

I N D I C E

R. J. GLAUBER – Preface	pag. xv
Gruppo fotografico dei partecipanti al Corso	fuori testo
D. TER HAAR – On the history of photon statistics.	pag. 1
R. J. GLAUBER - Coherence and quantum detection.	
Introduction.	» 15
1. The statistical properties of the electromagnetic field.	» 17
2. The ideal photon detector	» 18
3. Correlation functions and coherence.	» 20
4. Other correlation functions.	» 22
5. The coherent states	» 24
6. Expansions in terms of coherent states.. . . .	» 28
7. A few general observations	» 31
8. The damped harmonic oscillator	» 32
9. The density operator for the damped oscillator	» 36
10. Irreversibility and damping	» 39
11. The Fokker-Planck and Bloch equations	» 42
12. Theory of photodetection. The photon counter viewed as a harmonic oscillator	» 46
13. The density operator for the photon counter	» 52
F. T. ARECCHI – Photocount distributions and field statistics.	
1. Introduction	» 57
1'1. The Fourier-series description	» 59
1'2. The description by a sequence of probability distributions	» 60

2. The photocount distributions	pag. 62
3. Measurement of the photocount distributions	» 67
3'1. Nonlinear method and dead-time correction	» 68
3'2. Linear method	» 70
4. Errors and limits of the PCS (photocount statistics)	» 74
4'1. Errors due to the finite count number	» 74
4'2. Measurement of small fluctuations	» 75
4'3. Comparison of PCS and correlation functions $G^{(n)}$	» 77
5. Joint photocount distributions	» 78
6. Statistical properties of the laser radiation	» 82
6'1. A review of the theory	» 82
6'2. Stationary experiments (ensemble distributions and time correlations)	» 87
6'3. Transient experiments	» 93
7. Applications of the PCS to scattering problems	» 97
7'1. Statistical distributions	» 98
7'2. Frequency spectra	» 98
7'3. Experimental results	» 101
Appendix	» 106

H. A. HAUS – The measurement of $G^{(2)}$ and its signal-to-noise ratio.

Introduction	» 111
1. The mathematics and physics of photoelectron emission	» 113
2. Signal-to-noise ratio of photocounting experiments	» 117
3. The signal-to-noise ratios of photocounting experiments for specific illuminations	» 123
3'1. The signal for a Gaussian point source	» 123
3'2. Signal produced by a Gaussian source of finite spatial extent	» 127
3'3. Experimental results	» 128
3'4. The signal-to-noise ratio	» 129
3'5. Illumination by a number state	» 130
4. The spectral measurement and correlation measurement	» 131
4'1. Signal of spectral measurement produced by a source of finite spatial extent	» 134
4'2. Experiments on laser below and above threshold of oscillation	» 135
4'3. The noise in the spectral measurement	» 136
4'4. The Hanbury-Brown-Twiss experiment	» 138
5. Comparison among different detection schemes	» 140
Appendix I. Noise of counting experiment	» 143
Appendix II. Noise in Rebka-Pound experiment	» 144
Appendix III.	» 145

D. FALKOFF [†] – Another physical interpretation of coherent states.	
Introduction	pag. 147
1. One-photon source	» 149
2. Schully-Lamb laser field	» 150
3. Black-body radiation	» 150
U. M. TITULAER – Factorization properties of coherent fields. » 153	
E. R. PIKE – Some problems in the statistics of optical fields.	
1.	» 160
2.	» 164
2'1. Introduction	» 165
2'2. The moment-generating function.. . . .	» 166
2'3. The probability distribution	» 170
2'4. Asymptotic forms	» 172
L. MANDEL – Some experiments on interference of photons.	
1. Introduction	» 176
2. Classical and semi-classical description of interference . . .	» 177
3. Quantum-mechanical description of interference	» 181
4. Experimental observations	» 183
5. Quantum theory of the experiment.	» 186
A. E. GLASSGOLD – The dynamical characteristic function.	
1. Introduction	» 192
2. Outline of the DCF method	» 192
3. Problems solved with the DCF method	» 197
3'1. The laser amplifier	» 197
3'2. Model parametric amplifier	» 198
3'3. The approach of a radiation field to equilibrium . . .	» 199
3'4. Further comments on the application of the DCF method	» 199
4. Analysis of an ideal field measurement	» 201
J. P. BARRAT – Coherence narrowing of excited atomic energy levels.	
1. Introduction	» 206
2. Lifetime measurement methods, and widths of excited levels	» 206
3. Coherence narrowing.	» 211
3'1. Experimental facts	» 211
3'2. Coupling between atoms through the radiation field . .	» 213
3'3. Density matrix for a scattering process of order n . . .	» 214
3'4. Important physical results.	» 215
4. Conclusion	» 216

F. BAROCCHI, M. MANCINI, R. PRATESI and G. TORALDO DI
FRANCIA – Scattering of resonance radiation.

1. Introduction	pag. 218
2. Resonance radiation in gases.	» 219
3. Elementary quantum theory of resonance fluorescence . . .	» 220
4. Resonance radiation in solids	» 224
5. Sharp-line excitation of resonance fluorescence in pink ruby	» 225
6. Proposal of narrow-band excitation of a quasi-resonance line in Ne	» 231

N. G. VAN KAMPEN – Scattering of light by density fluctuations.

1. Introduction	» 235
2. Derivation of the fundamental formula	» 237
3. The static case	» 241
4. Inelastic scattering	» 244

H. Z. CUMMINS – Laser light scattering spectroscopy.

Introduction.	» 247
1. General theory of light scattering in homogeneous media. .	» 248
1'1. Classical scattering theory for isotropic substances . . .	» 248
1'2. Quantum-mechanical basis	» 254
1'3. Semi-classical limit	» 255
1'4. Correlation-function approach	» 256
1'5. Connection with optical-coherence theory	» 259
2. Brillouin scattering	» 261
2'1. Background	» 261
2'2. Crystals: acoustic modes.	» 263
2'3. Crystals: optical coupling	» 264
2'4. Coupled degrees of freedom	» 266
2'5. Single-relaxation theory	» 270
3. Raman scattering	» 274
3'1. Introduction	» 274
3'2. The normal modes	» 275
3'3. Raman activity.	» 275
3'4. Selection rules	» 276
3'5. Apparatus	» 278
3'6. Cross-sections.	» 279
3'7. Raman experiments.	» 279
4. Rayleigh scattering	» 282
4'1. The scattering spectrum.	» 282
4'2. Light-beating spectroscopy: Forrester's approach	» 285
4'3. Light-beating spectroscopy: correlation-function approach	» 287
4'4. Experimental methods.	» 290

R. LOUDON — Scattering of light by excitations in crystals.

1. Introduction	pag. 297
2. Basic scattering formula	» 299
3. Raman scattering by electronic excitations	» 301
4. Raman scattering by magnons	» 302
5. Theory of long-wavelength polar excitations	» 306
6. Raman scattering by plasmons	» 309
7. Raman scattering by optical phonons	» 313
8. Brillouin scattering by acoustic phonons	» 316
9. Raman scattering by polaritons	» 318

P. A. FLEURY — Magnon dispersion relations from light scattering in antiferromagnets.

1. Introduction	» 321
2. Kinematics	» 322
3. The Raman tensor	» 323
4. Scattering apparatus	» 324
5. Antiferromagnetic magnons	» 325
6. Experimental results in FeF_2	» 328
7. Experimental test of the exchange coupling mechanism in MnF_2	» 333
8. Magnon dispersion relation in NiF_2	» 335
9. Conclusion	» 338

J. J. HOPFIELD — Excitons and their electromagnetic interactions.

1. Introduction	» 340
2. Exciton models	» 341
3. Dielectric response due to excitons	» 357
4. Longitudinal excitons	» 363
5. Transverse polarization waves	» 372
6. Excitons in random lattices and gases	» 388

A. GOLD — Two-photon spectroscopy.

1. Introduction	» 397
2. Basic theory	» 397
3. Survey of experiments	» 404
4. Applications of the theory	» 406
4'1. Ionization and photodetachment	» 406
4'2. Molecular transitions	» 408
4'3. Solids	» 411

J. DUCUING – Nonlinear optical processes.

1. Introduction	pag. 421
2. General theory	» 423
2'1. Introduction	» 423
2'2. Constitutive relations in a nonlinear medium	» 425
2'3. Wave propagation in a medium with a nonlinear susceptibility	» 433
3. Second-order optical processes	» 435
3'1. Introduction	» 435
3'2. Properties of the second-order susceptibilities	» 435
3'3. Wave interactions.	» 439
4. Third order processes	» 448
4'1. Introduction	» 448
4'2. Self-trapping and self-focusing of light	» 449
4'3. Stimulated Raman scattering	» 453
4'4. Two-photon absorption	» 464
5. Final remarks	» 466
Appendix I. The structure of the second order susceptibility tensor $\chi^{(2)}(\omega_1, \omega_2)$ for some crystal classes	» 467
Appendix II. Second-harmonic susceptibilities $\chi^{(2)}(\omega, \omega)$ for various material	» 469

Y. R. SHEN – Quantum theory of nonlinear optics.

1. Introduction	» 473
2. Multiphoton absorption and emission, Raman transitions	» 474
3. Incoherent scattering	» 480
4. Sum-frequency generation	» 484
5. Parametric amplification and oscillation.	» 485
6. Multimode problems.	» 488
7. Traveling wave problems	» 489

J. A. GIORDMAINE – Parametric optics.

1. Introduction	» 493
2. Optical parametric amplification and oscillation	» 495
2'1. Nonlinear optical crystals	» 495
2'2. Optical parametric gain	» 499
2'3. Optical parametric oscillation	» 502
2'4. Optimum design of an optical parametric oscillator	» 507
2'5. Tuning.	» 508
2'6. Brief historical summary	» 509
3. Optical parametric noise.	» 509
4. The stimulated Raman effect	» 513

M. MATER, W. KAISER, M. STANKA and J. A. GIORDMAINE – Short light pulses in stimulated Raman scattering.	
1. Experimental set-up and general results.	pag. 521
2. Derivation of rate equations for laser and Raman light	» 523
3. Solution of the rate equations	» 524
4. Quantitative comparison between theory and experiments	» 527
4'1. Measurement of the total backward emitted Raman energy	» 527
4'2. Time duration and peak intensity of the Raman pulse	» 528
5. Conclusions	» 530
S. R. HARTMANN – Generation and relaxation of photon echoes	
» 532	
G. MAYER – Experimental features of first-order stimulated scattering.	
1. The classical calculation	» 551
1'1. Spontaneous scattering	» 552
1'2. Stimulated scattering	» 552
2. Quantum results (EINSTEIN-EHRENFEST-DIRAC).	» 556
3. Classical physics again.	» 558
4. Raman effect for independent molecules	» 561
5. Conclusion of an experimenter	» 562
R. W. HELLWARTH – Kerr effect in symmetric-molecule liquids.	
1. Introduction	» 563
2. Origin of Kerr effect in symmetric-molecule fluids	» 565
3. Relation between a Kerr constant due to molecular redistribu- tion and short-range order of a fluid	» 566
4. $\delta n_{\parallel}/\delta n_{\perp}$	» 569
5. Evaluation of χ_{islm} with the Kirkwood superposition ap- proximation	» 570
F. DE MARTINI and P. L. KELLEY – Nonlinear optical propaga- tion effects in Kerr-active media.	
1. Introduction	» 574
2. Weak wave generation. Stimulated Rayleigh gain and 4-pho- ton scattering.	» 575
3. Self-steepening and spectral evolution of light pulses.	» 580
M. SCULLY – The quantum theory of a laser, a problem in nonequilibrium statistical mechanics.	
Introduction.	» 586
1. Semiclassical theory of an optical maser	» 587

1'1. Philosophy of laser theory	pag. 587
1'2. Maxwell equations in the slowly varying phase and amplitude approximation	» 588
1'3. Atomic polarization	» 590
1'4. Atomic polarization $\rightarrow$ macroscopic polarization.	» 594
Appendix	» 596
2. The quantum theory of radiation and statistical physics . .	» 597
2'1. Review of quantum theory of radiation.	» 598
2'2. Review of quantum statistical mechanics	» 602
3. Equation of motion for laser radiation-density matrix . . .	» 605
3'1. Method I	» 606
3'2. Method II	» 609
4. Discussion of equation of motion, photon statistical distribu- tion and photoelectron statistics	» 613
4'1. Diagonal equations of density matrix and photon statistics	» 614
4'2. Time development of the photon statistical distribution	» 619
4'3. Photoelectron counting statistics	» 620
5. Off-diagonal elements of the density matrix and spectral profile	» 621
5'1. Time dependence of $\varrho_{n,n+k}(t)$	» 621
5'2. Decay of electric field.	» 623
5'3. Theory of a spectrum analyser	» 623
5'4. The correlation function $G^{(1)}(t)$ as obtained from the density matrix $\Phi_n(k, t)$	» 625

H. HAKEN and W. WEIDLICH - Quantum theory of the laser.

Introduction	» 630
1. The Hamiltonian of the laser system	» 633
2. Derivation of the fundamental laser equations.	» 636
2'1. Langevin equations	» 637
2'2. Master equation	» 640
2'3. Exact equation for a distribution function of macroscopic variables	» 644
3a. Solution of Langevin equations.	» 650
3a.1. Exact elimination of atomic co-ordinates. Homoge- neously or inhomogeneously broadened line	» 650
3a'2. Derivation of the Van der Pol equation for multimode operation	» 651
3a'3. Van der Pol equation for single mode operation . . .	» 653
3a'4. Qualitative discussion: Van der Pol equation.	» 654
3a'5. The potential model	» 655
3a'6. Quantitative treatment; quantum mechanical quasi- linearization	» 657
3b. Direct solution of the master equation	» 661
3c. Fokker-Planck equations and their solutions.	» 668
4. Discussion of the final results	» 676

W. H. LOUISELL – Quantum theory of noise.

PART I. – Properties of the radiation field	pag. 680
1. Equation of motion	» 680
1'1. The Schrödinger equation	» 680
1'2. Heisenberg equation of motion	» 681
1'3. Density operator equation of motion	» 682
2. The harmonic oscillator	» 683
2'1. Quantization of the radiation field	» 683
2'2. Eigenvalues and eigenvectors. Ortogonality and completeness	» 685
3. The coherent state	» 688
4. Ordered operators	» 691
4'1. Normal order	» 691
4'2. Antinormal order	» 692
PART II. – Quantum theory of damping	» 695
1. The reduced density operator	» 695
1'1. Arbitrary system	» 695
1'2. Damped oscillator	» 698
1'3. Atom interacting with reservoir	» 701
2. Fokker-Planck equation for damped oscillator	» 710
2'1. Eigenvalues and eigenfunctions	» 710
2'2. Conditional probability	» 712
2'3. Characteristic function	» 714
3. Two-time averages	» 715
PART III. – Quantum theory of a laser	» 719
1. The model	» 719
2. The laser Fokker-Planck equation	» 722
3. Adiabatic elimination of atomic variables	» 726
Appendix A. Properties of Fokker-Planck equations	» 729
Appendix B. Adiabatic elimination of variables	» 734
1. Introduction	» 734
2. Properties of the Hermite polynomials	» 736
3. Adiabatic elimination of x	» 739

J. P. GORDON – Quantum theory of a simple laser.

1. Introduction	» 743
2. The master equation	» 744
3. The ansatz	» 746
4. The Fokker-Planck equation	» 749
5. Adiabatic elimination of $\mathcal{M}$	» 753