

# CONTENTS

## PART I. FUNDAMENTAL PROPERTIES OF NUCLEI

CHAPTER 1. FUNDAMENTAL PROPERTIES OF NUCLEI . . . . .	3
1-1 Nucleons and nuclei . . . . .	3
CHAPTER 2. INTERNUCLEON FORCES: I . . . . .	10
2-1 Introduction . . . . .	10
2-2 Possible nucleon forces. . . . .	11
2-3 Scattering experiments. . . . .	17
2-4 Bound state . . . . .	24
2-5 Experimental results . . . . .	25
2-6 Proton-proton forces . . . . .	29
CHAPTER 3. SIZES OF NUCLEI. . . . .	37
3-1 Introduction . . . . .	37
3-2 Electron scattering . . . . .	39
3-3 Mu-mesic atoms . . . . .	50
3-4 Coulomb energy . . . . .	51
CHAPTER 4. NUCLEAR MOMENTS AND NUCLEAR SHAPES . . . . .	60
4-1 Electromagnetic multipoles . . . . .	60
4-2 Angular momentum . . . . .	62
4-3 Electric moments . . . . .	64
4-4 Magnetic moments . . . . .	70
CHAPTER 5. INTERNUCLEON FORCES: II . . . . .	77
5-1 Electromagnetic moments of the deuteron and tensor forces . . . . .	77
5-2 General features of high-energy scattering . . . . .	83
5-3 Polarization . . . . .	86
5-4 Experimental results and preliminary interpretations . . . . .	93
5-5 More precise analysis of experimental data at energies up to 40 Mev . . . . .	100
5-6 Higher-energy experiments and the spin-orbit force . . . . .	106
5-7 Summary . . . . .	116
CHAPTER 6. NUCLEAR BINDING ENERGIES . . . . .	121
6-1 Introduction . . . . .	121
6-2 The semiempirical formula . . . . .	123
6-3 Magic numbers . . . . .	132
6-4 Other mass formulas . . . . .	136

## PART II. NUCLEAR MODELS

CHAPTER 7. SINGLE-PARTICLE MODEL . . . . .	145
7-1 Introduction . . . . .	145
7-2 Single-particle orbits . . . . .	146
7-3 Extreme single-particle model and spin . . . . .	151
7-4 Single-particle model . . . . .	161
7-5 Configuration mixing . . . . .	168
CHAPTER 8. INDIVIDUAL-PARTICLE MODEL . . . . .	172
8-1 Basic antisymmetric states . . . . .	172
8-2 Matrix elements . . . . .	175
8-3 Center of mass motion . . . . .	177
8-4 Types of interaction . . . . .	178
8-5 Typical results . . . . .	180
CHAPTER 9. CORRELATIONS IN NUCLEAR MATTER . . . . .	190
9-1 Introduction . . . . .	190
9-2 The Brueckner method or the individual-pair model . . . . .	192
9-3 Results for an infinite medium . . . . .	198
9-4 Finite nuclei . . . . .	205
9-5 Model operators . . . . .	215
9-6 Long-range correlations and the ground state . . . . .	216
CHAPTER 10. COLLECTIVE NUCLEAR MOTION . . . . .	228
10-1 Introduction . . . . .	228
10-2 Collective modes of motion . . . . .	230
10-3 Coupling of particle and collective motions . . . . .	249
10-4 Weak coupling . . . . .	251
10-5 Strong coupling . . . . .	254
10-6 Particle states in distorted nuclei . . . . .	261
10-7 Calculation of equilibrium shape . . . . .	271
10-8 Levels of distorted odd- <i>A</i> nuclei . . . . .	274
10-9 Values of inertial parameters . . . . .	278
10-10 Comparison of nuclear models . . . . .	285

## PART III. ELECTROMAGNETIC PROPERTIES OF NUCLEI

CHAPTER 11. INTERACTION OF THE ELECTROMAGNETIC FIELD WITH MATTER . . . . .	295
11-1 General theory of photon radiation . . . . .	295
11-2 Internal conversion . . . . .	302
11-3 Internal pair creation . . . . .	309
11-4 Coulomb excitation . . . . .	310
11-5 Angular correlation . . . . .	315

CHAPTER 12. STATIC ELECTROMAGNETIC MOMENTS . . . . .	319
12-1 Shell model with interactions . . . . .	320
12-2 Collective model . . . . .	325
12-3 Electric quadrupole moments . . . . .	332
CHAPTER 13. GAMMA TRANSITIONS AND NUCLEAR MODELS . . . . .	333
13-1 Single-particle transition rates . . . . .	333
13-2 Electric dipole transitions . . . . .	336
13-3 Magnetic dipole transitions . . . . .	339
13-4 Electric quadrupole transitions . . . . .	341

## PART IV. PARTICLE RADIOACTIVITY

CHAPTER 14. ALPHA RADIOACTIVITY . . . . .	349
14-1 Introduction . . . . .	349
14-2 Basic theory . . . . .	355
14-3 One-body theory . . . . .	359
14-4 Higher electric moments . . . . .	369
14-5 Formation factors . . . . .	376
CHAPTER 15. BETA RADIOACTIVITY . . . . .	383
15-1 Introduction . . . . .	383
15-2 Theory of $\beta$ -decay . . . . .	394
15-3 Coulomb effects and forbidden transitions . . . . .	419
15-4 Spectrum shapes and lifetimes . . . . .	429
15-5 Electron capture . . . . .	438
15-6 Nuclear matrix elements . . . . .	442
15-7 Possible momentum dependence of the weak interaction . . . . .	455

## PART V. NUCLEAR REACTIONS

CHAPTER 16. BASIC REACTION THEORY . . . . .	465
16-1 Introductory definitions . . . . .	465
16-2 Collision matrix . . . . .	468
16-3 Symmetry of the collision matrix and reciprocity . . . . .	474
16-4 Cross sections and the collision matrix . . . . .	477
16-5 The $R$ -matrix and dispersion theory . . . . .	481
16-6 One-level formula . . . . .	492
16-7 Reaction mechanisms . . . . .	498
CHAPTER 17. COMPOUND NUCLEUS AND STATISTICAL THEORIES . . . . .	502
17-1 Experimental evidence . . . . .	502
17-2 Statistical assumptions . . . . .	505
17-3 Average cross sections . . . . .	508

17-4	Angular distributions . . . . .	514
17-5	Transmission coefficients . . . . .	515
17-6	Level density . . . . .	523
17-7	Decay of the statistical compound nucleus . . . . .	529
17-8	Emission of charged particles . . . . .	533
CHAPTER 18. THE OPTICAL MODEL . . . . .		538
18-1	Introduction . . . . .	538
18-2	Optical parameters . . . . .	544
18-3	Optical model and $R$ -matrix . . . . .	549
18-4	Theoretical considerations . . . . .	558
CHAPTER 19. DIRECT REACTIONS . . . . .		564
19-1	Theoretical introduction . . . . .	564
19-2	Important special cases . . . . .	567
19-3	Fundamental theory . . . . .	575
19-4	Inelastic scattering . . . . .	577
19-5	Stripping . . . . .	585
19-6	Some higher-energy reactions . . . . .	593
19-7	Electromagnetic reactions . . . . .	594
APPENDIX A . . . . .		600
APPENDIX B . . . . .		625
INDEX . . . . .		637