

Contents

1	Trajectory-Based Coulomb-Corrected Strong Field Approximation .	1
	T.-M. Yan, S.V. Popruzhenko, and D. Bauer	
1.1	Introduction	1
1.2	Theoretical Description of Atomic Strong Field Ionization	2
1.2.1	Strong Field Approximation	2
1.2.2	Steepest Descent Method Applied to the SFA	3
1.2.3	Trajectory-Based Coulomb Correction	5
1.2.4	Applications and Numerical Implementation	6
1.3	Results and Discussion	7
1.3.1	Categorization of Trajectories and Partial Reconstruction	8
1.3.2	Statistical Trajectory-Based Analysis	11
1.4	Conclusion	13
	References	15
2	The Role of Nuclear Vibrational Motion in Molecular High Harmonic Generation in a Mid-Infrared Laser Field	17
	Ruxin Li, Yinghui Zheng, Zhinan Zeng, Pengfei Wei, Yuxin Leng, and Zhizhan Xu	
2.1	Introduction	18
2.2	IAP Generation in the Water Window	18
2.2.1	NBO TDSE Model	19
2.2.2	Results and Discussion	20
2.3	Driving Wavelength Effect on Molecular HHG in a Tunable MIR Laser Field	23
2.3.1	Experimental Setup	25
2.3.2	Difference of Driving Wavelength Effect Between CH ₄ Molecules and Xe Atoms	25
2.3.3	Discussion	27
2.4	Summary	28
	References	28

3	Attosecond Dynamics of Coherent Electron–Nuclear Wave Packets in Molecules	31
	André D. Bandrauk, Timm Bredtmann, and Szczepan Chelkowski	
3.1	Introduction	31
3.2	Attosecond Photoionization of Coherent Electron Wave Packets (CEWP's)	34
3.3	Molecular High-Order Harmonic Generation (MHOHG) from Coherent Electron Wave Packets (CEWP)	39
3.4	Quantum Theory of HHG and MHOHG from a Coherent Superposition of Two Electronic States	43
3.5	Conclusion	50
	References	51
4	Gating Techniques for Shaping of Attosecond Pulses	55
	Francesca Calegari, Candong Liu, Matteo Lucchini, Giuseppe Sansone, and Mauro Nisoli	
4.1	Introduction	55
4.2	Shaping of Attosecond Pulses by Polarization Gating	57
4.2.1	Tunable Isolated Attosecond Pulses	58
4.2.2	Temporal Shaping of Pairs of Attosecond Pulses	59
4.3	Shaping of Attosecond Pulses by Ionization Gating	62
4.3.1	Tunable XUV Radiation by Ionization Gating	62
4.4	Shaping of the Polarization of Isolated Attosecond Pulses by Amplitude Gating	66
4.5	Conclusions	67
	References	68
5	Transform-Limited Attosecond Pulse Generation Through Atto-Chirp Compensation by Material Dispersion	71
	Chang Hee Nam, Kyung Taec Kim, and Dong Hyuk Ko	
5.1	Introduction	71
5.2	Basic Principle of Atto-Chirp Compensation by Material Dispersion	72
5.3	Atto-Chirp Compensation in a Gaseous Medium: Experiment	78
5.4	Generation of Sub-100-as Pulses: Experiment	84
5.5	Conclusion	87
	References	87
6	Carrier-Envelope Phase Stabilization	89
	Günter Steinmeyer, Bastian Borchers, and Fabian Lücking	
6.1	Introduction	89
6.2	Basic Definitions: The CEP and the Absolute Phase	90
6.3	Concepts for CEP Measurement	92
6.3.1	CEP Measurement of an Oscillator	92
6.3.2	CEP Measurement of Amplified Pulses	94
6.4	Practical CEP Detection Set-ups	95
6.4.1	CEP Detection of Oscillator Pulse Trains	95

6.4.2	Shot-to-Shot Detection of the CEP of Amplified Pulses Using Analog Processing	97
6.5	Stabilization	99
6.5.1	Feedback Stabilization	100
6.5.2	Feed-Forward Stabilization	101
6.6	Carrier-Envelope Phase Noise Characterization	104
6.7	Outlook and Conclusion	107
	References	108
7	Probing and Controlling Autoionization Dynamics of Atoms with Attosecond Light Pulses	111
	Wei-Chun Chu and Chii-Dong Lin	
7.1	Introduction	111
7.2	Evolution of an Isolated Autoionizing State	112
7.2.1	Time Evolution of an Autoionizing Wave Packet	113
7.2.2	Applications to the 2p4s Resonance in Beryllium	115
7.3	Electron Dynamics of Laser-Coupled Autoionizing States	117
7.3.1	Model for Total Wavefunction	118
7.3.2	Experiment in Helium	121
7.4	Photoabsorption of Laser-Coupled Autoionizing States	124
7.4.1	Model for Photoabsorption	124
7.4.2	Experiments in Argon	125
7.5	Resonant Coupling in Autoionizing Helium	126
7.5.1	Time-Delayed Electron and Photoelectron Spectra	127
7.5.2	Wavelength and Intensity Dependence	128
7.5.3	Dependence on Pulse Duration	131
7.6	Summary	132
	References	132
8	Attosecond Absorption Spectroscopy	135
	Michael Chini, He Wang, Baozhen Zhao, Yan Cheng, Shouyuan Chen, Yi Wu, and Zenghu Chang	
8.1	Introduction	135
8.2	Experimental Setup for Attosecond Transient Absorption Spectroscopy	137
8.2.1	Isolated Attosecond Pulses from Generalized Double Optical Gating	139
8.2.2	Delay Control	140
8.2.3	Absorption Gas Cell	140
8.2.4	Transmission Grating Spectrometer	142
8.3	Sub-cycle Transient Absorption in Helium 1snp Excited States	144
8.4	Attosecond Time-Resolved Autoionization in Argon	145
8.5	Summary and Outlook	147
	References	148

9	Shot-by-Shot Photoelectron Spectroscopy of Rare Gas Atoms in Ultrashort Intense EUV Free-Electron Laser Fields	151
	Mizuho Fushitani, Yasumasa Hikosaka, Akitaka Matsuda, Eiji Shigemasa, and Akiyoshi Hishikawa	
9.1	Introduction	151
9.2	Experimental	153
9.2.1	SPRing-8 SASE Compact Source (SCSS)	153
9.2.2	Magnetic Bottle Type Photoelectron Spectrometer	153
9.2.3	Shot-by-Shot Photoelectron Spectroscopy	154
9.3	Three-Photon Double Ionization of Ar	155
9.4	Nonlinear Double Excitation of He	158
9.5	Two-Color Above Threshold Ionization of Ar	160
9.6	Summary	161
	References	162
10	Rescattering Photoelectron Spectroscopy of Atoms and Molecules in Intense Laser Fields	165
	Misaki Okunishi and Kiyoshi Ueda	
10.1	Introduction	165
10.2	Experimental Apparatus and the QRS Theory	167
10.2.1	Experimental Apparatus	167
10.2.2	Theoretical Background	169
10.3	Results and Discussions	172
10.3.1	Rare Gas Atoms—Simplest Targets	172
10.3.2	O ₂ and CO ₂ Molecules—Linear Molecules	174
10.3.3	C ₂ H ₄ Molecule—A Non Linear Polyatomic Molecule	178
10.4	Summary and Outlook	178
	References	180
11	Few-Femtosecond and Attosecond Electron Dynamics at Surfaces	183
	Elisabeth Bothschafter, Stefan Neppl, and Reinhard Kienberger	
11.1	Introduction	184
11.2	Surface Electron Dynamics at Ultrashort Timescales	186
11.2.1	Excitation and Relaxation of Non-equilibrium Populations	186
11.2.2	Electronic Response Effects in Solid-State Photoemission	187
11.2.3	Lifetimes of Surface States	188
11.2.4	Charge Transfer and Transport Dynamics	188
11.2.5	Dynamics of the Photo-Electric Effect	189
11.3	Ultrashort Light Pulses for Time-Resolved Spectroscopy	192
11.3.1	Generation and Characterization of Isolated Attosecond XUV Pulses	193
11.3.2	Collinear Generation of Attosecond XUV and Few-fs UV Pulses	194
11.4	Principle and Setup for Time-Resolved Experiments on Surfaces with Few-fs to Sub-fs Resolution	196
11.4.1	Transient Reflectivity	196

11.4.2 Laser-Assisted Photoemission: Streaking vs. Sideband Regime	197
11.5 Recent Experimental Advances in Probing Ultrafast Dynamics at Surfaces	200
11.5.1 Transient UV-Reflectivity of Noble Metal Surfaces	200
11.5.2 Attosecond Streaking Experiments on Surfaces	201
11.5.3 Future Directions and Perspectives	205
References	207
12 From Above-Threshold Photoemission to Attosecond Physics at Nanometric Tungsten Tips	213
M. Krüger, M. Schenk, J. Breuer, M. Förster, J. Hammer, J. Hoffrogge, S. Thomas, and P. Hommelhoff	
12.1 Introduction	213
12.2 Experimental Setup	216
12.3 Above-Threshold Photoemission	217
12.4 Strong-Field Effects: Peak Shifting and Peak Suppression	219
12.5 Attosecond Physics: Elastic Recollision	220
12.6 Matter Wave Interference in the Time-Energy Domain—Carrier- Envelope Phase Effects	222
12.7 Outlook: From Attosecond Physics at Solids to Lightwave Electronics	222
References	223
Index	225

Progress in Ultrafast Intense Laser Science

Volume IX

Yamanouchi, K.; Midorikawa, K. (Eds.)

2013, XI, 228 p. 156 illus., 56 illus. in color., Hardcover

ISBN: 978-3-642-35051-1