

Computational Modeling of Intelligent Soft Matter

Shape Memory Polymers and Hydrogels



- Mostafa Baghani
- Majid Baniasadi
- Yves Rémond



Table 3.1 Summary of 3D printer settings [15]

Printer setting	Value
Layer height	0.2 mm
Shell thickness	0.4 mm
Fill density	100%
Print speed	20 mm/s
Nozzle size	0.4 mm
Nozzle temperature	200 °C
Print bed temperature	50 °C
Filament diameter	1.75 mm



Figure 3.15 The samples produced by FDM method [15]

this method of production. Whereas the initial printing conditions can affect the mechanical properties, all samples are printed with the same conditions. 3D printer specifications are listed in Table 3.1.

Printed parts using additive manufacturing are depicted in Fig. 3.15. As one may observe, beams are printed using the FDM method with high quality, while each one has a total mass of 4.8 g.

3.3.2.3 The effect of 3D printing on shape memory polymer response

The FDM manufacturing method has a layered structure, which should be considered in the printing of SMP structures. Samples produced using this method normally do not have a homogeneous structure. As shown in Fig. 3.15, layers are distinguishable. This layered structure affects the thermomechanical properties of samples. To eliminate these effects, Rauch et al. [20] conducted some analogous thermomechanical experiments on several additives manufactured samples, before and after the annealing process. Shape memory properties of the annealed samples were improved in some annealing temperatures. Therefore to assure compatibility between the experiments and model predictions, sample production conditions should be the same in both the final structures and those prepared for calibration tests. For example, dynamic mechanical analysis (DMA) tests should be carried out on the printed samples.

Modeling Of Soft Matter

Sidney Yip



Modeling Of Soft Matter:

Computational Methods for the Multiscale Modeling of Soft Matter Paola Carbone, Nigel Clarke, 2025-12-01

Computational Methods for the Multiscale Modeling of Soft Matter offers a thorough overview of various simulation techniques essential for the study of soft materials. This book delves into numerical and molecular modeling methods spanning multiple time and length scales. It is particularly valuable for postgraduate students and researchers in materials science, computational physics, chemistry, and chemical engineering. Alongside fundamental theoretical concepts, the book includes numerous examples from a wide range of soft materials demonstrating how computational methods complement experimental characterization and significantly advance the manufacturing sector. Chapters illustrate how modeling techniques aid in interpreting experimental data and how experiments help parameterize models. The book also enables experts in one technique to transition to other tools more easily, which is increasingly important as multiscale tools become more sophisticated and accessible. It brings together diverse modeling approaches and applications, creating a comprehensive resource for understanding simulation methods for soft materials such as polymers, surfactants, and colloids. Introduces the theoretical underpinnings of a broad range of soft matter modeling techniques. Demonstrates the critical assessment of the strengths and weaknesses of each of the techniques, including comparisons with experimental data when possible. Provides example applications to guide the reader through how techniques can be used in practice. Modeling of Soft Matter

Maria-Carme T. Calderer, Eugene M. Terentjev, 2008-08-26. This IMA Volume in Mathematics and its Applications, MODELING OF SOFT MATTER, contains papers presented at a very successful workshop with the same title. The event, which was held on September 27–October 1, 2004, was an integral part of the 2004–2005 IMA Thematic Year on Mathematics of Materials and Macromolecules: Multiple Scales, Disorder, and Singularities. We would like to thank Maria Carme T. Calderer, School of Mathematics, University of Minnesota, and Eugene M. Terentjev, Cavendish Laboratory, University of Cambridge, for their superb role as workshop organizers and editors of the proceedings. We take this opportunity to thank the National Science Foundation for its support of the IMA Series. Editors: Douglas N. Arnold, Director of the IMA; Arnd Scheel, Deputy Director of the IMA. PREFACE. The physics of soft matter, in particular focusing on such materials as complex fluids, liquid crystals, elastomers, soft ferroelectrics, foams, gels, and particulate systems, is an area of intense interest and contemporary study. Soft matter plays a role in a wide variety of important processes and applications, as well as in living systems. For example, gel swelling is an essential part of many biological processes, such as motility mechanisms in bacteria, and the transport and absorption of drugs. Ferroelectrics, liquid crystals, and elastomers are being used to design ever-faster switching devices. Experiments of the last decade have provided a great deal of detailed information on structures and properties of soft matter.

Understanding Soft Condensed Matter Via Modeling and Computation Wenbing Hu, An-Chang Shi, 2011

Introduction. Role of modeling in soft matter physics. D. Frenkel. 1. Applications of density functional theory in soft condensed

matter H Lowen 2 Polymer phase separation M Muller 3 Self consistent field theory of block copolymers F Qiu A C Shi and Y Yang 4 Dynamic self consistent field theories for polymer blends and block copolymers T Kawakatsu 5 Molecular dynamics in crystallization of helical polymers crystal ordering and chirality selection T Yamamoto 6 Interplay of liquid liquid demixing and polymer crystallization W Hu 7 Elucidation of single molecular observation of a giant DNA C Y Shew and K Yoshikawa 8 Theoretical modeling of hydrogen bonding in macro molecular solutions the combination of quantum mechanics and molecular mechanics J Ma N Jiang and H Li 9 Exotic electrostatics unusual features of electrostatic interactions between macroions A Naji et al 10 Computer modeling of liquid crystals R Hashim 11 Drop dynamics in complex fluids J J Feng et al

Advanced Computer Simulation Approaches for Soft Matter Sciences I Christian Holm, Kurt Kremer, 2005-02-14 Soft matter science is nowadays an acronym for an increasingly important class of materials which ranges from polymers liquid crystals colloids up to complex macromolecular assemblies covering sizes from the nanoscale up the microscale Computer simulations have proven as an indispensable if not the most powerful tool to understand properties of these materials and link theoretical models to experiments In this first volume of a small series recognized leaders of the field review advanced topics and provide critical insight into the state of the art methods and scientific questions of this lively domain of soft condensed matter research *Advanced Computer Simulation Approaches for Soft Matter Sciences III* Christian Holm, Kurt Kremer, 2008-12-30 Soft matter is nowadays used to describe an increasingly important class of materials that encompasses polymers liquid crystals molecular assemblies building hierarchical structures organic inorganic hybrids and the whole area of colloidal science Common to all is that fluctuations and thus the thermal energy kT and Boltzmann entropy play an important role Soft then means that these materials are in a state of matter that is neither a simple liquid nor a hard solid of the type studied in hard condensed matter hence sometimes many types of soft matter are also named complex fluids Soft matter either of synthetic or biological origin has been a subject of physical and chemical research since the early finding of Staudinger that long chain molecules exist From then on synthetic chemistry as well as physical characterization underwent an enormous development One of the outcomes is the abundant presence of polymeric materials in our everyday life Nowadays methods developed for synthetic polymers are being more and more applied to biological soft matter The link between modern biophysics and soft matter physics is quite close in many respects This also means that the focus of research has moved from simple homopolymers to more complex structures such as branched objects heteropolymers random copolymers proteins polyelectrolytes amphiphiles and so on *Multi-scale Modeling of Soft Matter* Hussein M. Ezz Eldin, 2012 Generalized Dynamics of Soft-Matter Quasicrystals Tian-You Fan, Wenge Yang, Hui Cheng, Xiao-Hong Sun, 2022-01-17 This book highlights the mathematical models and solutions of the generalized dynamics of soft matter quasicrystals SMQ and introduces possible applications of the theory and methods Based on the theory of quasiperiodic symmetry and symmetry breaking the book treats the dynamics of individual quasicrystal systems by reducing them to nonlinear partial differential equations and then

provides methods for solving the initial boundary value problems in these equations The solutions obtained demonstrate the distribution deformation and motion of SMQ and determine the stress velocity and displacement fields The interactions between phonons phasons and fluid phonons are discussed in some fundamental materials samples The reader benefits from a detailed comparison of the mathematical solutions for both solid and soft matter quasicrystals gaining a deeper understanding of the universal properties of SMQ The second edition covers the latest research progress on quasicrystals in topics such as thermodynamic stability three dimensional problems and solutions rupture theory and the photonic band gap and its applications These novel chapters make the book an even more useful and comprehensive reference guide for researchers in condensed matter physics chemistry and materials sciences

Modeling of Biologically Motivated Soft Matter Systems Ilpo Vattulainen, Mikko Karttunen, Helsingin yliopisto. Helsinki Institute of Physics, 2004

Advances in Soft Matter Mechanics Shaofan Li, Bohua Sun, 2012-04-24 This book covers developments in soft matter mechanics and physics from the perspective of applied and computational mechanics It Includes a selection of recent works on the subject and details the application of soft matter mechanics on engineering problems

Generalized Dynamics of Soft-Matter Quasicrystals Tian-You Fan, 2017-10-14 The book systematically introduces the mathematical models and solutions of generalized hydrodynamics of soft matter quasicrystals SMQ It provides methods for solving the initial boundary value problems in these systems The solutions obtained demonstrate the distribution deformation and motion of the soft matter quasicrystals and determine the stress velocity and displacement fields The interactions between phonons phasons and fluid phonons are discussed in some fundamental materials samples Mathematical solutions for solid and soft matter quasicrystals are compared to help readers to better understand the featured properties of SMQ

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Multilevel Monte Carlo Simulation of Soft Matter Using Coarse-grained Models Paul Rohrbach, 2022

Multiscale Modeling of Biological and Soft Matter Emma Falck, 2005

Multiscale Modelling of Soft Matter, 2010

Computational Modeling of Intelligent Soft Matter Mostafa Baghani, Majid Baniassadi, Yves Rémond, 2023-02-15 Computational Modelling of Intelligent Soft Matter Shape Memory Polymers and Hydrogels covers the multiphysics response of various smart polymer materials such as temperature sensitive shape memory polymers and temperature chemosensitive hydrogels Several thermo chemo mechanical constitutive models for these smart polymers are outlined and their real world applications are highlighted The numerical counterpart of each introduced constitutive model is also presented empowering readers to solve practical problems requiring thermomechanical

responses of these materials as well as design and analyze real world structures made of them Introduces constitutive models based on continuum thermodynamics for intelligent soft materials Presents calibration methods for identifying material model parameters as well as finite element implementation of the featured models Allows readers to solve practical problems requiring thermomechanical responses from these materials as well as the design and analysis of real world structures made of them

Top-down Modeling of Hierarchically Structured Soft Matter Patrick Gemünden,2015 *Development of Coarse-grained Models for the Simulation of Soft Matter Systems* Thomas David Potter,2019

Advanced Computer Simulation Approaches for Soft Matter Sciences I Christian Holm,Kurt Kremer,2005-02-14 Soft matter science is nowadays an acronym for an increasingly important class of materials which ranges from polymers liquid crystals colloids up to complex macromolecular assemblies covering sizes from the nanoscale up the microscale Computer simulations have proven as an indispensable if not the most powerful tool to understand properties of these materials and link theoretical models to experiments In this first volume of a small series recognized leaders of the field review advanced topics and provide critical insight into the state of the art methods and scientific questions of this lively domain of soft condensed matter research

Handbook of Materials Modeling Sidney Yip,2007-11-17 This Handbook contains a set of articles introducing the modeling and simulation of materials from the standpoint of basic methods and studies The intent is to provide a compendium that is foundational to an emerging field of computational research a new discipline that may now be called Computational Materials This area has become sufficiently diverse that any attempt to cover all the pertinent topics would be futile Even with a limited scope the present undertaking has required the dedicated efforts of 13 Subject Editors to set the scope of nine chapters solicit authors and collect the manuscripts The contributors were asked to target students and non specialists as the primary audience to provide an accessible entry into the field and to offer references for further reading With no precedents to follow the editors and authors were only guided by a common goal to produce a volume that would set a standard toward defining the broad community and stimulating its growth The idea of a reference work on materials modeling surfaced in conversations with Peter Binfield then the Reference Works Editor at Kluwer Academic Publishers in the spring of 1999 The rationale at the time already seemed quite clear the field of computational materials research was taking off powerful computer capabilities were becoming increasingly available and many sectors of the scientific community were getting involved in the enterprise

Field-Theoretic Simulations in Soft Matter and Quantum Fluids Glenn H. Fredrickson,Kris T. Delaney,2023 Intro cover Titlepage copyright preface Acknowledgements contents Introduction Mathematical preliminaries Functional notation Functional calculus Gaussian integrals Delta functions and functionals Phenomenological field theories Molecularly informed field theories Auxiliary field representation Coherent states representation Continuous polymer chains Bosonic quantum field theory Classical Equilibrium Theory Particles to Fields Classical monatomic fluids Density explicit auxiliary field representation Auxiliary field representation Auxiliary fields

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