Contents

LIST OF PARTICIPANTS v

DIRECTORS' NOTE ix

EDITORS' NOTE x

INTRODUCTORY REMARKS 1
R. M. SILLITTO

QUANTUM ELECTRODYNAMICS
T. W. B. KIBBLE

1. Hamiltonian Formalism 11
2. Classical Electrodynamics 22
3. Semiclassical Electrodynamics 26
4. Quantization of the Electromagnetic Field 30
5. Quantum Electrodynamics 42

QUANTUM THEORY OF COHERENCE
R. J. GLAUBER

1. Introduction 53
2. Classical Theory 59
3. Quantum Theory 62
4. Intensity and Coincidence Measurements 65
5. Coherence 79
6. Coherent States 87
7. The *P*-representation 92
8. Chaotic States 108
9. Wave Packet Structure of Chaotic Field 115

PHOTON STATISTICS
E. R. PIKE

1. Introduction 127
2. The Detection of a Light Field 138
3. Special Fields 146
4. Photon Statistics of Scattered Laser Light 162

QUANTUM-CLASSICAL CORRESPONDENCE FOR STOCHASTIC PROCESSES

W. H. LOUISELL

1. Review of Quantum Mechanics 177
2. Quantum Theory of Damping 184
3. Quantum-Classical Correspondence 191
4. Rotating Wave van der Pol Oscillator 197

THE SEMICLASSICAL AND QUANTUM THEORY OF THE LASER

H. HAKEN

1. The Structure of Laser Theory 201
2. Rate Equations 203
3. The Semiclassical Approach 219
4. The Fully Quantum Mechanical Treatment 242
5. The General Theory of Dissipation and Fluctuations of Quantum Systems Far from Thermal Equilibrium 293

Appendix 313

OPTICAL RESONATORS

G. TORALDO DI FRANCIA

1. Introduction 323
2. The Fabry–Pérot Cavity 324
3. The Confocal Resonator 331
4. Beam Waveguides and Non-Confocal Resonators 334
5. Periodic Systems and Stability 341
6. Roof-Mirror Resonators 345

REVIEW OF NONLINEAR OPTICAL PHENOMENA IN CONDENSED MATTER

N. BLOEMBERGEN

1. Introduction 355
2. Light Pulse Propagation Through a Two Level System 356
3. Lowest Order Nonlinear Susceptibility 359
4. Nonlinear Coupling between Electromagnetic Waves 363
5. Polarization Cubic in the Electric Field Amplitudes 365
6. Stimulated Raman Effect 370
7. Inelastic Rayleigh Scattering from Anisotropic Molecules 374
8. Stimulated Brillouin Effect 377
9. Thermally Induced Brillouin and Rayleigh Scattering 379
10. Stimulated Raman Scattering from Polaritons 382
11. Coupling of Light Waves with other Excitations 385
12. Transient Response 387

OPTICAL PUMPING AND RELATED TOPICS

G. W. SERIES

I A PRELIMINARY SURVEY
1. Introduction 395
2. The Brossel–Bitter Experiment 396
3. Double Resonance Method: Hyperfine Structures 401
4. Level-Crossings 407
5. Anticrossings 413
6. Ground States: Optical Pumping 414
7. Relaxation Processes 427
8. Frequency Shifts 430
9. Level-Crossing in Ground States 433
10. Description of Optical Pumping in Terms of Irreducible Spherical Tensor Operators 434

II EXPERIMENTAL DETAILS AND POINTS OF TECHNIQUE 435
1. Experimental Details 435
2. Spectrum of the Lamp 440
3. Excitation by Electrons and other Particles 440
4. Coherence Narrowing, Pressure Broadening and Depolarization .. 441
5. Comparison of Double Resonance and Level-Crossing Experiments: Modulation Techniques 442
6. Some Typical Results and some Recent Applications of Optical Pumping, Double Resonance and Level-Crossing Techniques 443
7. Application of Optical Methods to Molecules and Ions in Solids .. 445

III RADIO-FREQUENCY INTERACTIONS (a) COHERENCE AND OPTICAL MONITORING 446
1. Distinction Between Optical Fields and Radio-Frequency Fields .. 446
2. Monochromatic Fields: Semiclassical or Quantized Field Treatment? .. 447
3. Monochromatic Fields: Semiclassical Treatment 448
4. Application to Double Resonance Experiments 453
5. Modulation in Double Resonance and Optical Pumping Experiments .. 457
6. Transfer of Coherence 459
7. Appendix 464

IV RADIO-FREQUENCY INTERACTIONS (b) PERTURBATIONS 467
1. Systems of Three Unequally Spaced Levels Interacting with Rotating Magnetic Field 468
2. Two Level Systems with Oscillating Field Perpendicular to Static Field 470
3. Two Level System with Oscillating Field: Hanle Effect 473

V REFRACTIVE INDEX AS A MONITOR OF OPTICAL PUMPING 477
1. Interaction of Light with Individual Atoms 477
2. Coherence Between Radiation from Different Atoms 477

COHERENCE IN SPONTANEOUS EMISSION 483

H. HAKEN, R. HÜBNER AND K. ZEILE

QUANTUM STATISTICS OF OPTICAL PARAMETRIC OSCILLATION 489

R. GRAHAM

RADIATION FROM A SYSTEM OF N TWO LEVEL ATOMS .. 501
D. F. WALLS

NON-ADIABATIC EFFECTS IN THE LASER 507
F. HAAKE

DETERMINATION OF THE STATISTICAL PROPERTIES OF LIGHT FROM PHOTOELECTRIC MEASUREMENTS
J. PEŘINA

1. Introduction 513
2. The Photodetection Equation 515
3. Determination of the Integrated Intensity Distribution from the Photon-Counting Distribution 518
4. The Form of the Integrated Intensity Distribution 523
5. s-Ordering of Field Operators in Quantum Optics 524
6. Superposition of Coherent and Thermal Fields 526

PARTICLE BEAM FLUCTUATIONS IN QUANTUM MECHANICS
C. M. BÉNARD

1. The Wave Packet Formalism 535
2. Ideal Detectors 536
3. General Formulation of Coincidence Probabilities 536
4. Coincidence Probability in the Stationary Incoherent Case 538
5. Discussion 539
6. Conclusions 542

AUTHOR INDEX 545

SUBJECT INDEX 553