

Contents

Abstract (German)	vii
1 Introduction	1
2 Optical pulse propagation in nonlinear media	5
2.1 Optical wave equation	5
2.2 Conventional nonlinear optics	6
2.2.1 Polarization response functions and susceptibilities	7
2.2.2 Symmetry properties	8
2.3 Envelope propagation equation	9
2.4 Polarization envelopes	11
2.4.1 Adiabatic limit	12
2.4.2 Kerr effect	13
2.5 Slowly varying envelope approximation	14
2.6 Coupled waves	15
2.7 Nonlinear Schrödinger equation	16
2.8 Summary	17
3 Gaussian pulse dynamics	19
3.1 Analytical solutions of the nonlinear Schrödinger equation	20
3.2 Variational formulation	23
3.3 Ritz procedure	25
3.4 Equations of motion for pulse parameters	27
3.5 Self-focusing in a dispersive medium	28
3.6 Split-step Fourier method	29
3.7 Accuracy of Gaussian description	31
3.8 Summary	35
4 Steady-state solutions in a nonlinear cavity	37
4.1 The Kerr-lens mode-locked laser	38
4.2 Laser model	40
4.3 Propagation of a Gaussian pulse	44

4.3.1	Kerr medium	44
4.3.2	Linear optical system	44
4.4	Steady-state solution	47
4.5	Application of the Gaussian model	50
4.6	Numerical simulation	55
4.7	Comparison	58
4.8	Summary	62
5	Two-level system	65
5.1	Dynamics	66
5.1.1	Schrödinger equation	66
5.1.2	Dissipative systems	67
5.2	Two-level model for light-matter interaction	69
5.2.1	Two-level Hamiltonian	69
5.2.2	Parameters	69
5.2.3	Observables	70
5.2.4	Simplified equations of motion	70
5.2.5	Rotating frame of reference	71
5.3	Rotating wave approximation	72
5.3.1	Sinusoidal excitation of non-dissipative systems	73
5.3.2	Susceptibilities	75
5.4	Beyond the rotating wave approximation	77
5.4.1	Carrier-wave Rabi flopping	78
5.4.2	Bloch-Siegert shift	79
5.5	Maxwell-Bloch equations	80
5.5.1	Envelope equations	81
5.6	Summary	82
6	Carrier-envelope phase sensitive inversion in a two-level system	85
6.1	Carrier-envelope phase	86
6.1.1	The f -to- $2f$ interferometer	87
6.1.2	Opto-electronic phase detectors	87
6.1.3	CE phase sensitive carrier-wave Rabi flopping	88
6.2	CE phase detection based on inversion	89
6.3	Symmetry properties and modulation depth	90
6.3.1	Inversion invariance for time reversal of the field	91
6.3.2	Modulation depth	92
6.4	Weak field limit	96
6.5	CE phase sensitivity for rectangular pulses	97
6.5.1	Systems without dissipation	98
6.5.2	Systems with dissipation	99

6.6	CE phase sensitivity for sinc-shaped pulses	100
6.7	Two-band semiconductor model	102
6.7.1	Optical Bloch equations for a semiconductor	102
6.7.2	Semiconductor model	104
6.7.3	CE phase sensitive inversion	106
6.8	Prospects for experiments	108
6.9	Summary	110
7	Conclusion	111
A	Fourier transformation	113
A.1	Dirac function	114
A.2	Shifted variables	114
A.3	Differentiation	115
A.4	Convolution	115
A.5	Complex conjugate	116
A.6	Parseval's theorem	116
B	Derivation of the equations of motion	117
C	Floquet theorem	121
D	Proof of the inversion invariance for time reversal of the field	123
E	Weak field approximation	125
F	Modulation depth of the rectangular pulse	127
G	Almost degenerate perturbation theory	129
	Glossary	131
	List of Figures	139
	List of Tables	143
	Bibliography	145
	Publications	153
	Acknowledgment	155