

Contents

Preface	ix
Introduction	1
1 Quantum electrodynamics of atoms and ions	3
1.1 Relativistic electrons in atoms	3
1.2 Interaction of atomic electrons with the photon field	11
1.3 Adiabatic formalism	22
1.4 Feynman graph techniques in the Furry picture	25
2 Energy levels	35
2.1 Review of modern theoretical methods	35
2.2 Classification of the energy corrections for bound electrons	40
2.3 One-photon exchange corrections	46
2.4 Two-photon Coulomb–Coulomb corrections	53
2.5 Two-photon Coulomb–Breit and Breit–Breit corrections	58
2.6 Electron self-energy correction	65
2.7 Vacuum polarization correction	74
2.8 Energy corrections for the excited states	80
2.9 Hyperfine structure of the levels, isotope shift and recoil corrections	89
3 Transition probabilities and line shape theory	101
3.1 Transition probabilities for one-electron ions	101
3.2 Transition probabilities for two-electron ions	109
3.3 The natural line width	115
3.4 The natural line shape for one-electron ions	121
3.5 The natural line shape for two-electron ions	128
3.6 The theory of overlapping resonances	132
3.7 Overlapping double-excited states of the helium-like uranium ion	143
4 Parity violation effects in multicharged ions	151

4.1	Effective weak interaction potentials for atoms	151
4.2	Mechanism of parity violation in atoms and ions	157
4.3	Level crossings and possible parity violation experiments in ions	160
4.4	Noise and spurious effects	165
5	Atomic systems in external fields	169
5.1	Relativistic perturbation theory for energy levels in the presence of constant fields	169
5.2	The relativistic Coulomb Green function	177
5.3	Quasienergy states in time-periodic external fields	185
5.4	Perturbation theory for degenerate levels interacting with an oscillating electric field	189
5.5	The case of almost degenerate levels	193
5.6	Perturbation theory for transition probabilities in the presence of external fields	196
6	Spectra of multicharged ions in constant external fields	204
6.1	The energy levels of one-electron ions in a constant electric field	204
6.2	The case of a constant magnetic field	210
6.3	Transition probabilities for one-electron ions in constant fields	214
6.4	Two-electron ions in constant fields	218
7	Spectra of multicharged ions in oscillating electric fields	225
7.1	The quasienergy levels of one-electron ions: the two-level approximation	225
7.2	The three-level approximation for the first excited state of one-electron ions	232
7.3	Probability of multipole transitions for one-electron ions in an oscillating field	238
7.4	The spectra of two-electron ions in an oscillating field	244
7.5	Experimental observation of the relativistic quasienergy effects	250
7.6	Spectra of one-electron ions in complicated field configurations	259
8	<i>S</i>-matrix based perturbation theory for the energy and width of bound states	265
8.1	Main properties of the adiabatic evolution operator	265
8.2	Adiabatic theorem and Gell-Mann and Low formulae for energy shift	269

8.3	Gell-Mann and Low formalism in model subspace of degenerate or quasidegenerate states	273
8.4	Factorization of adiabatic divergences in the S_γ -matrix	277
8.5	Adiabatic formulae for secular operators	279
8.6	Adiabatic formalism and Riesz-Kato perturbation expansion	286
8.7	Calculation of the adiabatic limit in perturbation series	289
8.8	Perturbation of bound states embedded in continuum	294
9	<i>S</i>-matrix based theory of atomic states in external oscillating fields	301
9.1	Quasienergy states of quantum systems in external polychromatic fields	302
9.2	Adiabatic formalism for quasienergy states in the extended Hilbert space	309
9.3	Adiabatic formalism for quasienergy states in the conventional Hilbert space	313
	References	323
	Index	335