
Soft Matter Characterization

Soft Matter Characterization

Editors: Redouane Borsali and Robert Pecora

With 664 Figures and 38 Tables

 Springer

Redouane Borsali
CERMAV, CNRS-UPR 5301 and Joseph
Fourier University
Grenoble Cedex 9
France

Robert Pecora
Professor
Department of Chemistry
University of California – Stanford
Stauffer II
375 North-South Mall
Stanford, CA 94305-5080
USA

ISBN: 978-1-4020-4464-9

This publication is available also as:

Electronic publication under ISBN: 978-1-4020-4465-6 and

Print and electronic bundle under ISBN: 978-1-4020-8290-0

Library of Congress

© 2008 Springer Science+Business Media, LLC.

All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer Science+Business Media, LLC., 233 Spring Street, New York, NY 10013, USA), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden.

The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

springer.com

Printed on acid free paper

SPIN: 11592440 2109spi - 5 4 3 2 1 0

Preface

Soft matter (or soft condensed matter) refers to a group of systems that includes polymers, colloids, amphiphiles, membranes, micelles, emulsions, dendrimers, liquid crystals, polyelectrolytes, and their mixtures. Soft matter systems usually have structural length scales in the region from a nanometer to several hundred nanometers and thus fall within the domain of “nanotechnology.” The soft matter length scales are often characterized by interactions that are of the order of thermal energies so that relatively small perturbations can cause dramatic structural changes in them. Relaxation on such long distance scales is often relatively slow so that such systems may, in many cases, not be in thermal equilibrium.

Soft matter is important industrially and in biology (paints, surfactants, porous media, plastics, pharmaceuticals, ceramic precursors, textiles, proteins, polysaccharides, blood, etc.). Many of these systems have formerly been grouped together under the more foreboding term “complex liquids.” A field this diverse must be interdisciplinary. It includes, among others, condensed matter physicists, synthetic and physical chemists, biologists, medical doctors, and chemical engineers. Communication among researchers with such heterogeneous training and approaches to problem solving is essential for the advancement of this field.

Progress in basic soft matter research is driven largely by the experimental techniques available. Much of the work is concerned with understanding them at the microscopic level, especially at the nanometer length scales that give soft matter studies a wide overlap with nanotechnology.

These volumes present detailed discussions of many of the major techniques commonly used as well as some of those in current development for studying and manipulating soft matter. The articles are intended to be accessible to the interdisciplinary audience (at the graduate student level and above) that is or will be engaged in soft matter studies or those in other disciplines who wish to view some of the research methods in this fascinating field.

The books have extensive discussions of scattering techniques (light, neutron, and X-ray) and related fluctuation and optical grating techniques that are at the forefront of soft matter research. Most of the scattering techniques are Fourier space techniques. In addition to the enhancement and widespread use in soft matter research of electron microscopy, and the dramatic advances

in fluorescence imaging, recent years have seen the development of a class of powerful new imaging methods known as scanning probe microscopies. Atomic force microscopy is one of the most widely used of these methods. In addition, techniques that can be used to manipulate soft matter on the nanometer scale are also in rapid development. These include the aforementioned scanning probe microscopies as well as methods utilizing optical and magnetic tweezers. The articles cover the fundamental theory and practice of many of these techniques and discuss applications to some important soft matter systems. Complete in-depth coverage of techniques and systems would, of course, not be practical in such an enormous and diverse field and we apologize to those working with techniques and in areas that are not included.

Part 1 contains articles with a largely (but, in most cases, not exclusively) theoretical content and/or that cover material relevant to more than one of the techniques covered in subsequent volumes. It includes an introductory chapter on some of the time and space-time correlation functions that are extensively employed in other articles in the series, a comprehensive treatment of integrated intensity (static) light scattering from macromolecular solutions, as well as articles on small angle scattering from micelles and scattering from brush copolymers. A chapter on block copolymers reviews the theory (random phase approximation) of these systems, and surveys experiments on them (including static and dynamic light scattering, small-angle X-ray and neutron scattering as well as neutron spin echo (NSE) experiments). This chapter describes block copolymer behavior in the “disordered phase” and also their self-organization. The volume concludes with a review of the theory and computer simulations of polyelectrolyte solutions.

Part 2 contains material on dynamic light scattering, light scattering in shear fields and the related techniques of fluorescence recovery after photo bleaching (also called fluorescence photo bleaching recovery to avoid the unappealing acronym of the usual name), fluorescence fluctuation spectroscopy, and forced Rayleigh scattering. Part 2 concludes with an extensive treatment of light scattering from dispersions of polysaccharides.

Part 3 presents articles devoted to the use of X-rays and neutrons to study soft matter systems. It contains survey articles on both neutron and X-ray methods and more detailed articles on the study of specific systems - gels, melts, surfaces, polyelectrolytes, proteins, nucleic acids, block copolymers. It includes an article on the emerging X-ray photon correlation technique, the X-ray analog to dynamic light scattering (photon correlation spectroscopy).

Part 4 describes direct imaging techniques and methods for manipulating soft matter systems. It includes discussions of electron microscopy techniques, atomic force microscopy, single molecule microscopy, optical tweezers (with

applications to the study of DNA, myosin motors, etc.), visualizing molecules at interfaces, advances in high contrast optical microscopy (with applications to imaging giant vesicles and motile cells), and methods for synthesizing and atomic force microscopy imaging of novel highly branched polymers.

Soft matter research is, like most modern scientific work, an international endeavor. This is reflected by the contributions to these volumes by leaders in the field from laboratories in nine different countries. An important contribution to the international flavor of the field comes, in particular, from X-ray and neutron experiments that commonly involve the use of a few large facilities that are multinational in their staff and user base. We thank the authors for taking time from their busy schedules to write these articles as well as for enduring the entreaties of the editors with patience and good (usually) humor.

R. Borsali

R. Pecora

September 2007



Editors-in-Chief



Dr Redouane Borsali is a CNRS Director of Research and since 2007 the Director of CERMAV, Centre de Recherche sur les Macromolécules Végétales, CNRS-UPR 5301, located on the Campus University of Grenoble, France. He studied physics at the University of Tlemcen, Algeria and received his Master and Ph.D. in polymer physics at the Institute Charles Sadron (Louis Pasteur University, Strasbourg, France) in 1988. After his postdoctoral research position at the Max-Planck-Institute for Polymer Research (MPI-P) at Mainz, Germany, he joined, in 1990, the CNRS (Grenoble, France) as a researcher. In 1995/1997, he spent a sabbatical leave at Stanford University and at IBM Almaden Research Center, CA, USA as a visiting scientist. In 2000, he joined the LCPO, a Polymer Research CNRS Laboratory, as the Polymer Physical-Chemistry Group Leader till 2006 and back to Grenoble in 2007 as the Director of CERMAV. His main research activities are focused on the study of the physical-chemistry properties: the structure, the dynamics, and the self-assemblies of “soft matter” and particularly of controlled architecture polymers such as block copolymers, polymer mixtures, polyelectrolytes including polysaccharides, nanoparticles such as micelles, vesicles, and rod-like morphologies, using scattering techniques. He has organized three international meeting on polymers and colloids, and he is the author or co-author of over 140 research articles and two books.



Robert Pecora is a professor of chemistry at Stanford University. He received his A.B., A.M. and Ph.D. degrees from Columbia University. After postdoctoral work at the Université Libre de Bruxelles and Columbia University, he joined the Stanford University faculty in 1964. His research interests are in the areas of condensed phase dynamics of small molecules, macromolecules, and colloids of both materials and biological interest. He is one of the developers of the dynamic light scattering technique and has utilized this and many of the other techniques described in these volumes in his research. His recent work emphasizes dynamics in dispersions of rodlike polymers, polyelectrolytes, and composite liquids. He is the author or coauthor of over 134 research articles and five books.

List of Contributors

BALLAUFF, MATTHIAS

University of Bayreuth
Bayreuth
Germany

BERRY, GUY C.

Carnegie Mellon University
Pittsburgh, PA
USA

BORSALI, REDOUANE

CERMAV, CNRS-UPR 5301 and Joseph
Fourier University
Grenoble Cedex
France

BURCHARD, WALTHER

Albert-Ludwig-University of Freiburg
Freiburg
Germany

CASTELLETTO, VALERIA

University of Leeds
Leeds
UK

CHOI, YOUNG-WOOK

Hanyang University
Seoul
South Korea

CHU, BENJAMIN

Stony Brook University
Stony Brook, NY
USA

COHEN-BOUHACINA, TOURIA

University of Bordeaux 1
Pessac Cedex
France

DAS, RHIJU

Stanford University
Stanford, CA
USA

DEFFIEUX, ALAIN

University of Bordeaux I
Pessac, Cedex
France

DÖBEREINER, HANS-GÜNTHER

Columbia University
New York, NY
USA

DONIACH, SEBASTIAN

Stanford University
Stanford, CA
USA

DOUCET, GARRETT J.

Louisiana State University
Baton Rouge, LA
USA

DUXIN, NICOLAS

McGill University
Montreal, QC
Canada

EDWIN, NADIA

Louisiana State University
Baton Rouge, LA
USA

EISENBERG, ADI

McGill University
Montreal, QC
Canada

ESAKI, SIEJI

Osaka University
Osaka
Japan

GIACOMELLI, CRISTIANO

University of Caxias do Sul (UCS)
Caxias do Sul
Brazil

GRILLO, ISABELLE

Institute Laue Langevin
Grenoble Cedex
France

GRUBEL, GERHARD

Hasylab/DESY
Hamburg
Germany

HAMLEY, IAN

University of Leeds
Leeds, UK

HASHIMOTO, TAKEJI

Kyoto University
Katsura, Kyoto
Japan

HAUSTEIN, ELKE

Biotec TU Dresden
Dresden
Germany

HOLM, CHRISTIAN

Max-Planck-Institute for Polymer
Research
Mainz
Germany

ISHII, YOSHIHARU

Osaka University
Osaka
Japan

KOZUKA, JUN

Japan Science and Technology Agency
Osaka
Japan

LAZZARONI, ROBERTO

University of Mons-Hainaut
Mons
Belgium

MAALI, ABDELHAMID

University of Bordeaux I
Pessac, Cedex
France

MADSEN, ANDERS

European Synchrotron Radiation Facility
Grenoble Cedex
France

NAKAMURA, YO

Kyoto University
Kyoto
Japan

NARAYANAN, T.

European Synchrotron Radiation Facility
Grenoble Cedex
France

NOIREZ, LAURENCE

Laboratory Léon Brillouin
Cedex
France

NORISUYE, TAKASHI

Osaka University
Osaka
Japan

PECORA, ROBERT

Stanford University
Stanford, CA
USA

PEDERSEN, JAN SKOV

University of Aarhus
Aarhus
Denmark

QIU, JIANHONG

Louisiana State University
Baton Rouge, LA
USA

REITER, GUNTER

Institute of Chemistry of Surfaces and
Interfaces
Cedex
France

RICKGAUER, JOHN PETER

University of California – San Diego
San Diego, CA
USA

ROBERT, AYMERIC

European Synchrotron Radiation Facility
Grenoble Cedex
France

RUSSO, PAUL S.

Louisiana State University
Baton Rouge, LA
USA

SCHAPPACHER, MICHEL

University of Bordeaux 1
Pessac Cedex
France

SCHÄRTL, WOLFGANG

Johannes-Gutenberg-University Mainz
Mainz
Germany

SCHWILLE, PETRA

Biotec TU Dresden
Dresden
Germany

SHIBAYAMA, MITSUHIRO

University of Tokyo
Tokyo
Japan

SMITH, DOUGLAS E.

University of California – San Diego
San Diego, CA
USA

SOHN, DAEWON

Hanyang University
Seoul
South Korea

TIRRELL, MATTHEW

University of California – Santa Barbara
Santa Barbara, CA
USA

TOOMEY, RYAN

University of South Florida
Tampa, FL
USA

VIVILLE, PASCAL

University of Mons-Hainaut
Mons
Belgium

YANAGIDA, TOSHIO

Osaka University
Osaka
Japan

Table of Contents

VOLUME 1

1 Basic Concepts – Scattering and Time Correlation Functions	1
<i>R. Pecora</i>	
1 Introduction	3
2 Basic Scattering Theory – Interference	3
3 Fundamentals of Time Correlation Functions	7
3.1 Stochastic (Random) Functions or “Signals”	8
3.2 Time Averages	8
3.3 Some Properties of Time Autocorrelation Functions	10
3.4 Ensemble-Averaged Time Correlation Functions	12
3.5 Spectral Densities of Time Correlation Functions	14
4 Correlation Functions for Number Densities in Fluids	15
4.1 Spatial Fourier Transforms	15
4.2 Local Density and Its Fourier Transform	16
4.3 Space Time Correlation Function of the Local Density	16
4.4 The Van Hove Space Time Correlation Function	17
4.5 The Self Correlation Function	18
4.6 Physical Interpretation, Limiting Values and the Radial Distribution Function	18
4.7 The Structure Factor	19
4.8 Dynamic Scattering Experiments	20
4.9 Space Time Correlation Functions for Perfect Gases	20
5 The Translational Self-Diffusion Model	23
5.1 Derivation of the Diffusion Equation	23
5.2 Random Walk	25
5.3 Solution of the Diffusion Equation for $G_s(\vec{r}, t)$	26
5.4 Solution of Partial Differential Equations	26

5.5	Expression for the Diffusion Coefficient	28
5.6	The Langevin Equation	29
5.7	The Stokes-Einstein Relation	30
6	<i>More Refined Models for Motions in Liquid</i>	31
6.1	Translational Motion of Small Molecules in Liquids – The Gaussian Approximation	31
6.2	Molecular Dynamics Simulations	32
6.3	Molecular Dynamics Test of the Gaussian Approximation	33
6.4	Molecular Dynamics Tests of the Stokes – Einstein Relation for Hard Sphere Fluids	33
6.5	Long-Time Tails in the Velocity Autocorrelation Function	34
6.6	Diffusion in Quasi-Two Dimensional Systems	34
7	<i>Macromolecular and Colloidal Dispersions</i>	35
7.1	The Hydrodynamic Radius	35
7.2	Relations between D and Molecular Dimensions for Nonspherical Particles	36
7.3	Non-Dilute Dispersions	37
8	<i>Conclusion</i>	38
2	Total Intensity Light Scattering from Solutions of Macromolecules	41
	<i>G. C. Berry</i>	
1	<i>Introduction</i>	43
2	<i>General Relations</i>	46
3	<i>Scattering at Infinite Dilution and Zero Scattering Angle</i>	49
3.1	The Basic Relation	49
3.2	Identical Scattering Elements	50
3.3	Optically Diverse Scattering Elements	51
3.4	Optically Anisotropic Scattering Elements	53
3.5	Scattering Beyond the RGD Regime	55
4	<i>Scattering at Infinite Dilution and Small q</i>	57
4.1	The Basic Relation	57
4.2	Identical Scattering Elements	57
4.3	Optically Diverse Scattering Elements	62
4.4	Optically Anisotropic Scattering Elements	64
4.5	Scattering Beyond the RGD Regime	66

5	<i>Scattering at Infinite Dilution and Arbitrary q</i>	68
5.1	The Basic Relation	68
5.2	Identical Scattering Elements	68
5.3	Optically Diverse Scattering Elements	79
5.4	Optically Anisotropic Scattering Elements	81
5.5	Scattering Beyond the RGD Regime	82
6	<i>Scattering from a Dilute Solution at Zero Scattering Angle</i>	85
6.1	The Basic Relation	85
6.2	Monodisperse Solute, Identical Optically Isotropic Scattering Elements	87
6.3	Heterodisperse Solute, Identical Optically Isotropic Scattering Elements	89
6.4	Optically Diverse, Isotropic Scattering Elements	92
6.5	Optically Anisotropic Scattering Elements	94
7	<i>Scattering from Non Dilute Solution at Zero Scattering Angle</i>	94
7.1	The Basic Relation	94
7.2	Low Concentrations: the Third Virial Coefficient	95
7.3	Concentrated Solutions	96
7.4	Moderately Concentrated Solutions	100
8	<i>Scattering Dependence on q for Arbitrary Concentration</i>	104
8.1	The Basic Relation	104
8.2	Dilute to Low Concentrations	105
8.3	Concentrated Solutions	106
8.4	Moderately Concentrated Solutions	107
8.5	Behavior for a Charged Solute	112
9	<i>Special Topics</i>	114
9.1	Intermolecular Association in Polymer Solutions	114
9.2	Intermolecular Association in Micelle Solutions	118
9.3	Online Monitoring of Polymerization Systems	119
3	Disordered Phase and Self-Organization of Block Copolymer Systems	133
	<i>C. Giacomelli & R. Borsali</i>	
1	<i>Introduction</i>	135
2	<i>Disordered Phase</i>	136
2.1	RPA: Historical Sketch and Theoretical Developments	136
2.2	Experimental Evidence	141

2.3	Results and Discussion	143
2.4	Elastic Scattering	147
2.5	Dynamic Structure Factors	154
2.6	Extension to the Diblock Copolymer in the Melt Case	159
3	<i>Self-organization of Block Copolymers</i>	160
3.1	Self-Assembly in Bulk	162
3.2	Self-Assembly in Solution	168
4	<i>Conclusion</i>	183
4	Small-Angle Scattering from Surfactants and Block Copolymer Micelles	191
	<i>J. S. Pedersen</i>	
1	<i>Introduction</i>	192
2	<i>Thermodynamics and Packing Parameters</i>	194
3	<i>Scattering from Surfactant Micelles</i>	196
3.1	Basic Expressions and Homogeneous Models	196
3.2	Globular Core-Shell Micellar Models	203
3.3	Cylindrical Elongated and Disk-Like Core-Shell Micelles	207
3.4	Long Cylindrical and Worm-Like Micelles	208
4	<i>Block Copolymer Micelles</i>	217
4.1	Models with Non-Interacting Gaussian Chains	218
4.2	Models with Interacting Excluded-Volume Chains	219
4.3	Calculation of Radial Profiles	225
5	<i>Summary and Outlook</i>	227
5	Brush-Like Polymers	235
	<i>Y. Nakamura & T. Norisuye</i>	
1	<i>Introduction</i>	236
2	<i>Theoretical Models for Brush-Like Polymers</i>	238
2.1	Rigid Cylinders	239
2.2	WormLike Cylinders	242
2.3	Gaussian Brushes	252
2.4	Semi-Flexible Brushes	256

3	<i>Comparison Between Theory and Experiment</i>	260
3.1	Polymacromonomers	260
3.2	Combs and Centipedes	279
6	Polyelectrolytes-Theory and Simulations	287
	<i>C. Holm</i>	
1	<i>Introduction</i>	288
2	<i>The Cell Model</i>	289
3	<i>Solutions of the Cell Model</i>	292
3.1	Specification of the Cell Model	292
3.2	Poisson–Boltzmann Theory	294
3.3	Solution of the Poisson–Boltzmann Equation for the Cylindrical Case	295
3.4	Manning Condensation	297
3.5	Limiting Laws of the Cylindrical PB-Solution	297
4	<i>Additional Salt: The Donnan Equilibrium</i>	299
5	<i>Beyond PB</i>	302
5.1	Simulations of Osmotic Coefficients and Counterion Induced Attractions	304
5.2	Simulations of Rods of Finite Length	307
6	<i>Simulations of Polyelectrolyte Solutions in Good Solvent</i>	312
7	<i>Polyelectrolytes in Poor Solvent</i>	314
7.1	Introduction	314
7.2	Pearl-Necklace Conformation	315
7.3	Simulations	317
8	<i>Polyelectrolyte Networks</i>	325
8.1	Conformation in Poor Solvent	328
9	<i>Summary</i>	329
7	Dynamic Light Scattering	335
	<i>B. Chu</i>	
1	<i>Introduction</i>	336
1.1	Static Light Scattering	336

1.2	Dynamic Light Scattering and Laser Light Scattering	336
1.3	Laser Light Scattering and X-Ray/Neutron Scattering	337
2	<i>Single-Scattering Photon Correlation Spectroscopy</i>	339
2.1	Energy Transfer versus Momentum Transfer	339
2.2	Siegert Relation and Time Correlation Functions	340
2.3	Diffusions and Internal Motions	342
2.4	Practice of (Single-Scattering) Photon Correlation Experiments	344
3	<i>Photon Cross-Correlation Techniques</i>	348
3.1	Single Scattering versus Multiple Scattering	348
3.2	Photon Cross-Correlation Spectroscopy	350
4	<i>Practice of Photon Correlation and Cross-Correlation</i>	355
4.1	General Considerations [10]	355
4.2	Use of Optical Fibers	356
5	<i>Recent Developments</i>	361
5.1	Echo Dynamic Light Scattering	361
5.2	Phase Analysis Light Scattering (PALS)	364
6	<i>Final Remarks</i>	369
8	Light Scattering from Multicomponent Polymer Systems in Shear Fields: Real-time, In Situ Studies of Dissipative Structures in Open Nonequilibrium Systems	377
	<i>T. Hashimoto</i>	
1	<i>Introduction</i>	378
1.1	General Background	378
1.2	Principles of Rheo-Optics	379
2	<i>Shear Rheo-Optics</i>	380
2.1	Background of Shear Rheo-Optics	380
2.2	Shear-Induced Phase Transition: Two Opposing Phenomena, Mixing and Demixing	383
3	<i>Dynamical Asymmetry and Stress–Diffusion Coupling in Multicomponent Systems</i>	385
3.1	Dynamical Asymmetry Versus Dynamical Symmetry	385
3.2	Some Anticipated Effects of Dynamical Asymmetry on Self-Assembly in the Quiescent State	387

3.3	Basic Time-Evolution Equation and a Theoretical Analysis of the Early Stage Self-Assembly in Dynamically Asymmetric Systems	393
3.4	General Background on the Effects of Shear Flow on Self-Assembly of Both Dynamically Symmetric and Asymmetric Systems	397
4	Methodology	399
4.1	Simultaneous Measurements of Stress, Optical Microscopy, Light Scattering, Transmittance, Birefringence, etc	399
4.2	Examples: Simultaneous Measurements of Stress, Shear-SALS, and Shear-Microscopy	407
5	Shear-Induced Mixing	415
5.1	Shear-Rate Dependence of Steady-State Structures	416
5.2	Uniformity of Droplet Size in Regime II	419
5.3	String Structure in Regime IV	421
5.4	Shear-Induced Phase Transition	424
5.5	Small Molecules Versus Polymers	429
5.6	Tracing Back the Growth History of Phase-Separated Structures	432
5.7	Further Remarks	434
6	Shear-Induced Demixing (Phase Separation)	434
6.1	Observation of Shear-Induced Dissipative Structures	435
6.2	Origin of Shear-Induced Formation of Dissipative Structures	437
6.3	Shear-Rate Dependence	439
6.4	Time-Evolution of Transient Dissipative Structures	446
6.5	Further Remarks	450
6.6	Shear-Induced Dissipative Structures Formed for Semidilute Crystallizable Polymer Solutions	455
9	Light Scattering from Polysaccharides as Soft Materials	463
	<i>W. Burchard</i>	
1	Introduction	465
1.1	Polysaccharides are Archetypes for Soft Materials	465

2	<i>Some General Considerations</i>	468
2.1	Can Static Light Scattering Shed some Light onto the Reasons for Softness?	469
2.2	New Insight by Dynamic Light Scattering in Combination with Static Light Scattering	472
3	<i>Flexibility and Rigidity</i>	476
3.1	Pullulan	476
3.2	Homoglucans of the $\alpha(1-4)$ and $\beta(1-4)$ Type	480
4	<i>Single- and Multiple Helices. Exocellular Polysaccharides</i>	503
4.1	Xanthan	504
4.2	Gellan and Polysaccharides from the <i>Rhizobia</i> Family	509
4.3	Schizopolyan	515
4.4	ρ -Parameter and Second Virial Coefficient	517
4.5	Effects of Coulomb Charges and of Flexible Side Chains	518
5	<i>Gelation Versus Crystallization</i>	520
5.1	Alginates: Evidence for Bundle Formation	524
5.2	The Carrageenans: Evidence for Double Helix Formation	528
5.3	Summary of the Dispute on Double or Single Helices as Unimers	535
6	<i>Thickeners – What Inhibits Gel Formation?</i>	536
6.1	Galactomannans and Xyloglucans	537
6.2	Properties of Nonheated Tamarind Polysaccharides	541
6.3	Properties of Enzymatically Oxidized Tamarind Polysaccharides	543
7	<i>Branched Polysaccharides</i>	546
7.1	Random and Hyperbranched Types of Long Chain Branching	546
7.2	Experimental Verification	552
8	<i>Chain Dynamics</i>	564
8.1	Effects of Segmental Concentration in the Particle	565
8.2	Angular Dependence of the First Cumulant	568
8.3	Cluster Growth and Changes in Correlation Lengths in the Sol–Gel Transition	574
9	<i>Basic Relationships and Models</i>	581
9.1	Objectives of this Section	581

9.2	Static Light Scattering	582
9.3	Dynamic Light Scattering	589
10	Fluorescence Photobleaching Recovery	605
	<i>P. S. Russo, J. Qiu, N. Edwin, Y. W. Choi, G. J. Doucet, & D. Sohn</i>	
1	<i>Introduction</i>	607
2	<i>When to Choose FPR</i>	608
3	<i>Labeling the Macromolecule</i>	609
3.1	General Considerations	609
3.2	How much Dye to Attach	611
3.3	Cleanup	611
3.4	Validating the Labeled Macromolecule	613
3.5	Recipes	614
4	<i>Different Types of FPR Instruments</i>	615
4.1	General Considerations	615
4.2	Single-Beam FPR Devices	618
4.3	Two-Beam Instruments	624
5	<i>Applications</i>	627
5.1	Dilute Macromolecular Solutions	627
5.2	Concentrated Solutions and Suspensions	627
5.3	Probe Diffusion	628
5.4	Liquid Crystals	628
5.5	Gels	629
5.6	Polyelectrolytes	630
5.7	Thin Films and Surfaces	630
5.8	Other Applications	631
6	<i>Expected Future Trends</i>	632
11	Fluorescence Correlation Spectroscopy	637
	<i>E. Haustein & P. Schwille</i>	
1	<i>Introduction</i>	638
2	<i>Experimental Realization</i>	640
2.1	One-Photon Excitation	640

2.2	Two-Photon Excitation	642
2.3	Fluorescent Dyes	644
3	<i>Theoretical Concepts</i>	646
3.1	Autocorrelation Analysis	646
3.2	Cross-Correlation Analysis	655
4	<i>FCS Applications</i>	657
4.1	Concentration and Aggregation Measurements	657
4.2	Consideration of Residence Times: Determining Mobility and Molecular Interactions	658
4.3	Consideration of Cross-Correlation Amplitudes: A Direct Way to Monitor Association/Dissociation and Enzyme Kinetics	664
4.4	Consideration of Fast Flickering: Intramolecular Dynamics and Probing of the Microenvironment	671
5	<i>Conclusions and Outlook</i>	673
12	Forced Rayleigh Scattering – Principles and Application (Self Diffusion of Spherical Nanoparticles and Copolymer Micelles)	677
	<i>W. Schärtl</i>	
1	<i>Introduction</i>	678
2	<i>Basics of Forced Rayleigh Scattering</i>	679
2.1	Experimental Setup	679
2.2	Dynamical Processes Studied by FRS	682
3	<i>Applications</i>	689
3.1	Self Diffusion of Colloidal Particles in Highly Concentrated Colloidal Dispersions	690
3.2	Self Diffusion of Copolymer Micelles in a Homopolymer Melt	693
4	<i>Concluding Remarks</i>	701
	<i>Subject Index of Volume 1</i>	705
	<i>Author Index</i>	721

VOLUME 2

13 Small-Angle Neutron Scattering and Applications in Soft Condensed Matter	723
<i>I. Grillo</i>	
1 Introduction	725
2 Description of SANS Instruments	725
2.1 The Steady-State Instrument D22	726
2.2 The Time-of-Flight Instrument LOQ	727
2.3 Detectors for SANS Instruments	729
2.4 Sample Environments	731
3 Course of a SANS Experiment	731
3.1 Definition of the q-Vector	731
3.2 Choice of Configurations and Systematic Required Measurements	732
3.3 Conclusion	735
4 From Raw Data to Absolute Scaling	736
4.1 Determination of the Incident Flux Φ_0	737
4.2 Normalization with a Standard Sample	737
4.3 Solid Angle $\Delta\Omega(Q)$	739
4.4 Transmission	740
4.5 Multiple Scattering	743
4.6 Subtraction of Incoherent Background	745
4.7 Conclusion	746
5 Modeling of the Scattered Intensity	746
5.1 Rules of Thumb in Small-Angle Scattering	746
5.2 SLD, Contrast Variation, and Isotopic Labeling	749
5.3 Analytical Expressions of Particle Form Factors	753
5.4 Indirect Fourier Transform Method	759
5.5 Structure Factors of Colloids	761
6 Instrument Resolution and Polydispersity	763
6.1 Effect of the Beam Divergence and Size: θ Resolution	765
6.2 Effect of the λ Distribution	765
6.3 Smearing Examples	767
6.4 Polydispersity	769
6.5 Instrumental Resolution and Polydispersity	770

sample content of Soft-Matter Characterization

- [1,000 Places to See in the United States and Canada Before You Die \(Updated Edition\) here](#)
- [download online Consider Phlebas \(Culture, Book 1\)](#)
- [download online Gifts With No Giver: A Love Affair With Truth for free](#)
- [click Me, Who Dove into the Heart of the World: A Novel online](#)

- <http://www.uverp.it/library/1-000-Places-to-See-in-the-United-States-and-Canada-Before-You-Die--Updated-Edition-.pdf>
- <http://deltaphenomics.nl/?library/The-First-Philosophers--The-Presocratics-and-Sophists--Oxford-World-s-Classics-.pdf>
- <http://aircon.servicessingaporecompany.com/?lib/Welcome-to-Dead-House--Goosebumps--Book-1-.pdf>
- <http://toko-gumilar.com/books/Me--Who-Dove-into-the-Heart-of-the-World--A-Novel.pdf>