



# Solid State Nmr Spectroscopy

**Melinda J. Duer**



## **Solid State Nmr Spectroscopy:**

Solid-State NMR David C. Apperley, Robin K. Harris, Paul Hodgkinson, 2012-06-10 The power of nuclear magnetic resonance NMR for characterizing molecules dissolved in solution is widely acknowledged and NMR forms an essential component of undergraduate chemistry degrees However the application of NMR to the solid state is much less well appreciated This text sets out the fundamental principles of solid state NMR explaining how NMR in solids differs from that in solution showing how the various interactions of NMR can be manipulated to yield high resolution spectra and to give information on local structure and dynamics in solids This book aims to take some of the mystique out of solid state NMR by providing a comprehensible discussion of the methodology including the basic concepts and a practical guide to implementation of the experiments A basic knowledge of solution state NMR is assumed and is only briefly covered The text is intended for those in academia and industry expecting to use solid state NMR in their research and looking for an accessible introduction to the field It will also be valuable for non experts interested in learning how NMR can be usefully applied to solid systems Detailed mathematical treatments are delayed to a chapter at the mid point of the text and can be skipped Introductions to experiments and numerical simulations are provided to help link NMR results to experimental practice The different aspects of solid state NMR from basic pulse and acquire experiments to sophisticated techniques for the measurement of anisotropy information are presented Examples illustrate the wide variety of applications of the technique and its complementarity to other solid state characterization techniques such as X ray diffraction Various aspects of NMR crystallography are covered as are topics of motion in solids

**Multinuclear Solid-State Nuclear Magnetic Resonance of Inorganic Materials** Kenneth J.D. MacKenzie, M.E. Smith, 2002-04-26 Techniques of solid state nuclear magnetic resonance NMR spectroscopy are constantly being extended to a more diverse range of materials pressing into service an ever expanding range of nuclides including some previously considered too intractable to provide usable results At the same time new developments in both hardware and software are being introduced and refined This book covers the most important of these new developments With sections addressed to non specialist researchers providing accessible answers to the most common questions about the theory and practice of NMR asked by novices as well as a more specialised and up to date treatment of the most important areas of inorganic materials research to which NMR has application this book should be useful to NMR users whatever their level of expertise and whatever inorganic materials they wish to study

**Modern Methods in Solid-state NMR** Paul Hodgkinson, 2018-04-05 Solid state NMR covers an enormous range of material types and experimental techniques Although the basic instrumentation and techniques of solids NMR are readily accessible there can be significant barriers even for existing experts to exploring the bewildering array of more sophisticated techniques In this unique volume a range of experts in different areas of modern solid state NMR explain about their area of expertise emphasising the practical aspects of implementing different techniques and illustrating what questions can and cannot be

addressed Later chapters address complex materials showing how different NMR techniques discussed in earlier chapters can be brought together to characterise important materials types The volume as a whole focusses on topics relevant to the developing field of NMR crystallography the use of solids NMR as a complement to diffraction crystallography This book is an ideal complement to existing introductory texts and reviews on solid state NMR New researchers wanting to understand new areas of solid state NMR will find each chapter to be the equivalent to spending time in the laboratory of an internationally leading expert learning the hints and tips that make the difference between knowing about a technique and being ready to put it into action With no equivalent on the market it will be of interest to every solid state NMR researcher academic and postgraduate working in the chemical sciences Solid-State NMR in Materials Science Vladimir I. Bakhmutov, 2016-04-19 Solid state NMR is a powerful physical method widely applied in modern fundamental and applied science medicine and industry Its role is particularly valuable in materials chemistry due to the capability of solid state NMR to rapidly solve tasks connected with structural descriptions of complex systems on macro and or molecular levels and the i Multidimensional Solid-State NMR and Polymers Klaus Schmidt-Rohr, Hans Wolfgang Spiess, 2012-12-02 NMR spectroscopy is the most valuable and versatile analytical tool in chemistry While excellent monographs exist on high resolution NMR in liquids and solids this is the first book to address multidimensional solid state NMR Multidimensional techniques enable researchers to obtain detailed information about the structure dynamics orientation and phase separation of solids which provides the basis of a better understanding of materials properties on the molecular level Dramatic progress much of it pioneered by the authors has been achieved in this area especially in synthetic polymers Solid state NMR now favorably competes with well established techniques such as light x ray or neutron scattering electron microscopy and dielectric and mechanical relaxation The application of multidimensional solid state NMR inevitably involves use of concepts from different fields of science This book also provides the first comprehensive treatment of both the new experimental techniques and the theoretical concepts needed in more complex data analysis The text addresses spectroscopists and polymer scientists by treating the subject on different levels descriptive technical and mathematical approaches are used when appropriate It presents an overview of new developments with numerous experimental examples and illustrations which will appeal to readers interested in both the information content as well as the potential of solid state NMR The book also contains many previously unpublished details that will be appreciated by those who want to perform the experiments The techniques described are applicable not only to the study of synthetic polymers but to numerous problems in solid state physics chemistry materials science and biophysics Presents original theories and new perspectives on scattering techniques Provides a systematic treatment of the whole subject Gives readers access to previously unpublished material Includes extensive illustrations Solid State NMR Klaus Müller, Marco Geppi, 2021-06-23 Solid State NMR A thorough and comprehensive textbook covering the theoretical background experimental approaches and major applications of solid state NMR spectroscopy Nuclear Magnetic Resonance

NMR spectroscopy is a powerful non destructive technique capable of providing information about the molecular structure and dynamics of molecules. Alongside solution state NMR, a well established technique to study chemical structures and investigate physico chemical properties of molecules in solutions, solid state NMR (SSNMR) offers many exciting possibilities for the analysis of solid and soft materials across scientific fields. SSNMR shows unique capabilities for a detailed investigation of structural and dynamic properties of materials over wide space and time ranges. For this reason and thanks to significant advances in the past several years, the application of SSNMR to materials is rapidly increasing in disciplines such as chemistry, physics and materials and life sciences.

*Solid State NMR: Principles, Methods and Applications* offers a systematic introduction to the theory, methodological concepts and major experimental methods of SSNMR spectroscopy. Exploring the unique potential of SSNMR for the structural and dynamic characterization of soft and either amorphous or crystalline solid materials, this comprehensive textbook provides foundational knowledge and recent developments of SSNMR, covering physical and theoretical background, experimental methods and applications to pharmaceuticals, polymers, inorganic and hybrid materials, liquid crystals and model membranes. Written by two expert authors to ensure a clear and consistent presentation of the subject, this textbook includes a brief introduction to the historical aspects and broad theoretical background of solid state NMR spectroscopy. Provides helpful illustrations to explain the various SSNMR concepts and methods. Features accessible descriptive text with self consistent use of quantum mechanics. Covers the experimental aspects of SSNMR spectroscopy and in particular a description of many useful pulse sequences. Contains references to relevant literature.

*Solid State NMR: Principles, Methods and Applications* is the ideal textbook for university courses on SSNMR, advanced spectroscopies and a valuable single volume reference for spectroscopists, chemists and researchers in the field of materials.

Solid-State NMR IV: Methods and Applications of Solid-State NMR, 2011-12-21

Solid State NMR is a branch of Nuclear Magnetic Resonance which is presently experiencing a phase of strongly increasing popularity. The most striking evidence is the large number of contributions from Solid State Resonance at NMR meetings, approaching that of liquid state resonance. Important progress can be observed in the areas of methodological developments and applications to organic and inorganic matter. One volume devoted to more or less one of each of these areas has been published in the preceding three issues. This volume can be considered an addendum to this series. Selected methods and applications of Solid State NMR are featured in three chapters. The first one treats the recoupling of dipolar interactions in solids which are averaged by fast sample rotation. Following an introduction to effective Hamiltonians and Floquet theory, different types of experiment such as rotary resonance, dipolar chemical shift correlation spectroscopy, rotational resonance and multipulse recoupling are treated in the powerful Floquet formalism. In the second chapter, the different approaches to line narrowing of quadrupolar nuclei are reviewed in a consistent formulation of double resonance, DARR and dynamic angle spinning, DASH. Practical aspects of probe design are considered as well as advanced 2D experiments, sensitivity enhancement techniques and spinning sideband

manipulations The use of such techniques dramatically increases the number of nuclei which can be probed in high resolution NMR spectroscopy The final chapter describes new experimental approaches and results of structural studies of noncrystalline solids

**Current Developments in Solid State NMR Spectroscopy** Norbert Müller, Perunthiruthy K. Madhu, 2013-04-17 Why to apply solid state NMR By now we should have learned that NMR is mainly used for the study of molecules in solution while x ray diffraction is the method of choice for solids Based on this fact the two recent NMR Nobel prizes went indeed into the liquid phase my own one eleven years ago and particularly the most recent one to Kurt Wuthrich His prize is beyond any doubts very well justified His contribution towards the study of biomolecules in solution in their native or almost native environment is truly monumental We all will profit from it indirectly when one of our future diseases will be cured with better drugs based on the insightful knowledge gained through liquid state NMR Two fields of NMR are still left out of the Nobel Prize game magnetic resonance imaging MRI and solid state NMR The disrespect for MRI in Stockholm is particularly difficult to understand but this is not a subject to be discussed at the present place Solid state NMR is the third of the three great fields of NMR powerful already today and very promising for the near future

**Solid State NMR Spectroscopy** Melinda J. Duer, 2008-04-15 This book is for those familiar with solution state NMR who are encountering solid state NMR for the first time It presents the current understanding and applications of solid state NMR with a rigorous but readable approach making it easy for someone who merely wishes to gain an overall impression of the subject without details This dual requirement is met through careful construction of the material within each chapter The book is divided into two parts Fundamentals and Further Applications The section on Fundamentals contains relatively long chapters that deal with the basic theory and practice of solid state NMR The essential differences and extra scope of solid state NMR over solution state is dealt with in an introductory chapter The basic techniques that all chapters rely on are collected into a second chapter to avoid unnecessary repetition later Remaining chapters in the Fundamentals part deal with the major areas of solid state NMR which all solid state NMR spectroscopists should know about Each begins with an overview of the topic that puts the chapter in context The basic principles upon which the techniques in the chapter rely are explained in a separate section Each of these chapters exemplifies the principles and techniques with the applications most commonly found in current practice The Further Applications section contains a series of shorter chapters which describe the NMR techniques used in other more specific areas The basic principles upon which these techniques rely will be expounded only if not already in the Fundamentals part

Solid State NMR Jerry C. C. Chan, 2011-10-12 Dipolar Recoupling by Niels Chr Nielsen Lasse A Strass and Anders B Nielsen Solid State NMR Techniques for the Structural Determination of Amyloid Fibrils by Jerry C C Chan Solid State  $^{19}\text{F}$  NMR of Peptides in Native Membranes by Katja Koch Sergii Afonin Marco Ieronimo Marina Berditsch and Anne S Ulrich Probing Quadrupolar Nuclei by Solid State NMR Spectroscopy Recent Advances by Christian Fernandez and Marek Pruski Solid State NMR of Porous Materials Zeolites and Related Materials by Hubert Koller

and Mark Wei Solid State NMR of Inorganic Semiconductors by James P Yesinowski      *Introduction to Solid-State NMR Spectroscopy* Melinda J. Duer, 2005-07-29 Introduction to Solid State NMR Spectroscopy is written for undergraduate and graduate students of chemistry either taking a course in advanced or solid state nuclear magnetic resonance spectroscopy or undertaking research projects where solid state NMR is likely to be a major investigative technique It will also serve as a practical introduction in industry where the techniques can provide new or complementary information to supplement other investigative techniques By covering solid state NMR spectroscopy in a clear straightforward and approachable way with detailed descriptions of the major solid state NMR experiments focussing on what the experiments do and what they tell the researcher this book will serve as an ideal introduction to the subject These descriptions are backed up by separate mathematical explanations for those who wish to gain a more sophisticated quantitative understanding of the phenomena With additional coverage of the practical implementation of solid state NMR experiments integrated into the discussion this book will be essential reading for all those using or about to use solid state NMR spectroscopy Dr Melinda Duer is a senior lecturer in the Department of Chemistry at the University of Cambridge Cambridge UK      **Introduction to Solid-State NMR Spectroscopy** Duer, 2010-03-01      **Solid-State NMR I Methods** B. Blümich, 2012-12-06 1 A R Grimmer Berlin FRG B Bl mich Aachen FRG Introduction to Solid State NMR 2 F Laupretre Paris France High Resolution <sup>13</sup>C NMR Investigations of Local Dynamics in Bulk Polymers at Temperatures Below and Above the Glass Transition Temperature 3 D Raftery Philadelphia PA B F Chmelka Santa Barbara CA Xenon NMR Spectroscopy 4 G Fleischer Leipzig FRG F Fajarsa Mainz FRG NMR as a Generalized Incoherent Scattering Experiment 5 P Bl mler B Bl mich Mainz FRG NMR Imaging of Solids      **New Techniques in Solid-State NMR** Jacek Klinowski, 2004-12-10 With contributions by numerous experts      *Solid-State NMR III Organic Matter* Bernhard Blümich, 2012-12-06 Solid State NMR is a branch of Nuclear Magnetic Resonance which is presently experiencing a phase of strongly increasing popularity The most striking evidence is the large number of contributions from Solid State Resonance at NMR meetings approaching that of liquid state resonance Important progress can be observed in three areas Methodological developments applications to inorganic matter and applications to organic matter These developments are intended to be captured in three volumes in this series each of them being devoted to more or less one of these areas The present volume on Solid State NMR III is devoted mainly to organic matter The recent developments of deuteron NMR and their applications are reviewed in the first chapter Crosspolarization MAS and dynamic angle spinning are being explored for enhancement of information and sensitivity In addition to the analysis of classical relaxation times and modern 2D spectra detailed dynamic information becomes accessible from investigations of the relaxation time anisotropies The second chapter examines cross polarization in static and rotating solids under conditions of spin diffusion and thermal motion The underlying dipole dipole interaction is further exploited by the techniques described in the third chapter for studies of polymer polymer miscibility Short range techniques are discriminated from long range techniques based on spin

diffusion The use of these techniques is illustrated by a case study of PMMA/PVF blends The last chapter addresses novel methods and applications of two dimensional exchange NMR for investigations of relative molecular orientations polymer morphology molecular dynamics and macroscopic molecular order

**Solid State NMR Studies of Biopolymers** Anne E. McDermott, Tatyana Polenova, 2010-09-20 The content of this volume has been added to eMagRes formerly Encyclopedia of Magnetic Resonance the ultimate online resource for NMR and MRI The field of solid state NMR of biological samples ssNMR has blossomed in the past 5-10 years and a cohesive overview of the technology is needed for new practitioners in industry and academia This title provides an overview of Solid State NMR methods for studying structure dynamics and ligand binding in biopolymers and offers an overview of RF pulse sequences for various applications including not only a systematic catalog but also a discussion of theoretical tools for analysis of pulse sequences Practical examples of biochemical applications are included along with a detailed discussion of the many aspects of sample preparation and handling that make spectroscopy on solid proteins successful About EMR Handbooks eMagRes Handbooks The Encyclopedia of Magnetic Resonance up to 2012 and eMagRes from 2013 onward publish a wide range of online articles on all aspects of magnetic resonance in physics chemistry biology and medicine The existence of this large number of articles written by experts in various fields is enabling the publication of a series of EMR Handbooks eMagRes Handbooks on specific areas of NMR and MRI The chapters of each of these handbooks will comprise a carefully chosen selection of articles from eMagRes In consultation with the eMagRes Editorial Board the EMR Handbooks eMagRes Handbooks are coherently planned in advance by specially selected Editors and new articles are written together with updates of some already existing articles to give appropriate complete coverage The handbooks are intended to be of value and interest to research students postdoctoral fellows and other researchers learning about the scientific area in question and undertaking relevant experiments whether in academia or industry Have the content of this Handbook and the complete content of eMagRes at your fingertips Visit [www.wileyonlinelibrary.com/ref/eMagRes](http://www.wileyonlinelibrary.com/ref/eMagRes) View other eMagRes publications here

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**NMR Spectroscopy of Biological Solids** A. Ramamoorthy, 2005-09-22 Over the past decade a myriad of techniques have shown that solid state nuclear magnetic resonance NMR can be used in a broad spectrum of applications with exceptionally impressive results Solid state NMR results can yield high resolution details on the structure and function of many important biological solids including viruses fibril formin

*Solid State NMR Spectroscopy* Melinda J. Duer, 2008 This book is for those familiar with solution state NMR who are encountering solid state NMR for the first time It presents the current understanding and applications of solid state NMR with a rigorous but readable approach making it easy for



someone wh     **Solid-state NMR Spectroscopy of Inorganic Materials** John J. Fitzgerald, American Chemical Society. Meeting, 1999 This book strikes a balance between state of the art solid state NMR techniques and the applications of these techniques to problems in materials science The applications focus on modern inorganic materials such as metal oxides catalysts zeolites glasses ceramics semiconductors ion conductors superconductors and composites The book features chapters on multiple quantum MAS NMR dynamic angle spinning NMR for quadrupolar nuclides and two dimensional NMR methods It includes an introductory chapter that provides an a thorough and integrated overview of the field complete with numerous references

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