

CONTENTS

PREFACE	vii
CONTENTS	ix
TABLES OF SPECIFIC REFERENCES	xv
INTRODUCTION (with general bibliography)	xvii

Part I. Two-body collisions 1–101

1. BACKGROUND MATERIAL	3–73
1. Frames of reference, conservation laws and equations of motion	3
General references	6
2. Classical treatment of elastic scattering	6
2.1. <i>Introduction</i>	6
2.2. <i>Scattering in the relative frame of reference</i>	7
2.3. <i>Scattering in the centre-of-mass frame</i>	12
2.4. <i>Scattering in the laboratory frame</i>	15
General references	22
3. The concept of scattering cross sections	22
3.1. <i>The differential cross section in the relative frame of reference</i>	22
3.2. <i>Transformation to the laboratory frame</i>	25
3.3. <i>Transformation to variables other than scattering angle</i>	27
3.4. <i>Differential cross sections with several variables</i>	30
3.5. <i>General differential cross sections</i>	33
3.6. <i>Total and partial cross sections</i>	33
3.7. <i>Common concepts for beams interacting with targets</i>	36
General references	37
4. Relativistic treatment of scattering	37
4.1. <i>Introduction</i>	37
4.2. <i>Elastic scattering in the centre-of-mass frame</i>	40

4.3. Elastic scattering in the laboratory frame	42
General references	46
5. Quantal treatment of scattering	46
5.1. The limits of classical treatment	46
5.2. The theory of time-independent scattering	49
5.3. The method of partial waves	51
5.4. Born approximation	53
General references	55
6. Simple examples of scattering	55
6.1. The hard/core potential	55
6.2. The $1/r$ -potential	58
6.3. The $1/r^2$ -potential	60
General references	61
7. Approximations	61
7.1. General	61
7.2. Approximations to the interaction potential (matching potentials)	61
7.3. Approximations to the scattering law	66
7.3.1. Small angle scattering (forward scattering)	66
7.3.2. Large angle scattering (backward scattering)	70
7.3.3. Approximations for all angles	72
General references	73
2. COLLISIONS BETWEEN ELECTRONS AND ATOMS	74-77
1. Rutherford scattering	74
2. Darwin-Rutherford scattering	75
3. Mott scattering	76
General references	77
3. ELASTIC COLLISIONS BETWEEN HEAVY CHARGED PARTICLES AND ATOMS	78-87
1. The problem of interatomic potentials	78
2. Forms of interatomic potentials	79
3. The inversion problem	84
4. Differential cross sections	86
General references	87
4. COLLISIONS BETWEEN UNCHARGED PARTICLES AND ATOMS	88-92
1. Fast neutrons	88
General references	89
2. Gamma particles	89
General references	92

5. INELASTIC COLLISIONS BETWEEN ATOMS	93–101
1. Introduction	93
2. Kinetics of inelastic scattering	94
3. Physical aspects of inelastic scattering events	96
General references	100
Part II. Interaction of particles with matter (random)	103–196
6. FATE OF IRRADIATING PARTICLE	105–152
1. Introduction	105
2. Range concepts	107
3. The energy loss processes and the concept of stopping power	110
4. Heavy ions	114
4.1. <i>Electronic stopping</i>	114
4.1.1. <i>Introduction</i>	114
4.1.2. <i>Electronic stopping at high velocities</i>	116
4.1.3. <i>Electronic stopping at low velocities</i>	122
4.2. <i>Nuclear stopping</i>	123
4.3. <i>Surface effects</i>	127
General references	137
5. Fast electrons and positrons	138
5.1. <i>Introduction</i>	138
5.2. <i>Stopping processes</i>	138
5.3. <i>Energy straggling</i>	146
5.4. <i>Multiple scattering</i>	147
5.5. <i>Range and range straggling</i>	148
5.6. <i>Backscattering</i>	148
General references	149
6. Neutrons	149
General reference	150
7. Gamma particles	151
General references	152
7. FATE OF THE PRIMARY KNOCK-ON	153–169
1. Introduction	153
2. Point defects	153
3. Defect production	155
3.1. <i>Introduction</i>	155
3.2. <i>The displacement process</i>	155
3.3. <i>The threshold energy surface</i>	159
3.4. <i>The displacement cross section</i>	163
General references	168

8. THE FATE OF HIGHER KNOCK-ONS	170-196
1. Introduction	170
2. The displacement cascade	171
2.1. <i>The number of displacements in a cascade</i>	171
2.2. <i>The spatial distribution of displacements in a cascade</i>	176
3. Sputtering	183
3.1. <i>The basic processes</i>	183
3.2. <i>Sputtering yield</i>	184
3.3. <i>Sputtering efficiency</i>	193
3.4. <i>High density effects</i>	194
3.5. <i>Secondary ion and secondary electron emission</i>	194
3.6. <i>Miscellaneous</i>	195
General references	195
 Part III. Influence of lattice structure	 197-252
9. CORRELATED COLLISIONS WITHIN ATOMIC ROWS	199-214
1. Introduction	199
2. The basic events	199
3. Physical implications	204
3.1. <i>Defect production</i>	204
3.2. <i>Disordering of polyatomic structures</i>	205
3.3. <i>Influence on displacement cascades</i>	205
3.4. <i>Sputtering</i>	206
3.5. <i>Secondary ion and secondary electron emission</i>	214
General references	214
 10. CHANNELLING	 215-247
1. Introduction	215
2. The basic process	217
2.1. <i>Continuum-potential approach</i>	217
2.2. <i>Channel trajectories</i>	220
2.3. <i>Influence of thermal vibrations and multiple scattering</i>	223
2.4. <i>The yield curve</i>	224
2.5. <i>Flux distribution</i>	226
2.6. <i>Quantal limits to a classical treatment of channelling</i>	227
3. Physical implications	227
3.1. <i>Energy losses</i>	227
3.2. <i>Surface effects</i>	232
3.2.1. <i>Sputtering</i>	232
3.2.2. <i>Secondary ion and secondary electron emission</i>	234

3.2.3. <i>Surface scattering</i>	234
3.3. <i>Defect production</i>	234
3.4. <i>Applications of channelling</i>	240
4. Positrons and electrons	243
General references	247
 11. BLOCKING	248–252
1. Introduction	248
2. The basic process	249
3. Physical implications and applications	251
General references	252
 Part IV. Miscellany	253–275
 12. ASYMPTOTES OF TRAJECTORIES IN THE LABORATORY FRAME	255–258
 13. THE LITERATURE PROBLEM	259–263
 14. GENERAL TABLES	264–275
1. Atomic masses, atomic numbers, crystal structures and lattice spacings of elements	264
2. Distances and numbers of neighbour atoms in fcc and bcc crystal lattices	267
3. Physical constants	270
4. Mathematical constants	272
5. Physical units	272
6. Conversion tables and formulas	273
Conversion table for energy units	273
Conversion formulas for energy and velocity	274
non-relativistic	274
relativistic	274
Range conversion	274
Conversion formulas for De Broglie wavelength	275
non-relativistic	275
relativistic	275
 BIBLIOGRAPHY	276
 AUTHOR INDEX	307
 SUBJECT INDEX	323