

CONTENTS

Preface	iv
Recent Advances in Ultra-Violet Absorption Spectroscopy. By W. C. PRICE . . .	1
Anomalous Fine Structure of Hydrogen and Singly Ionized Helium. By W. E. LAMB, Jr.	19
New Techniques in Optical Interferometry. By H. KUHN	64
The Diffraction Theory of Aberrations. By E. WOLF	95
The Spectrum of the Airglow and the Aurora. By A. B. MEINEL	121
The Microphysics of Clouds. By B. J. MASON and F. H. LUDLAM	147
Angular Correlations in Nuclear Reactions. By M. DEUTSCH	196
The Nuclear Interactions of Cosmic Rays. By G. D. ROCHESTER and W. V. G. ROSSER	227
Nuclear Effects in Atomic Spectra. By E. W. FOSTER	288
A Critical Survey of Ionospheric Temperatures. By N. C. GERSON	316
Some Applications of Nuclear Physics in Medicine. By W. V. MAYNEORD	366

RECENT ADVANCES IN ULTRA-VIOLET ABSORPTION SPECTROSCOPY

By W. C. PRICE
King's College, London

CONTENTS

	PAGE
§ 1. Introduction	1
§ 2. Photoelectric spectrophotometers	2
§ 3. Light sources and photocells	3
§ 4. Double-beam recording spectrophotometers	5
§ 5. Cathode-ray presentation of spectra	7
§ 6. Ultra-violet microspectroscopy	8
§ 7. Colour translation ultra-violet microscopy	9
§ 8. Spectrophotometry in the vacuum ultra-violet	9
§ 9. Extension of the solar spectrum into the ultra-violet	11
§ 10. Sources for the vacuum ultra-violet	12
§ 11. High intensity light sources	12
§ 12. Photographic emulsions	13
§ 13. The logarithmic cam	14
§ 14. Interpretation of ultra-violet spectra	14
References	17

ANOMALOUS FINE STRUCTURE OF HYDROGEN AND SINGLY IONIZED HELIUM

BY WILLIS E. LAMB, JR.

Department of Physics, Columbia University, New York, N.Y.

CONTENTS

	PAGE
§ 1. Introduction	20
§ 2. Theory of hydrogen-like atoms	20
2.1. Bohr-Sommerfeld theory	20
2.2. Wave mechanics	21
2.3. Dirac theory	22
§ 3. Observations of the H_{α} line prior to 1940	22
§ 4. Departures from the Dirac theory	24
4.1. Positron theory	25
4.2. Electromagnetic self-energy	25
4.3. Other unsuccessful attempts to account for possible discrepancies	26
4.4. Theory of finite quantum electrodynamical level shifts	27
§ 5. Possible uses of radio waves in hydrogen spectroscopy	30
5.1. Choice of method	30
5.2. Atomic beam method	31
5.3. Metastable hydrogen atoms	31
5.4. Production of a beam of metastable hydrogen atoms	33
5.5. Dissociation of molecular hydrogen	34
5.6. Excitation of hydrogen atoms by electron bombardment	35
5.7. Recoil due to bombardment	36
5.8. Detection of metastable hydrogen atoms	37
5.9. Estimate of yield	39
5.10. Radio-frequency power required	41
5.11. Breadth of resonance curves	42
5.12. Zeeman effect of the fine structure of hydrogen	42
5.13. Production of a polarized beam of atoms	44
5.14. Effect of hyperfine structure on energy levels	47
5.15. Transitions $\alpha\beta\ 2^2S_{1/2} (m_s = \frac{1}{2} \rightarrow m_s = -\frac{1}{2})$	50
§ 6. Apparatus	50
6.1. Pumps	50
6.2. Gas supply	50
6.3. Hydrogen dissociator	51
6.4. Electron bombarder	51
6.5. Quenching region	52
6.6. Detector	52
6.7. Radio-frequency techniques	52
6.8. Magnetic field	52
§ 7. Observations on hydrogen fine structure	53
7.1. Procedure	53
7.2. Resonance curves	54
7.3. Symmetry of resonances	54
7.4. Results	55
7.5. Sharp resonances	55
§ 8. Fine structure of singly ionized helium	58
8.1. Theoretical expectations for He II level shifts	58
8.2. Spectroscopic observations of He II fine structure	58
8.3. Microwave method for study of He II fine structure	59
8.4. Results for He II fine structure	61
References	62

NEW TECHNIQUES IN OPTICAL INTERFEROMETRY

By H. KUHN

The Clarendon Laboratory, Oxford

CONTENTS

PART I : THIN FILMS AND INTERFERENCE FILTERS

	PAGE
§ 1. Introduction	65
§ 2. Dielectric films.....	65
§ 3. Metal films	68
§ 4. Dielectric films on metal	69
§ 5. The intensity distribution in multiple beam fringes	70
§ 6. Interference filters	71
§ 7. Polarization filters	74

PART II : SPECTROSCOPIC INTERFEROMETRY

§ 8. The single etalon	74
§ 9. The double etalon	77
§ 10. Photoelectric recording	79
§ 11. Solar interferometry	80

PART III : STANDARDS AND TESTING METHODS

§ 12. Light sources and wavelength standards.....	81
§ 13. Gauge testing methods.....	83
§ 14. Testing of wavefronts.....	83
§ 15. Testing of interferometer plates.....	84

PART IV : THE STUDY OF SURFACE STRUCTURES

§ 16. The principle of the method.....	85
§ 17. Fringes in monochromatic light.....	86
§ 18. Heterochromatic fringes	87
§ 19. Technical details and applications.....	88

PART V : INTERFERENCE REFRACTOMETERS AND INTERFERENCE MICROSCOPES

§ 20. Refractometry of homogeneous media.....	88
§ 21. Applications to aerodynamics.....	89
§ 22. Interference microscopes	91

THE DIFFRACTION THEORY OF ABERRATIONS

By E. WOLF*

The Observatory, Cambridge University

CONTENTS

§ 1. Introduction	95
§ 2. Geometrical treatment of aberrations	96
§ 3. The diffraction theory of aberrations	97
3.1. A historical review	97
3.2. Advances since 1940	101
3.21. Images in the presence of small aberrations	101
3.22. Tolerance conditions	106
3.23. Asymptotic behaviour of the diffraction integral	108
3.24. Images formed by waves of non-uniform amplitude	109
3.25. Other researches	112
Acknowledgments	119
References	119

THE SPECTRUM OF THE AIRGLOW AND THE AURORA

By A. B. MEINEL *

Yerkes Observatory, University of Chicago

CONTENTS

	PAGE
§ 1. Introduction	121
§ 2. The spectrum of the night glow	122
2.1. Ultra-violet region from 3000 A. to 4000 A.	123
2.2. Visible region from 4000 A. to 7000 A.	124
2.3. Near infra-red region from 7000 A. to 11,000 A.	126
2.4. Infra-red region beyond 11,000 A.	129
2.5. Continuum.	130
§ 3. The spectrum of the twilight glow.....	130
§ 4. The spectrum of the aurora	133
4.1. Ultra-violet region from 3000 A. to 4000 A.	133
4.2. Visible region from 4000 A. to 7000 A.	134
4.3. Infra-red region from 7000 A. to 11,000 A.	135
4.4. Microwave region	136
4.5. Atomic emission features	137
§ 5. Heights of the night-glow emissions	140
§ 6. Temperature determinations from the night-glow emissions	143
§ 7. Temperature determinations from the auroral emissions	144
§ 8. Conclusions	144
Acknowledgments	145
References	145

THE MICROPHYSICS OF CLOUDS

BY B. J. MASON AND F. H. LUDLAM
Department of Meteorology, Imperial College, London

CONTENTS

	PAGE
§ 1. Introduction	148
§ 2. Spontaneous nucleation in water vapour	149
§ 3. The initial stages of condensation—condensation nuclei	151
(i) Mode of action of a nucleus	151
(ii) Nature and origin of atmospheric condensation nuclei	153
§ 4. The growth of droplets in clouds and fog	159
(i) Factors influencing droplet growth	159
(ii) Determination of cloud droplet sizes	159
(a) Direct methods	159
(b) Indirect methods	160
(iii) Total liquid water content of clouds	161
(iv) Theoretical studies of the growth of droplet populations	161
(a) Schumann's 'growth by collision' theory	161
(b) Howell's computations	162
(c) Langmuir's 'time of rise' theory	164
§ 5. The initial stages of ice formation—ice-forming nuclei	166
(i) 'Freezing' and 'sublimation' nuclei	166
(ii) Laboratory experiments on the supercooling and freezing of water and aqueous solutions	167
(iii) Laboratory investigations into the properties and behaviour of ice-forming nuclei	169
(iv) Discussion of experimental results	175
§ 6. The growth of ice particles	177
(i) The formation of ice crystals and snowflakes	178
(ii) The formation and growth of hail	183
§ 7. The development of precipitation	184
(i) Forms of precipitation	184
(ii) The formation of precipitation elements	185
(iii) Growth of coagulation elements	185
(iv) The multiplication of raindrops by a chain reaction	187
(v) The artificial stimulation of precipitation	191
§ 8. Conclusion	192
References	194

ANGULAR CORRELATIONS IN NUCLEAR REACTIONS

BY MARTIN DEUTSCH

Laboratory for Nuclear Science and Engineering,
Massachusetts Institute of Technology, Cambridge, Mass.

CONTENTS

	PAGE
§ 1. Introduction	196
§ 2. The basic physical processes	197
(i) Experiments involving conservation of momentum	197
(ii) Experiments testing laws of interaction	197
(iii) Experiments to study properties of nuclear states	198
(iv) Elementary theory of angular correlations	199
§ 3. Experimental techniques	204
(i) Angular distributions	204
(ii) Angular correlations	210
(iii) Experiments involving more than one angle	213
§ 4. Experimental results	214
(i) Induced reactions	214
(ii) Radioactive decay	220
References	224

THE NUCLEAR INTERACTIONS OF COSMIC RAYS

BY G. D. ROCHESTER AND W. G. V. ROSSER

The Physical Laboratories, University of Manchester

CONTENTS

	PAGE
I. Introduction	228
II. Types of nuclear interaction	229
§ 1. Evaporation stars	229
1.1. Star types	229
1.2. General features of evaporation stars	231
1.3. Nuclear evaporation	235
1.4. Evaporation stars in electron-sensitive emulsions	238
1.5. Heavy fragments	240
§ 2. Penetrating showers	241
2.1. The investigation of penetrating showers by counter arrangements and the cloud chamber	241
2.2. Penetrating showers in electron-sensitive emulsions	242
2.3. The determination of the momentum spectrum of shower particles by the cloud chamber	248
2.4. Mixed showers	249
2.5. Heavy unstable particles in penetrating showers	252
§ 3. The nuclear interactions of heavy nuclei	253
§ 4. The nuclear interactions of the non-nucleonic components of cosmic rays	254
4.1. Electrons and photons	254
4.2. μ -mesons	254
4.3. π -mesons	256
III. The transition effects of the nucleonic and nuclear components	257
§ 1. Interaction mean free path and attenuation lengths	257
§ 2. The interaction mean free paths of the heavy primaries	259
§ 3. The interaction mean free paths of the primaries and secondaries of penetrating showers	259
3.1. Introduction	259
3.2. The transition effect of penetrating showers	260
3.3. The determination of the interaction mean free path of charged primaries	260
3.4. The determination of the interaction mean free path of neutral primaries	262
3.5. The secondary interactions of the particles produced in stars in the photographic emulsion	264
3.6. The large-angle scatterings and the secondary interactions of the penetrating particles observed in the cloud chamber	265
§ 4. The attenuation of high-energy nucleons in the atmosphere	265
4.1. Introduction	265
4.2. Counter experiments on the variation of penetrating showers with altitude	267
4.3. Photographic-plate experiments on the variation of high-energy stars with altitude	267
4.4. The barometer effect of penetrating showers	268
4.5. The angular distribution of the primaries of penetrating showers	269

§ 5. The attenuation of star-producing nucleons in the atmosphere and in condensed matter	269
5.1. Introduction	269
5.2. Photographic-plate experiments on the variation of evaporation stars with altitude	269
5.3. Ionization-chamber experiments on the variation of low-energy stars with altitude	270
5.4. Transition effects in condensed matter	270
§ 6. The latitude effects of penetrating showers and stars	271
6.1. Penetrating showers	271
6.2. Stars	271
IV. The nucleonic components in the atmosphere and their correlation . . .	272
§ 1. Introduction	272
§ 2. The primaries of penetrating showers : the A component	273
2.1. Exponential absorption	273
2.2. Meson production	273
§ 3. Single protons	275
§ 4. The primaries of evaporation stars : the B component	277
§ 5. The correlation of different types of stars	278
§ 6. Slow protons and slow neutrons : the C component	279
6.1. Slow protons	279
6.2. Slow neutrons	280
V. Conclusion	283
Acknowledgments	285
References	285

NUCLEAR EFFECTS IN ATOMIC SPECTRA

By E. W. FOSTER

CONTENTS

	PAGE
§ 1. Introduction	288
§ 2. Isotope structure	289
§ 3. The nuclear mass effect	290
§ 4. The nuclear field effect	293
(i) Nature of the observational material	293
(ii) Assignment of isotope shifts to spectrum terms	295
(iii) Theory of isotope shift in heavy element spectra ('volume effect')	296
(iv) Comparisons of experimental data with volume effect calculations	299
(v) The effect of screening of the inner electrons by the optical electrons	304
(vi) Configuration perturbation	306
(vii) Second approximation in the calculation of the volume effect . .	306
(viii) The 'staggering' of the odd isotope centroids	307
§ 5. Nuclear moments	308
(i) The effect of finite distribution of nuclear charge	309
(ii) The effect of finite distribution of nuclear magnetic moment	311
(iii) The effect of the proton motion in hydrogen and deuterium	312
Conclusion	313
Acknowledgments	313
References	313

A CRITICAL SURVEY OF IONOSPHERIC TEMPERATURES

By N. C. GERSON

Air Force Cambridge Research Laboratories, Massachusetts

CONTENTS

§ 1. Introduction	318
§ 2. Basic ionospheric equations	320
§ 3. Model atmosphere	322
§ 4. Temperature and collisional frequency	324
4.1. Experimental data	324
4.2. Theoretical considerations	325
4.3. Collisional cross section of atomic oxygen	328
4.4. Effective collisional frequency	329
§ 5. Hypsometry and collisional frequency	330
5.1. Theoretical considerations	330
5.2. Effect of neutral particles and ions	331
5.3. Comparison with other investigators	333
§ 6. Temperature and scale height	334
6.1. Scale heights from auroral data	334
6.2. Scale heights determined by other methods	335
§ 7. Temperature and electron concentration	336
7.1. General	336
7.2. Simplifications to Chapman layer	336
7.3. Assumption of a Chapman layer	340
7.4. Conclusions	342
§ 8. Temperature and the recombination coefficient	343
8.1. Recombination at low pressure	343
8.2. Diurnal cycle of recombination coefficient	346
8.3. Limitations of the method	346
8.4. Seasonal F2 region temperature variation	348
8.5. Latitudinal F2 region temperature variations	350
8.6. Conclusion	350
§ 9. Temperature and the influx function	351
9.1. Atmospheric contractive effects	351
9.2. Diurnal chronothermal function	351
9.3. Development of equations	352
9.4. Computational results	353
§ 10. Thermal equilibrium in the mesosphere	357
§ 11. Electron temperatures	358
§ 12. Assumed ionospheric temperatures	359
§ 13. Heating by electrical currents	360
§ 14. Direction of necessary further research	361
Acknowledgments	362
References	362

SOME APPLICATIONS OF NUCLEAR PHYSICS IN MEDICINE

By W. V. MAYNEORD

Department of Physics, Royal Cancer Hospital, London

CONTENTS

	PAGE
§ 1. Introduction	367
§ 2. The use of the chain-reacting pile for medical purposes	368
§ 3. Fission products	372
§ 4. Comparison of radioactive isotopes from cyclotron and pile	374
§ 5. Medical applications of isotopes	376
(i) Phosphorus	376
(ii) Iodine	381
(iii) Iron	385
(iv) Sodium	386
§ 6. Therapeutic sources of gamma-rays	392
§ 7. External beta-ray sources for therapeutic use	394
§ 8. Dosimetry of artificial radioactive substances	395
(i) Energy absorption and the röntgen	396
(ii) Dosage rates due to radioactive sources	397
(iii) Dosimetry of beta-ray emitters	398
(iv) Dosimetry of gamma-ray emitters	399
(v) Dosimetry of positron emitters	400
(vi) Fast and slow neutrons	401
§ 9. Medical use of high energy quanta and particles	401
§ 10. Therapeutic use of high speed neutrons	402
§ 11. High energy x-rays	402
§ 12. Protection	407
Acknowledgment	410
References	410

