciencias Nucleares, UNAM, México* Ramon Lopez-Pena, *Instituto de Ciencias Nucleares, UNAM, México*

- 1. Introduction
- 2. Origin and Development of Quantum Mechanics
 - 2.1. Wave-particle Duality
 - 2.2. Quantum Mechanics in a Space of States
 - 2.3. Phase Space Formulation
 - 2.3.1. Wigner Function
 - 2.3.2. Properties of the Wigner Function
 - 2.3.3. Time Evolution of the Wigner Function
 - 2.3.4. Tomograms and Probability Representation
- 3. Bose-Einstein Condensates
 - 3.1. Identical Particles
 - 3.2. Bose-Einstein Condensation
 - 3.3. Cooling of Atoms
 - 3.3.1. Absorption and Emission of Light
 - 3.3.2. Doppler Cooling
 - 3.3.3. Sisyphus Cooling
 - 3.3.4. Evaporative Cooling
- 4. Quantum Information Theory
 - 4.1. Quantum Computation
 - 4.1.1. Qubits and Quantum Algorithms
 - 4.1.2. Entanglement
 - 4.2. Quantum Communications and Cryptography
 - 4.2.1. Quantum Teleportation
 - 4.2.2. Dense Coding

Stationary States in Potential Well

146

Haret Rosu, Instituto Postosino de Investigacion Cientifica y Tecnologica, SLP, Mexico Jose Luis Moran-Lopez, Instituto Potosino de Investigación Científica y Tecnológica, SLP, Mexico

- 1. Introduction
- 2. Stationary Orbits in Old Quantum Mechanics
 - 2.1. Quantized Planetary Atomic Model
 - 2.2. Bohr's Hypotheses and Quantized Circular Orbits
 - 2.3. From Quantized Circles to Elliptical Orbits
 - 2.4. Experimental Proof of the Existence of Atomic Stationary States
- 3. Stationary States in Wave Mechanics
 - 3.1. The Schrödinger Equation
 - 3.2. The Dynamical Phase
 - 3.3. The Schrödinger Wave Stationarity
 - 3.4. Stationary Schrödinger States and Classical Orbits
 - 3.5. Stationary States as Sturm-Liouville Eigenfunctions
- 4. The Infinite Square Well: The Stationary States Most Resembling the Standing Waves on a String
- 5. 1D Parabolic Well: The Stationary States of the Quantum Harmonic Oscillator
 - 5.1. The Solution of the Schrödinger Equation
 - 5.2. The Normalization Constant
 - 5.3. Final Formulas for the HO Stationary States
 - 5.4. The Algebraic Approach: Creation and Annihilation Operators
 - 5.5. HO Spectrum Obtained from Wilson-Sommerfeld Quantization Condition
- 6. The 3D Coulomb Well: The Stationary States of the Hydrogen Atom
 - 6.1. The Separation of Variables in Spherical Coordinates
 - 6.2. The Angular Separation Constants as Quantum Numbers
 - 6.2.1. The Azimuthal Solution and the Magnetic Quantum Number
 - 6.2.2. The Polar Solution and the Orbital Quantum Number

6.2.3. The Space Quantization

- 6.3. Polar and Azimuthal Solutions Set Together
- 6.4. The Radial Solution and the Principal Quantum Number
- 6.5. Final Formulas for the Hydrogen Atom Stationary States
- 6.6. Electronic Probability Density
- 6.7. Other 3D Coordinate Systems Allowing Separation of Variables
- 7. The 3D Parabolic Well: The Stationary States of the Isotropic Harmonic Oscillator
- 8. Stationary Bound States in the Continuum
- 9. Conclusion

Atoms and Molecules 196

Rocio Jauregui, Instituto de Fisica, UNAM, Mexico

Carlos Federico Bunge, Instituto de Fisica, Universidad Nacional Autonoma de Mexico, Mexico

- 1. Introduction
- 2. High Precision Atomic Spectroscopy
- 3. Negative Ions
- 4. Atomic Collisions
 - 4.1. Hollow Atoms
 - 4.2. Heavy Ion Collisions
 - 4.3. Cold Collisions
- 5. Rydberg Atoms
- 6. Parity Nonconservation in Atoms
- 7. Exotic Atoms
- 8. Atom Optics
- 9. Molecules
- 10. Gases
- 11. Molecules in Solids and Liquids
- 12. Basic Molecular Principles
- 13. Water Molecules and Some Chemical Reactions
- 14. Photosynthesis

Quantum-Mechanical Description of Solids

215

Timothy B. Boykin, Department of Electrical and Computer Engineering, University of Alabama-Huntsville, USA

- 1. Introduction
 - 1.1. The Many-Electron, Many-Ion Problem
 - 1.2. Non-interacting Electrons and the Pauli Exclusion Principle
- 2. Energy Bands
 - 2.1. Translational Symmetry: Bloch's Theorem
 - 2.2. Features of Energy Bands
 - 2.3. Manifestations of Other Crystal Symmetries in the Energy Bands
 - 2.4. Metals, Semiconductors, and Insulators
- 3. Bandstructure Calculation Methods
 - 3.1. Pseudopotential Methods
 - 3.2. Tight-Binding Methods
- 4. Interface States
- Conclusions

Quantum Phenomena in Low-Dimensional Systems

233

Michael R. Geller, Department of Physics and Astronomy, University of Georgia, USA

- Introduction
- 2. Making Low-Dimensional Quantum Structures

3.	Physics in Quantum Systems of Reduced Dimensions 3.1. Effective Mass Theory 3.2. Density of States 3.3. Mesoscopic Physics 3.3.1. Aharonov-Bohm Effect 3.3.2. Persistent Currents 3.3.3. Phase-Coherent Transport 3.3.4. Dephasing by Electron-Electron Interaction 3.3.5. Thouless Energy 3.4. Integrable Systems 3.5. Fermi Liquid Theory and Beyond		
4.	Two-Dimensional Quantum Systems 4.1. Surface Science 4.2. Heterostructures 4.3. Quantum Wells and Superlattices 4.4. Two-Dimensional Electron Gas 4.4.1. The Electron Solid 4.4.2. The Metal-Insulator Transition 4.4.3. The Quantum Hall Effect 4.4.4. Composite Fermions 4.5. High-Temperature Superconductors		
5.	 4.6. Two-Dimensional Magnetism One-Dimensional Quantum Systems 5.1. Quantum Wires 5.2. Carbon Nanotubes 5.3. The Luttinger Liquid State 5.4. Edge States of the Quantum Hall Fluid 5.5. Spin Chains 		
6.	 Zero-Dimensional Quantum Systems 6.1. Quantum Dots 6.1.1. Coulomb Blockade and the Single Electron Transistor 6.1.2. Quantum Computers 6.1.3. Exact Diagonalization 6.2. Artificial Molecules 6.3. Nanocrystals and Nanoparticles 		
Index		257	
Ab	out EOLSS	263	
VOLUME III			
	ructure of Solids and Liquids: Crystallography un Leslie Finney, Department of Physics and Astronomy, University College London, UK	1	
1. 2. 3.	Introduction The Basic Principle of Atomic Structure Determination 2.1. The Scope of Crystallography 2.2. The Crystallographic Ruler Crystallography of Crystals 3.1. Diffraction from 'Ideal' Single Crystals 3.2. Diffraction from Powders 3.3. The Use of Powder and Single Crystal Methods in Structure Determination 3.4. Probing Disorder in Crystals 3.5. X-ray and Neutron Rulers		

- 4. Crystallography of Glasses and Liquids
 - 4.1. Liquids, Glasses and Crystals
 - 4.2. Determining Liquid Structures
 - 4.3. Clustering of an Alcohol in Water
 - 4.4. Salting out of an Aqueous Amphiphile
- 5. A note on Systems with Intermediate Order
- 6. Concluding Remarks

Fluctuations 35

Benedito Jose Costa Cabral, *Grupo de Física Matemática and Departamento de Química e Bioquímica, Universidade de Lisboa, Portugal*

Jean-Claude Zambrini, Grupo de Física Matemática and Departamento de Química e Bioquímica, Universidade de Lisboa, Portugal

- 1. Introduction
- 2. Fluctuations and Physical Properties
- 3. Fluctuations, Time Correlation Functions and Transport Properties
- 4. Quantum Fluctuations
- Conclusions

Phase Transitions and Spontaneously Broken Symmetries

51

Roelof Bijker, Institute of Nuclear Sciences, UNAM, Mexico

- 1. Introduction
- 2. Ferromagnetism
- 3. Continuous Global Symmetry: Nambu-Goldstone Bosons
- 4. Continuous Local Symmetry: Higgs Bosons
- 5. Electroweak Unification

Universality In Chaos: Evolution Of Turbulence

61

- J.J. Godina-Nava and M.A. Rodríguez Segura, Departamento de Física CINVESTAV-IPN, México, D.F.
- G. A. Vázquez Coutiño, Depto. de Química, Area de Química Analítica, México, D.F.
- G. Serrano Luna, Depto. de Ingeniería Eléctrica, Sección de Bioelectrónica, CINVESTAV IPN, México, D.F.
- S. Carreto García, Departamento de Ciencias Químicas, Facultad de Estudios Superiores, México, D.F.
- 1. Introduction
- 2. The Universality
 - 2.1. The Dynamical Systems
 - 2.2. The Logistic Map
 - 2.3. The Lorenz Model
 - 2.4. The Chemical Reactions
 - 2.5. The Symbolic Dynamics
- 3. The Tools to Characterize Chaos
 - 3.1. The Poincaré Map
 - 3.2. The Fractal Dimension $d_{\rm F}$
 - 3.3. The Lyapunov Exponents and the Entropy
 - 3.4. The Bifurcations
- 4. Time Series Analysis
 - 4.1. The Correlation Integral
 - 4.2. The State Space Reconstruction
 - 4.2.1. Method of Mutual Information
 - 4.2.2. The Method of False Nearest Neighbors
- 5. Turbulence Phenomena
 - 5.1. Description

- 5.2. Experimental Evidence and Measurements
- 5.3. Interpretation
- 5.4. Description of Dissipative Systems
- 5.5. The Navier-Stokes Equation
 - 5.5.1. The Navier-Stokes Equation with Wavelets

Non-Equilibrium Processes

88

M. Lopez de Haro, Centro de Investigación en Energía, U.N.A.M., Priv. Xochicalco s/n, Zona Cultural Xochicalco Temixco, Morelos 62580 México

Antonio Del Rio, Centro de Investigación en Energía, U.N.A.M., Priv. Xochicalco s/n, Zona Cultural Xochicalco Temixco, Morelos 62580 México

- 1. Introduction
- 2. Non-equilibrium Thermodynamics
 - 2.1. Classical (linear) Irreversible Thermodynamics
 - 2.2. A Recent Application
- 3. Microscopic Foundations
 - 3.1. Kinetic Theory
 - 3.2. Fluctuations
- 4. Concluding Remarks

Topical Review: Nuclear Processes

103

Peter Otto Hess, Instituto de Ciencias Nucleares, Universidad Nacional Autonoma de Mexico (UNAM), México

- 1. Introduction (A Historical Review)
- 2. Comments on Different Aspects of Nuclear Processes
 - 2.1. Nature of Nuclear Processes and Nuclear Models
 - 2.2. Natural and Artificial Radioactivity
 - 2.3. Nuclear Reactions
 - 2.4. Interactions of Nuclear Radiation with Matter
 - 2.5. Nucleosynthesis in Nature
- 3. Political and Social Implications of Nuclear Physics: Past, Present and Future
- 4. Conclusions

Nuclear Models: Shell Structure and the Extension of the Periodic System

127

Walter Greiner, Institut für Theoretische Physik, J.W. Goethe-Universität, Frankfurt, Germany Joachim A Maruhn, Institut für Theoretische Physik, J.W. Goethe-Universität, Frankfurt, Germany Thomas Burvenich, Institut für Theoretische Physik, J.W. Goethe-Universität, Frankfurt, Germany

- 1. Introduction
- 2. Cold Valleys in the Potential
- 3. Shell Structure in the Superheavy Region
- 4. Asymmetric and Superasymmetric Fission cluster Radioactivity
- 5. Fission Observed with the Gamma-sphere: Long Living Nuclear Molecules
- 6. Extension of the Periodic System into the Sections of Hyper- and Antimatter
- 7. Concluding Remarks Outlook

Natural and Human-Produced Radioactivity

151

Maria-Ester Brandan, Physics Institute, Universidad Nacional Autonoma de Mexico (UNAM), México

- 1. Introduction
- 2. Half-life
- 3. Types of radioactivity

- 3.1. Alpha Decay
- 3.2. Beta Decay
- 3.3. Gamma Decay
- 3.4. Proton Radioactivity
- 3.5. Heavy-nucleus Radioactivity
- 3.6. Spontaneous Fission
- 4. Natural Radioactivity
 - 4.1. Primordial Radioactivity
 - 4.2. Cosmogenic Radioactivity
 - 4.3. Natural Radioactivity in the Soil and the Ocean
 - 4.4. Natural Radioactivity in the Body
- 5. Human-produced Radioactivity
 - 5.1. Nuclear Weapons Testing
 - 5.2. Nuclear Energy
 - 5.3. Medical, Industrial, and Research Uses of Radioactivity
 - 5.4. Accidents
- 6. Human Exposure to Radioactivity
- 7. Conclusions

Nuclear Reactions 166

Werner Scheid, Institut für Theoretische Physik der Justus-Liebig-Universität, Germany

- 1. Introduction
- 2. Cross Section and Collision (S-) Matrix
 - 2.1. Energy Relations
 - 2.2. Differential Cross Section
 - 2.3. Hamiltonian and Asymptotic Wave Function
 - 2.4. The S Matrix, Reciprocity Relation and Principle of Detailed Balance
 - 2.5. Cross Sections for Neutron induced Reactions
- 3. Compound Nucleus Reactions
 - 3.1. Compound Nucleus
 - 3.2. R-Matrix Theory
 - 3.3. Cross Sections for Compound Nucleus Reactions
- 4. The Optical Model
 - 4.1. Formal Theory of Optical Model
 - 4.2. Parametrization of the Optical Potential for Nucleons
- 5. Direct Reactions
 - 5.1. Distorted Wave Born Approximation
 - 5.2. Transfer Reactions
- 6. Nuclear Reactions with Heavy Ions
 - 6.1. Quasimolecular Resonances
 - 6.2. Fusion and Quasifission of Heavy Nuclei
 - 6.3. Relativistic Heavy Ion Reactions

Interaction of Nuclear Radiation with Matter

190

Arturo Menchaca-Rocha, Institute of Physics, Universidad Nacional Autonoma de Mexico (UNAM), México

- 1. Introduction
- 2. Basic Concepts
- 3. Energy loss by heavy charged particles
- 4. Energy loss by electrons and positrons
- 5. Energy deposition by γ -rays
- 6. Interaction of neutrons with matter
- 7. Nuclear radiation detection
- 8. Dosimetry and biological effects

Nu	clear Synthesis in Nature	202
	Langanke, Institute for Physics and Astronomy, University of Aarhus, DK-8000 Aarhus	
	Denmark	
M	ichael Wiescher, Department of Physics, University of Notre Dame, USA	
_		
1.	The General Concept	
	Big Bang Nucleosynthesis	
3.	Stellar Nucleosynthesis	
	3.1. Stellar Core Burning	
	3.2. Stellar Shell Burning	
	3.3. The s-Process	
4.	Core Collapse Supernovae	
	4.1. Collapse Phase	
	4.2. Explosion Mechanism	
	4.3. The r-Process	
	4.4. Neutrino Nucleosynthesis	
5.	Nucleosynthesis in Explosive Binary Systems	
	5.1. Nova Explosions	
	5.2. Type Ia Supernovae	
	5.3. X-Ray Bursts and X-Ray Pulsars	
6.	Nucleosynthesis and Cosmic Rays	
7.	Conclusion	
Ind	Index	
About EOLSS		223