

Contents

1. Heavy-Ion Atomic Physics—Theoretical

Joachim Reinhardt and Walter Greiner

1. General Introduction	3
2. Quantum Electrodynamics of Strong Fields	7
2.1. Introduction	7
2.2. The Dirac Equation with an External Potential	8
2.3. Supercritical Electron States	12
2.4. Radiative Corrections	21
3. Theory of Electronic Excitations	26
3.1. Introduction	26
3.2. The Semiclassical Theory	26
3.3. Excitations of the Many-Electron System	37
3.4. Special Approaches	41
4. Theory of Inner Shell Excitation	47
4.1. Introduction	47
4.2. Atomic Models	49
4.3. Molecular Models	53
4.4. Electron Excitation in Superheavy Systems	68
4.5. Strong Collisional Magnetic Fields	80
4.6. High-Energy Collisions	83
5. Molecular Orbital X-Ray Radiation	85
5.1. Introduction	85
5.2. Theory: S-Matrix Formulation	85
5.3. Theory: Field Theoretical Formalism	88
5.4. The Angular Distribution	91
5.5. Selected Results	93
6. Positron Creation in Heavy-Ion Collisions	103
6.1. Introduction	103
6.2. Dynamical Theory of Supercritical Collisions	104
6.3. Results	112
6.4. Discussion	115
7. Atomic Physics and Nuclear Reactions	118
7.1. Introduction	118
7.2. Interference Effects	119

7.3. Compound Nucleus X-Rays	124
7.4. Positron Creation	126
Note Added in Proof	130
References	130

2. High-Energy Atomic Physics—Experimental

Jack S. Greenberg and Paul Vincent

1. Introduction	141
1.1. Scope of Review	141
1.2. Excitation Mechanisms	144
1.3. Quasimolecular Phenomena	147
1.4. Superheavy Quasiatoms	151
1.5. The Unstable Vacuum	153
1.6. Recent Experiments	157
1.7. Organization of Discussion	157
2. The Quasimolecule	158
2.1. General Features of the Quasimolecular Model	159
2.2. Coupling Mechanisms	166
2.3. $1s\sigma$ Excitation in Very-Heavy Collision Systems	171
3. X-Ray Spectroscopy	176
3.1. Introduction	176
3.2. Experimental Considerations	178
3.3. X Rays from Lighter Collision Systems	186
3.4. X Rays from Heavy Collisions	236
3.5. Other X-Ray Measurements	265
4. Delta-Electron Spectroscopy	278
4.1. Introduction	278
4.2. Qualitative Features of Delta-Electron Spectra	280
4.3. Delta-Electron Spectrometers	290
4.4. Selected Results	295
5. Positron Spectroscopy with Heavy-Ion Collisions; Search for the Decay of the Vacuum	317
5.1. Introduction	317
5.2. Positron Emission Mechanisms	323
5.3. Positron Spectrometers	351
5.4. Experimental Results	365
6. Summary	406
Acknowledgments	408
References	409

3. Beam-Foil Spectroscopy

Indrek Martinson

1. Introduction	425
2. The Beam-Foil Light Source	426

3. Experimental Methods	428
3.1. Accelerators	428
3.2. Spectrometers and Detectors	430
3.3. Targets	432
4. Atomic Energy Level Studies	433
4.1. Experimental Problems	433
4.2. Results of Spectral Studies	435
5. Lifetime Measurements	446
5.1. Experimental Problems	446
5.2. Experimental Modifications	450
5.3. Special Methods	452
5.4. Results of Lifetime Measurements	453
6. Quantum-Beat Experiments	461
6.1. General Comments	461
6.2. Zero-Field Oscillations	463
6.3. Stark Beats	466
6.4. Zeeman Beats	466
7. Lamb-Shift Experiments	467
8. Applications of Beam-Foil Results	471
8.1. Atomic Theory	471
8.2. Astrophysics	471
8.3. Plasma Physics and Fusion Research	473
9. Excitation Mechanisms	474
9.1. Energy Level Populations	475
9.2. Coherence, Orientation, and Alignment	475
Note Added in Proof	479
Acknowledgments	479
References	480
Note Added in Proof (Chapter 1)	490
Index	493