CONTENTS

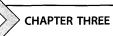
Pre	face	vii
For	eword	ix
Fut	ure Contributions	xiii
1.	Theory and Data Analysis in Time-Resolved Electron Diffraction	1
	1.1. Basic Assumptions and Approximations	1
	1.2. Illustration of the Diffraction Signatures of Excited Molecules	7
	1.3. Simplified Cumulant Analysis	10
	1.4. Complete Cumulant Analysis	15
	1.5. Manifestation of Chaotic Nuclear Dynamics in TRED Studies References	17 23
2.	Structural Dynamics in Isolated Molecules	27
	2.1. The Development of TRED	30
	2.2. The Time Dependence of the Intensity of Electrons Scattered by Photoexcited Molecules	54
	2.3. Coherent Nuclear Dynamics of Spatially Oriented Molecules in the	54
	Laser Field	72
	2.4. Dynamics of Spectrally Invisible Structures	82
	Conclusion	90
	References	92
3.	Ultrafast Electron Crystallography and Nanocrystallography	101
	3.1. Experimental Setups	102
	3.2. Structural Dynamics in Condensed Phase	109
	3.3. Time-Resolved Electron Nanocrystallography	117
	Conclusion	137
	References	139
4.	Coherent Dynamics of Nuclei and Electrons: Femtosecond	
	and Attosecond Resolution in the TRED Technique	145
	4.1. Experimental Technique	149
	4.2. Theory	164
	4.3. Solution of the Inverse Problem	171
	4.4. The Dynamics of the Wave Packets	173
	4.5. Dynamics of Electrons—Attosecond Temporal Resolution of the TRED	197

v

vi	Contents
Conclusion	218
References	218
. Ultrafast Electron Microscopy	231
5.1. Transmission and Scanning Electron Microscopy	232
5.2. Ultrafast Electron Microscopy	235
5.3. Examples of Instrument Designs	240
5.4. Applications of Time-Resolved Microscopy	244
5.5. Future Trends	251
Conclusions	257
References	259
ontents of Volumes 151–183	263
Index	269

Structural Dynamics in Isolated Molecules

2.1.	The D	evelopment of TRED	30
	2.1.1.	Early Implementations of TRED	31
	2.1.2.	Further Development of Experimental Techniques for TRED	34
	2.1.3.	Determination of Time-Zero in TRED	40
	2.1.4.	The Method of Reference Frames and Synchronization of Structures	41
		Difference Method for Time-Dependent Diffraction Data Analysis	42
	2.1.5.	The Influence of the Coulomb Interaction in the Electron Bunch on the	
		Determined Structural Parameters	43
		Description of the Model	44
		Method for Calculating Corrections to the Electron Scattering Angle Based on the	
		Conservation of Energy Law	45
		Estimation of the Distortion of the Measured Parameters of the Molecules	48
	2.1.6.	Effects of Space Charge and Energy Distribution in the Electron Bunch	51
2.2.	The T	ime Dependence of the Intensity of Electrons Scattered by Photoexcited	
	Molecules		
	2.2.1.	Coherent Nuclear Dynamics	55
		Stochastic Approach to TRED Data Analysis	56
	2.2.2.	Molecular Quantum State Tomography	58
	2.2.3.	Photodissociation of CS ₂	63
	2.2.4.	Unimolecular Photodissociation of 1,2-diiod-tetrafluoroethane	66
		Structural Dynamics of the Elimination Reaction of Iodine Atoms From the Free	
		C ₂ F ₄ I ₂ Molecules Under Collisionless Conditions	66
		Structural Dynamics of lodine Cleavage Reaction in $C_2H_4I_2$ and $C_2F_4I_2$ Molecules	
		in Solution	68
2.3.	Coherent Nuclear Dynamics of Spatially Oriented Molecules in the Laser Field		
	2.3.1.	Theory	73
	2.3.2.	Spatially Oriented Intermediate Structures in the Absence of External	
		Orienting Fields	79
2.4.	Dynai	mics of Spectrally Invisible Structures	82
	Pyridir	ne, 2-Methylpyridine, and 2,6-Dimethylpyridine	83
	clusior		90
Refe	erences		92



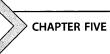
Ultrafast Electron Crystallography and Nanocrystallography

3.1. Experimental Setups	102
3.2. Structural Dynamics in Condensed Phase	109
3.2.1. Surfaces and Crystals	112
3.2.2. Conversion of Graphite into Diamond	113
3.2.3. Fatty Acid Crystal Bilayers: Molecular Ensembles	115
3.3. Time-Resolved Electron Nanocrystallography	117
3.3.1. Basic Concepts	119
3.3.2. Sample Preparation	120
3.3.3. Initial Data Analysis	123
3.3.4. Experimental Results	129
Photoinduced Structural Changes in Gold Nanocrystals	129
4D-Refinement of the Structure by the Inverse Monte-Carlo Method	134
Conclusion	
References	139



Coherent Dynamics of Nuclei and Electrons: Femtosecond and Attosecond Resolution in the TRED Technique

4.1. Experimental Technique	149
4.1.1. Diffraction of Relativistic Electron Bunches	149
4.1.2. Diffraction of Single Electrons	158
4.1.3. Temporary Lens and the Nonorthogonal Intersection of	
the Wave Front of Optical Exciting Pulse and the Electron Probe	160
The Experiments in the Reflection mode for the Study of the Structural	
Dynamics at the Surface	163
4.2. Theory	164
4.3. Solution of the Inverse Problem	171
4.4. The Dynamics of the Wave Packets	173
4.4.1. Photoelectron Spectroscopy with Temporal Resolution	175
4.4.2. UED	181
The Dynamics of the Dissociation	182
The Dynamics of the Photopredissociation	185
4.4.3. Quantum-Dynamical Simulation of Dissociation	190
4.4.4. Supplementary of the Methods of Spectroscopy of	
the Transient State and UED	193
4.5. Dynamics of Electrons—Attosecond Temporal Resolution of the TRED	197
4.5.1. Ultrashort Pulses of Electromagnetic Radiation	197
The First Steps in Attosecond Physics	1 <i>9</i> 8
Ultrashort Pulses and Quantum Control	200
4.5.2. Molecular Dynamics and Tomography of the Electron Density	204
4.5.3. Laser-Induced Electron Diffraction	212
Alignment of Molecules in a Strong Laser Field	216
Conclusion	218
References	218



Ultrafast Electron Microscopy

5.1.	Transmission and Scanning Electron Microscopy	232
5.2.	Ultrafast Electron Microscopy	235
5.3.	Examples of Instrument Designs	240
5.4.	Applications of Time-Resolved Microscopy	244
	5.4.1. Phase Transitions in Nanoparticles	244
	5.4.2. Laser-Induced Crystallization	244
	5.4.3. Musical Nanoscale Instruments: A Drum, a Harp, and a Piano	245
	5.4.4. 4D Electron Tomography	249
5.5.	Future Trends	251
	5.5.1. Spatial and Temporal Electron Microscopy with Additional Spectral	
	Resolution	251
	5.5.2. Controlling the Motions of Free Electrons by Femtosecond Light Pulses	252
Con	Iclusions	257
Refe	erences	259