Contents

| 1 | Hor | s d'œuvre | 1 | | |
|----|----------------------------|--|----|--|--|
| | 1.1 | Fundamental Constituents of Matter | 1 | | |
| | 1.2 | Fundamental Interactions | 2 | | |
| | 1.3 | Symmetries and Conservation Laws | 4 | | |
| | 1.4 | Experiments | 5 | | |
| | 1.5 | Units | 6 | | |
| Pa | rt I | Analysis: The Building Blocks of Matter | | | |
| 2 | Glo | bal Properties of Nuclei | 11 | | |
| | 2.1 | The Atom and its Constituents | 11 | | |
| | 2.2 | Nuclides | 13 | | |
| | 2.3 | Parametrisation of Binding Energies | 18 | | |
| | 2.4 | Charge Independence of the Nuclear Force and Isospin | 21 | | |
| | Prob | olem | 23 | | |
| 3 | Nuc | lear Stability | 25 | | |
| | 3.1 | β-Decay | 26 | | |
| | 3.2 | α-Decay | 31 | | |
| | 3.3 | Nuclear Fission | 34 | | |
| | 3.4 | Decay of Excited Nuclear States | 36 | | |
| | Prob | olems | 39 | | |
| 4 | Scat | Scattering | | | |
| | 4.1 | General Observations About Scattering Processes | 41 | | |
| | 4.2 | Cross Sections | 44 | | |
| | 4.3 | The "Golden Rule" | 48 | | |
| | 4.4 | Feynman Diagrams | 49 | | |
| | Prob | olems | 52 | | |
| 5 | Geometric Shapes of Nuclei | | | | |
| | 5.1 | Kinematics of Electron Scattering | | | |
| | 5.2 | The Rutherford Cross-Section | | | |
| | 5.3 | The Mott Cross-Section | 60 | | |

| X | C | Contents | |
|----|--|--|----|
| | 5.4 | Nuclear Form Factors | 51 |
| | 5.5 | | 59 |
| | Prob | olems | 71 |
| 6 | Elas | stic Scattering off Nucleons | 73 |
| | 6.1 | Form Factors of the Nucleons | 73 |
| | 6.2 | Quasi-elastic Scattering | 78 |
| | 6.3 | Charge Radii of Pions and Kaons | 30 |
| | Prob | blems | 32 |
| 7 | Deep | p Inelastic Scattering | 33 |
| | 7.1 | Excited States of the Nucleons | 33 |
| | 7.2 | Structure Functions | 35 |
| | 7.3 | The Parton Model | 38 |
| | 7.4 | Interpretation of Structure Functions in the Parton Model | 91 |
| | Prob | olems | 94 |
| 8 | Quarks, Gluons, and the Strong Interaction | | |
| | 8.1 | The Quark Structure of Nucleons | 97 |
| | 8.2 | Quarks in Hadrons |)2 |
| | 8.3 | The Quark–Gluon Interaction |)3 |
| | 8.4 | Scaling Violations of the Structure Functions |)7 |
| | Prob | blem | 11 |
| 9 | Part | ticle Production in e ⁺ e ⁻ Collisions | 13 |
| | 9.1 | Lepton Pair Production | 14 |
| | 9.2 | Resonances | 18 |
| | 9.3 | Non-resonant Hadron Production | 23 |
| | 9.4 | Gluon Emission | 25 |
| | Prob | olems | 26 |
| 10 | Phei | nomenology of the Weak Interaction | 27 |
| | 10.1 | The Lepton Families | 27 |
| | 10.2 | The Types of Weak Interactions | 31 |
| | | Coupling Strength of the Charged Current | |
| | 10.4 | The Quark Families | 38 |
| | | Parity Violation | |
| | | Deep Inelastic Neutrino Scattering | |
| | Prob | blems | 17 |
| 11 | Excl | hange Bosons of the Weak Interaction | 19 |
| | 11.1 | Real W and Z Bosons | 19 |
| | 11.2 | Electroweak Unification | 54 |
| | Prob | blem | 51 |
| 12 | The | Standard Model | 53 |

| Part II | | Synthesis: Composite Systems | |
|---------|--|---|--|
| 13 | 13.1 13.2 13.3 13.4 13.5 13.6 13.7 | Arkonia 16 1 The Hydrogen Atom and Positronium Analogues 16 2 Charmonium 17 3 Quark—Antiquark Potential 17 4 The Chromomagnetic Interaction 17 5 Bottonium and Toponium 17 6 The Decay Channels of Heavy Quarkonia 18 7 Decay Widths as a Test of QCD 18 blems 18 | |
| 14 | 14.1 14.2 14.3 14.4 | sons Made from Light Quarks 18 1 Mesonic Multiplets 18 2 Meson Masses 19 3 Decay Channels 19 4 Neutral Kaon Decay 19 blems 19 | |
| 15 | 15.1 15.2 15.3 15.4 15.5 15.6 | Baryons 19 The Production and Detection of Baryons 19 Baryon Multiplets 20 Baryon Masses 20 Magnetic Moments 21 Semileptonic Baryon Decays 21 How Good is the Constituent Quark Concept? 22 Belems 22 | |
| 16 | 16.2 16.3 | Nuclear Force 22 Nucleon–Nucleon Scattering 22 2 The Deuteron 23 3 Nature of the Nuclear Force 23 blems 24 | |
| 17 | 17.1 17.2 17.3 17.4 17.5 | e Structure of Nuclei 24 1 The Fermi Gas Model 24 2 Hypernuclei 24 3 The Shell Model 25 4 Deformed Nuclei 25 5 Spectroscopy Through Nuclear Reactions 26 6 β-Decay of the Nucleus 26 blems 27 | |

| XII | Contents |
|-----|----------|
| | |

| 18 | Collective Nuclear Excitations |
|-----|--|
| | 18.1 Electromagnetic Transitions |
| | 18.2 Dipole Oscillations |
| | 18.3 Shape Oscillations |
| | 18.4 Rotation States |
| | Problems |
| 19 | Nuclear Thermodynamics |
| | 19.1 Thermodynamical Description of Nuclei |
| | 19.2 Compound Nuclei and Quantum Chaos |
| | 19.3 The Phases of Nuclear Matter |
| | 19.4 Particle Physics and Thermodynamics in the Early Universe 316 |
| | 19.5 Stellar Evolution and Element Synthesis |
| | Problems |
| 20 | Many-Body Systems in the Strong Interaction |
| A | Appendix |
| | A.1 Accelerators |
| | A.2 Detectors |
| | A.3 Combining Angular Momenta |
| | A.4 Physical Constants |
| Sol | utions to the Problems |
| Bib | liography 379 |
| Ind | ex |