

CONTENTS

Preface	v
List of participants	vii
A Theoretical Outline of Laser Physics and Laser Instabilities <i>Lorenzo M. Narducci</i>	
Introductory Comments	2
1. An Introduction to the Theory of the Laser: The Rate Equations	4
2. The Interaction of Light and Matter	15
2.1 An overview: The early history	15
2.2 The classical picture of the interaction of radiation and matter	16
3. The Basic Laser Equation — Homogeneously Broadened Systems	24
4. Steady State Behavior of a Homogeneously Broadened Ring Laser	32
5. Linear Stability Analysis: The Resonant Case	38
6. The Adiabatic Elimination of the Fast Variables	46
7. Linear Stability Analysis: The General Case	51
8. The Single Mode Laser: Deterministic Chaos	72
9. Dynamical Behavior of the Maxwell-Bloch Equations	87
10. The Spectral Analysis of the Output Field	106
11. Theory of a Laser with Inhomogeneous Broadening	121
Appendix A: The Laser Rate Equations	142
Appendix B: An Improved Single-Mode Model	143
Appendix C: Bidirectional Propagation	147
Appendix D: Exact Steady State Equations: Resonant Inhomogeneously Broadened Laser	152
References	153
Selected Illustrations and Interpretations of Laser Physics and Laser Instabilities in Experimental Systems <i>Neal B. Abraham</i>	
I. Foreword	158
II. Background Notes for the Discussion of Laser Systems	159
A. Rate equations for multilevel systems	159
B. Lineshapes, dispersion and bandwidths of response	163
C. Evolution of the intensity upon propagation in a medium	173
D. Amplified spontaneous emission	175
E. Factors influencing gain and dispersion	179
F. Coherent dynamical response of the medium	181

G. Inhomogeneous broadening	183
H. Laser cavities and decay rates	185
I. Cavity resonances – mode structure	189
J. Comparisons of various laser materials and their associated parameters	200
K. References	207
III. Experimental Measurements of Dynamical Instabilities and their Analysis in Single-Mode Inhomogeneously Broadened Lasers	208
A. Introduction	208
B. Basic results for unidirectional ring lasers	210
C. Origins of single mode instabilities in inhomogeneously broadened lasers	215
D. Further subtleties revealed by heterodyne detection: Measuring the electric field amplitude of pulsing lasers	220
E. Measurements to confirm chaotic laser behavior	229
F. Results for standing wave-lasers	236
G. A careful look at field and intensity spectra and their correlation functions	242
H. Conclusions	252
I. References	252
IV. Other Examples of Dynamical Instabilities and Chaos in Lasers	256
A. Introduction	256
B. Single mode pulsations in FIR lasers	256
C. Laser with saturable absorber (LSA)	267
D. Modulated single-mode lasers	273
E. Laser with an injected signal (LIS)	281
F. Bidirectional ring lasers	283
G. The Risken-Nummedal multimode instability in homogeneously broadened lasers	289
H. Combination-tone generation in 3-mode lasers	293
I. References	299
V. Postscript	302
A. Reviews	302
B. Compendia of research articles	302