Contents

List of Contributors ix
Preface xi
Contents of Volumes 1–25 xiii

1. Magnetic Relaxation of Lanthanide-Based Molecular Magnets 1
Elena Bartolomé, Ana Arauzo, Javier Luzón, Juan Bartolomé, and Fernando Bartolomé

1 Introduction 2
2 Electronic Structure, Magnetism, and Relaxation of Lanthanide Ions 6
2.1 Electronic Structure of the Lanthanides 6
2.2 Mechanisms of Magnetic Relaxation of Molecules 12
2.3 Magnetic Interactions 24
2.4 Beyond the Anisotropy Barrier: Energy Spectrum and Relaxation Times 31
2.5 Summary 33
3 Computational Tools and Theoretical Methods 35
3.1 Introduction 35
3.2 Electrostatic Models 35
3.3 Quantum Chemistry Methods 41
3.4 CASSCF–CASPT2/RASSI-SO Method 45
4 Experimental Methods for Investigation of Relaxation Mechanisms in Lanthanide Molecular Magnets 60
4.1 Introduction 60
4.2 DC Magnetization and AC Susceptibility Experiments 61
4.3 Heat Capacity Measurements 76
4.4 Spectroscopic Methods 84
4.5 Conclusions 101
5 Lanthanide-Based SIMs 101
5.1 Introduction 101
5.2 Influence of the Lanthanide Ion 103
5.3 Crystal Field Environment 117
5.4 Conclusions and Outlook 137
6 Dinuclear Lanthanide-Based SMMs 139
6.1 Homo Dinuclear [Ln_2] SMMs 139

6.2 Heterodinuclear SMMs 163
6.3 Conclusions 167
7 Polynuclear Lanthanide-Based SMMs 168
7.1 Introduction 168
7.2 Homonuclear Ln Clusters (Ln_x, $x>2$): SMTs and SMMs 168
7.3 Heteronuclear Ln–3d Clusters 182
7.4 Conclusions 194
8 1D, 2D, and 3D Extended Systems 196
8.1 1D Molecular Magnets 197
8.2 Higher Dimensionality 215
8.3 Conclusions 226
9 Molecular Magnets on Surfaces 226
9.1 Selected Molecular Systems 232
9.2 Experimental Techniques 233
9.3 Surfaces and Substrates 235
9.4 Devices 240
9.5 Conclusions and Outlook 245
10 Conclusions and Perspectives 246
Acknowledgments 251
References 251

2. Laser-Induced Ultrafast Magnetic Phenomena 291
Karel Carva, Pavel Baláž, and Ilie Radu

1 Introduction 292
2 Theoretical Approaches to Describe Laser-Induced Magnetization Dynamics 297
2.1 Phenomenological Description of Laser-Driven Spin Dynamics 298
2.2 Derivation of Relativistic Effects 300
2.3 Interaction Between Light and Magnetic Medium 304
2.4 Magnetization Dynamics in the Ultrafast Range 310
2.5 Ab Initio Methods for Calculating Exchange Interactions, Magneto-Optical Response, and Scattering Processes 323
3 Experimental Methods to Study Laser-Induced Magnetization Dynamics 338
3.1 All-Optical Detection Techniques 339
3.2 Time-Resolved Magneto-Optical Spectroscopy 344
3.3 Time-, Energy-, Momentum-, and Spin-Resolved Electron Spectroscopy 346
3.4 Time-, Spatial-, and Element-Resolved X-Ray Measurements of Spin Dynamics 349
3.5 Time-Resolved THz-Based Studies 353
4 Ultrafast Demagnetization 356
4.1 Demagnetization in Transition Metals and Their Compounds or Alloys 356
4.2 Demagnetization in Rare-Earth Based Materials 361
4.3 Demagnetization in Half-Metals, Semiconductors, or Insulators 365

4.4 Discussion of the Relation Between the Observed MO Response and Magnetization 369
4.5 Character of the Demagnetized State 372
5 Ultrafast Magnetization Switching 378
5.1 Early Work on Magnetization Switching 379
5.2 Overview of Laser-Induced Magnetization Switching 383
5.3 Models of Heat-Driven Multisublattice Reversal 394
5.4 Inverse Faraday Effect 398
6 Ultrafast Generation of Spin Currents 402
6.1 Superdiffusive Model and Hot Electron Transport 407
6.2 Thermally Driven Spin Currents 407
6.3 Noncollinear Arrangement and Spin Torques 410
7 Discussion of Underlying Physical Mechanisms 416
7.1 Different Scattering Mechanisms 416
7.2 Spin Transport 428
8 Concluding Remarks and Outlook 431
Acknowledgments 434
References 434

Author Index 465
Subject Index 499
Material Index 505