Chapter 1

FIFTY YEARS OF THE SHELL MODEL - THE QUEST FOR THE EFFECTIVE INTERACTION

Igal Talmi

1. Introduction 2
2. The (Re)Emergence of the Shell Model 11
2.1. Single Nucleon Orbits 12
2.2. The Supermultiplet Scheme 19
3. Early Calculations 26
3.1. Energy Levels of Simple Configurations 26
3.2. Nuclear Magnetic Moments 37
3.3. Electromagnetic Moments and Transitions. Beta Decay 44
3.4. Seniority and the δ potential 53
3.5. Applications of the δ potential to Even-Even and Odd-Odd Nuclei 58
3.6. Simple Potential Interactions. Configuration Mixing 62
3.7. TheBetaDecayof14C 68
3.8. Simple Potential Interactions. Ignoring the Hard Core 73
3.9. The Pb RegionI 85
4. Effective Interactions from Experimental Nuclear Energies 89
4.1. Simple Configurations 91
4.2. Protons and Neutrons in Different Orbits. 11Be 102
4.3. The Zr Region I 109
4.4. The 1f7/2 Shell 115
4.5. Mixed Configurations in the 2p, 1f Shell 121
4.6. The Nickel Isotopes 133
4.7. The Pb Region II 140
4.8. The Zr region II 144
4.9. The 2s, 1d Shell 168
4.10. The Complete 1p-Shell and Beyond 175
4.11. "Pseudonium Nuclei" 179
5. Some Schematic Interactions and Applications 181
5.1. The Pairing Interaction 181
5.2. The Surface Delta Interaction, the Quasi-Spin Scheme and Extensions 193
5.3. The SU(3) Scheme 202
6. Seniority and Generalized Seniority in Semi-Magic Nuclei 215
6.1. The Seniority Scheme and Applications 215
6.2. Generalized Seniority 220

7. Large Scale Shell Model Calculations 232
7.1. The sd-Shwll and Beyond 232
7.2. The pf-Shell 241
7.3. Nuclei in which N = 20Loses Its Magicity 249
8. What have we learned? Where do we stand? 253
References 265

Chapter 2

INTRODUCTION TO CHIRAL PERTURBATION THEORY

Ste fan Scherer

1. Introduction 278
1.1. Scope and Aim of the Review 278
1.2. Introduction to Chiral Symmetry and Its Application to Mesons and Single Baryons 279
2. QCD and Chiral Symmetry 290
2.1. Some Remarks on SU(3) 290
2.2. The QCD Lagrangian 293
2.3. Accidental, Global Symmetries of Lqcd 297
2.4. Green Functions and Chiral Ward Identities 310
3. Spontaneous Symmetry Breaking and the Goldstone Theorem 323
3.1. Degenerate Ground States 324
3.2. Spontaneous Breakdown of a Global, Continuous, Non-Abelian Symmetry 330
3.3. Goldstone's Theorem 335
3.4. Explicit Symmetry Breaking: A First Look 338
4. Chiral Perturbation Theory for Mesons 339
4.1. Spontaneous Symmetry Breaking in QCD 340
4.2. Transformation Properties of the Goldstone Bosons 347
4.3. The Lowest-Order Effective Lagrangian 352
4.4. Effective Lagrangians and Weinberg's Power Counting Scheme 360
4.5. Construction of the Effective Lagrangian 365
4.6. Applications at Lowest Order 370
4.7. The Chiral Lagrangian at Order O(p4) 380
4.8. The Effective Wess-Zumino-Witten Action 384
4.9. Applications at Order O(4) 388
4.10. Chiral Perturbation Theory at O(p6) 405
5. Chiral Perturbation Theory for Baryons 417
5.1. Transformation Properties of the Fields 418

5.2. Lowest-Order Effective Baryonic Lagrangian 423
5.3. Applications at Tree Level 427
5.4. Examples of Loop Diagrams 440
5.5. The Heavy-Baryon Formulation 449
5.6. The Method of Infrared Regularization 483
6. Summary and Concluding Remarks 496
Appendix 501
A.1. Green Functions and Ward Identities 501
A.2. Dimensional Regularization: Basics 507
A.3. Loop Integrals. 512
A.4. Different Forms of L4 in SU(2) x SU(2) 522
References 529

Index 539