

Contents

1.	<i>Introduction - Properties of Synchrotron Radiation.</i> By C. Kunz (With 9 Figures).....	1
1.1	Historical Development	3
1.2	Quantitative Properties	7
1.2.1	Equations for Ideal Orbits	7
1.2.2	Considerations for Real Orbits	
a)	Coherence	12
b)	Periodic Wigglers	14
c)	Synchrotron Accelerators	14
d)	Beam Cross Section and Divergency	14
1.2.3	Time Structure	15
1.3	Comparison with other Sources	17
1.3.1	Infrared and Visible Range	18
1.3.2	Vacuum Ultraviolet Range	18
1.3.3	X-rays	19
1.4	Acknowledgments	20
	References	20
2.	<i>The Synchrotron Radiation Source.</i> By E.M. Rowe (With 8 Figures)	25
2.1	Fundamental Concepts	27
2.1.1	Orbit Dynamics	27
a)	Betatron Oscillations	27
b)	Betatron Oscillations of Off-energy Particles	29
c)	Phase Focusing and Synchrotron Oscillations	29
2.1.2	Radiation Damping	30
2.1.3	Beam Lifetime	32
2.1.4	Beam Cross Section	33
2.2	Design Considerations	34
2.2.1	Magnetic Field and Energy	34
2.2.2	Lattice	35
2.2.3	Injector	36

2.2.4 Accelerating System	37
2.2.5 Energy Shifter Wigglers	38
2.2.6 Multipole Wigglers (Undulator)	39
2.3. Design Examples	39
2.3.1 Aladdin	40
a) Lattice	42
b) Vacuum System	44
c) Accelerating System	45
d) Injector	45
e) Computer Control	48
2.3.2 The National Synchrotron Light Source (NSLS)	48
References	53
 3. <i>Instrumentation for Spectroscopy and other Applications.</i> By W. Gudat and C. Kunz (With 53 Figures)	55
3.1 Layout and Operation of Laboratories	56
3.1.1 VUV Laboratory at a Small Storage Ring	56
3.1.2 VUV and X-Ray Laboratory at a Large Storage Ring	59
3.1.3 Beam Line Optics	66
a) General Considerations	66
b) The Phase Space Method	67
c) Magic Mirrors	69
3.2 Optical Components	70
3.2.1 Mirrors and Reflective Coatings	71
a) General Remarks	71
b) Reflectivity in the Vacuum Ultraviolet	71
c) Coating Materials and Multilayer Coatings	76
d) Scattering and Stray Light	81
e) Mirror Substrate Materials	82
f) Imaging in VUV	83
3.2.2 Dispersive Elements	84
a) Reflection Grating Dispersors	84
b) Spherical Concave Gratings	85
c) Aspherical Concave Gratings	89
d) Efficiency and Blaze	89
e) Holographic Gratings	93
f) Zone Plates and Transmission Gratings	95
g) Crystals for Monochromators	97
3.2.3 Filters and Polarizers	100
a) Filters and higher Order Problems	100
b) Polarizers	102

3.3 VUV Monochromators	105
3.3.1 General Considerations	105
3.3.2 Normal Incidence Monochromators	108
3.3.3 Grazing Incidence Monochromators	113
a) Plane Grating Monochromators	113
b) Rowland Mountings	116
c) Non-Rowland Monochromators	120
3.3.4 New Concepts	120
3.4 X-Ray Monochromators	122
3.4.1 Plane Crystal Instruments	122
3.4.2 Higher Order Rejection	125
3.4.3 Bent Crystal Monochromators	127
3.5 Photon Detectors	132
3.5.1 Detectors for the Vacuum Ultraviolet	132
3.5.2 X-Ray Detectors	139
3.6 Typical Experimental Arrangements	143
3.6.1 Experiments in the Vacuum Ultraviolet	143
a) Absorption Reflection, Ellipsometry	143
b) Luminescence, Fluorescence	145
c) Photoionisation, Fotofragmentation	146
d) Photoemission	146
e) Radiometry	148
f) Microscopy	149
3.6.2 Experiments in the X-Ray Range	150
a) Single Crystal Diffraction	150
b) Small Angle Diffraction	150
c) Small Angle Scattering	152
d) Mössbauer Scattering	152
e) Energy Dispersive Diffraction	153
f) Interferometry	155
g) Absorption (EXAFS)	155
h) Topography	156
i) Standing wave excited Fluorescence	157
j) Fluorescence Excitation	158
k) Compton Scattering	158
l) Resonant Raman Scattering	159
m) Photoelectron Spectroscopy (XPS)	159
3.7 Acknowledgements	160
References	160

4.	<i>Theoretical Aspects of Inner-Level Spectroscopy.</i> By A. Kotani and Y. Toyozawa (With 9 Figures)	169
4.1.	Basic Concepts and Relations in Radiative Processes	170
4.1.1	Polarizability and Dielectric Function	170
a)	Self-consistent field Method	171
b)	Direct Method for Longitudinal Part	171
4.1.2	Absorption Coefficient and Oscillator Strength	172
4.1.3	Dispersion Relations and Sum Rules	173
4.2	Distribution of Oscillator Strength	175
4.2.1	Absorption Spectra in Atoms	175
4.2.2	A Unified Picture for Spectra in Atoms, Molecules and Solids	177
a)	Cancellation of Oscillator Strength, Giant and Subgiant Bands	178
b)	Pseudo Potential and Energy Band Effect	179
c)	Effect of Coulomb Attraction	181
4.2.3	Extended X-Ray Absorption Fine Structure (EXAFS)	181
4.3	Electron-Hole Interactions	183
4.3.1	General Treatment of Excitons	183
4.3.2	Wannier and Frenkel Excitons	185
a)	Wannier Exciton	186
b)	Frenkel Exciton	186
4.3.3	Optical Absorption Spectra	188
a)	First Class Transition	189
b)	Second Class Transition	190
4.3.4	Effects of Spin and Orbital Degeneracies	191
4.4	Configuration Interactions	193
4.4.1	Auger Process	193
4.4.2	Fano Effect	196
4.5	Simultaneous Excitations and Relaxations	199
4.5.1	Localized Excitation and Relaxation in Deformable Lattice	199
4.5.2	Host Excitation in Deformable Medium	201
a)	Slow Modulation Limit	203
b)	Rapid Modulation Limit	203
4.5.3	Sideband Structures	205
4.5.4	Relaxation in Exciton-Phonon Systems	207
4.6	Many Body Effects in Metals	209
4.6.1	Friedel Sum Rule and Anderson Orthogonality Theorem	209
4.6.2	Infrared Divergence	211
4.6.3	Fermi Edge Singularity	212
4.7	Final State Interactions Associated with Incomplete Shells	214

4.7.1	Multiplet Splitting	214
4.7.2	Local Versus Band Pictures	216
4.7.3	Correlation Effects in Narrow d-Band	219
4.8	Inelastic X-Ray Scattering	220
4.8.1	Compton and Raman Scattering	220
4.8.2	Resonant Raman Scattering	222
4.9.	Topics of Recent and Future Interest	225
References	226
5.	<i>Atomic Spectroscopy</i> . By K. Codling (With 16 Figures)	231
5.1.	Atomic Photoabsorption Spectroscopy in the Extreme Ultraviolet	232
5.2	The Basic Experiments in Photoabsorption Spectroscopy	233
5.2.1	Photoabsorption Spectroscopy	235
5.2.2	Photoelectron Spectroscopy	236
5.2.3	Mass Spectrometry	238
5.2.4	Fluorescence	239
5.3	Limitations of Photon Absorption Experiments	239
5.4	The General Theoretical Framework	240
5.5	Experimental Results	242
5.5.1	Photoabsorption Spectroscopy	242
a)	Discrete Resonances	242
b)	Gross Features	248
5.5.2	Photoelectron Spectroscopy	256
a)	Partial Photoionisation Cross Sections	256
b)	Angular Distributions of Photoelectrons	260
5.5.3	Mass Spectrometry	262
5.6	Future Work	264
References	265
6.	<i>Molecular Spectroscopy</i> . By E. E. Koch and B. F. Sonntag (With 44 Figures)	269
6.1	Concepts	270
6.2	Absorption Spectroscopy	277
6.2.1	Valence Spectra of Simple Di- and Tri-Atomic Molecules	277
6.2.2	Valence and Rydberg Excitations in N ₂	279
6.2.3	Rydberg Series in the Valence Absorption Spectrum of H ₂ O and D ₂ O	283
6.2.4	Core-Spectra of Simple Di-Atomic and Tri-Atomic Molecules ..	285
a)	N ₂	286
b)	NO	289

6.2.5 d-Spectra of Se_2 , Te_2 and I_2	291
a) Se_2	291
b) Te_2	292
c) I_2	292
6.2.6 Alkali Halides	294
a) Li 1s-absorption in LiF	294
b) Cs-halides	297
6.2.7 Xenon Fluorides	299
6.2.8 Inner-well Resonances	303
6.2.9 EXAFS	306
6.2.10 Valence Shell Spectra of Organic Compounds	308
a) Saturated Hydrocarbons: Alkanes, Neopentane	308
b) Molecules with bonding σ - and π -orbitals	312
6.2.11 Core Spectra of Organic Compounds	316
6.3 Photoelectron Spectroscopy	321
6.3.1 Intensities of Photoelectron Spectra and Partial Photoionization Cross Sections	322
6.3.2 Photoionization Resonance Spectroscopy and Coincidence Measurements	325
6.4 Fluorescence	326
6.4.1 Fluorescence- and Excitation-Spectra	326
6.4.2 Time resolved Fluorescence Spectroscopy	330
6.5 Mass-Spectrometry	334
6.6. Acknowledgments	338
6.7. Appendix	338
References	348
7. <i>Solid-State Spectroscopy</i> . By David W. Lynch (With 23 Figures)	357
7.1 Quantitative Description of Optical Properties	358
7.1.1 Macroscopic Optical Properties	358
7.1.2 Microscopic Description	362
7.1.3 Modulation Spectroscopy	365
7.1.4 Summary	367
7.2 Metals and Alloys	368
7.2.1 Vacuum Ultraviolet	368
a) Simple Metals	368
b) Noble Metals	369
c) Transition Metals	371
d) Rare Earths	374
7.2.2 Soft X-Ray	376
a) Simple Metals	376

b) Transition Metals	378
c) Rare Earths	379
7.2.3 Summary	379
7.3 Semiconductors	380
7.3.1 Vacuum Ultraviolet	380
a) II-VI Compounds	385
b) Pb-Chalcogenides	387
c) Other Semiconductors	388
7.3.2 Soft X-ray	390
7.3.3 Summary	392
7.4 Insulators	393
7.4.1 Rare Gas Solids	393
7.4.2 Alkali Halides	400
7.4.3 Other Metal Halides	406
7.4.4 Other Inorganic Insulators	411
7.4.5 Organic Insulators	411
7.4.6 Summary	412
References	412
<i>Additional References with Titles</i>	423
<i>Subject Index</i>	429