

NanoScience and Technology

Srinivasan Gopalakrishnan  
Saggam Narendar

# Wave Propagation in Nanostructures

Nonlocal Continuum Mechanics  
Formulations



Springer

# Wave Propagation In Nanostructures Nonlocal Continuum Mechanics Formulations Nanoscience And Technology

**Farzad Ebrahimi, Ali Dabbagh**



## **Wave Propagation In Nanostructures Nonlocal Continuum Mechanics Formulations Nanoscience And Technology:**

*Wave Propagation in Nanostructures* Srinivasan Gopalakrishnan, Saggam Narendar, 2013-09-10 *Wave Propagation in Nanostructures* describes the fundamental and advanced concepts of waves propagating in structures that have dimensions of the order of nanometers. The book is fundamentally based on non local elasticity theory which includes scale effects in the continuum model. The book predominantly addresses wave behavior in carbon nanotubes and Graphene structures although the methods of analysis provided in this text are equally applicable to other nanostructures. The book takes the reader from the fundamentals of wave propagation in nanotubes to more advanced topics such as rotating nanotubes, coupled nanotubes and nanotubes with magnetic field and surface effects. The first few chapters cover the basics of wave propagation, different modeling schemes for nanostructures and introduce non local elasticity theories which form the building blocks for understanding the material provided in later chapters. A number of interesting examples are provided to illustrate the important features of wave behavior in these low dimensional structures. *Nanotechnology* Muhammad Bilal Tahir, Muhammad Rafique, Muhammad Sagir, 2021-05-24 This book presents the basic and fundamental aspects of nanomaterials, its types and classifications with respect to different factors. It contains methods of preparation and characterization of unique nanostructured materials. Consisting of six chapters, this book appeals to a wide readership from academia and industry professionals and is also useful to undergraduate and graduate students focusing on nanotechnology and nanomaterials, sustainable chemistry, energy conversion and storage, environmental protection, optoelectronics, sensors and surface and interface science. It also appeals to readers who wish to know about the design of new types of materials with controlled nanostructures. *Nanomechanics of Structures and Materials* Krzysztof Kamil Żur, S Ali Faghidian, 2024-07-24 *Nanomechanics of Structures and Materials* highlights and compares the advantages and disadvantages of diverse modeling and analysis techniques across a wide spectrum of different nanostructures and nanomaterials. It focuses on the behavior of media with nanostructural features where the classic continuum theory ceases to hold and augmented continuum theories such as nonlocal theory, gradient theory of elasticity and the surface elasticity model should be adopted. These generalized frameworks tailored to address the intricate characteristics inherent at the nanoscale level are discussed in depth and their application to a variety of different materials and structures including graphene shells, arches, nanobeams, carbon nanotubes, porous materials and more is covered. Outlines the advantages and limitations of size dependent continuum theories and modeling techniques when studying fundamental problems in the nanomechanics of structures and materials. Discusses various analytical and numerical tools for identifying nanomechanical defects in structures. Explores a diverse array of structures and materials including graphene shells, arches, nanobeams, carbon nanotubes and porous materials. **Non-classical Wave Dynamics of Ultrathin Structures** S. Narendar, 2012-10-23

Research Paper postgraduate from the year 2012 in the subject Engineering Aerospace Technology grade Indian Institute of Science course Aerospace Engineering language English abstract In this paper the nonlocal elasticity theory has been incorporated into classical 1D rod model to capture unique features of the rod like structures at Nanoscale which are considered as ultra thin structures under the umbrella of continuum mechanics theory The strong effect of the nanoscale has been obtained which leads to substantially different wave behaviors of nanoscale rods from those of macroscopic rods Nonlocal bar model is developed for nanorods The analysis shows that the wave characteristics are highly over estimated by the classical rod model which ignores the effect of small length scale The studies also show that the nonlocal scale parameter introduces certain band gap region in axial wave mode where no wave propagation occurs This is manifested in the spectrum curves as the region where the wavenumber tends to infinite or wave speed tends to zero These results are also compared with the Born Karman model and also with the second and fourth order strain gradient models The results can provide useful guidance for the study and design of the next generation of nanodevices that make use of the wave propagation properties of single walled carbon nanotubes

**Wave Propagation Analysis of Smart Nanostructures** Farzad Ebrahimi, Ali Dabbagh, 2019-12-06 Wave Propagation Analysis of Smart Nanostructures presents a mathematical framework for the wave propagation problem of small scale nanobeams and nanoplates manufactured from various materials including functionally graded composites smart piezoelectric materials smart magneto electro elastic materials smart magnetostrictive materials and porous materials In this book both classical and refined higher order shear deformation beam and plate hypotheses are employed to formulate the wave propagation problem using the well known Hamilton s principle Additionally the influences of small scale nanobeams on the mechanical behaviors of nanostructures are covered using both nonlocal elasticity and nonlocal strain gradient elasticity theories Impacts of various terms such as elastic springs of elastic foundation damping coefficient of viscoelastic substrate different types of temperature change applied electric voltage and magnetic potential and intensity of an external magnetic field on the dispersion curves of nanostructures are included in the framework of numerous examples

*Terahertz Wave Characteristics of Nanostructures* Saggam Narendar, 2012

**Wavelet And Wave Analysis As Applied To Materials With Micro Or Nanostructure** Carlo Cattani, Jarema Jaroslavich Rushchitski, 2007-09-06 This seminal book unites three different areas of modern science the micromechanics and nanomechanics of composite materials wavelet analysis as applied to physical problems and the propagation of a new type of solitary wave in composite materials nonlinear waves Each of the three areas is described in a simple and understandable form focusing on the many perspectives of the links among the three All of the techniques and procedures are described here in the clearest and most open form enabling the reader to quickly learn and use them when faced with the new and more advanced problems that are proposed in this book By combining these new scientific concepts into a unitary model and enlightening readers on this pioneering field of research readers will hopefully be inspired to explore the more advanced aspects of this promising scientific direction

The application of wavelet analysis to nanomaterials and waves in nanocomposites can be very appealing to both specialists working on theoretical developments in wavelets as well as specialists applying these methods and experiments in the mechanics of materials

*Wave Propagation in Materials for Modern Applications* Andrey Petrin, 2010-01-01 In the recent decades there has been a growing interest in micro and nanotechnology The advances in nanotechnology give rise to new applications and new types of materials with unique electromagnetic and mechanical properties This book is devoted to the modern methods in electrodynamics and acoustics which have been developed to describe wave propagation in these modern materials and nanodevices The book consists of original works of leading scientists in the field of wave propagation who produced new theoretical and experimental methods in the research field and obtained new and important results The first part of the book consists of chapters with general mathematical methods and approaches to the problem of wave propagation A special attention is attracted to the advanced numerical methods fruitfully applied in the field of wave propagation The second part of the book is devoted to the problems of wave propagation in newly developed metamaterials micro and nanostructures and porous media In this part the interested reader will find important and fundamental results on electromagnetic wave propagation in media with negative refraction index and electromagnetic imaging in devices based on the materials The third part of the book is devoted to the problems of wave propagation in elastic and piezoelectric media In the fourth part the works on the problems of wave propagation in plasma are collected The fifth sixth and seventh parts are devoted to the problems of wave propagation in media with chemical reactions in nonlinear and disperse media respectively And finally in the eighth part of the book some experimental methods in wave propagations are considered It is necessary to emphasize that this book is not a textbook It is important that the results combined in it are taken from the desks of researchers Therefore I am sure that in this book the interested and actively working readers scientists engineers and students will find many interesting results and new ideas

*Wave Propagation in Materials and Structures* Srinivasan Gopalakrishnan, 2016-11-03 This book focuses on basic and advanced concepts of wave propagation in diverse material systems and structures Topics are organized in increasing order of complexity for better appreciation of the subject Additionally the book provides basic guidelines to design many of the futuristic materials and devices for varied applications The material in the book also can be used for designing safer and more lightweight structures such as aircraft bridges and mechanical and structural components The main objective of this book is to bring both the introductory and the advanced topics of wave propagation into one text Such a text is necessary considering the multi disciplinary nature of the subject This book is written in a step by step modular approach wherein the chapters are organized so that the complexity in the subject is slowly introduced with increasing chapter numbers Text starts by introducing all the fundamental aspects of wave propagations and then moves on to advanced topics on the subject Every chapter is provided with a number of numerical examples of increasing complexity to bring out the concepts clearly The solution of wave propagation is computationally very

intensive and hence two different approaches namely the Finite Element method and the Spectral Finite method are introduced and have a strong focus on wave propagation The book is supplemented by an exhaustive list of references at the end of the book for the benefit of readers

**Wave Propagation in Materials for Modern Applications** Andrey Petrin, 2010-01-01 In the recent decades there has been a growing interest in micro and nanotechnology The advances in nanotechnology give rise to new applications and new types of materials with unique electromagnetic and mechanical properties This book is devoted to the modern methods in electrodynamics and acoustics which have been developed to describe wave propagation in these modern materials and nanodevices The book consists of original works of leading scientists in the field of wave propagation who produced new theoretical and experimental methods in the research field and obtained new and important results The first part of the book consists of chapters with general mathematical methods and approaches to the problem of wave propagation A special attention is attracted to the advanced numerical methods fruitfully applied in the field of wave propagation The second part of the book is devoted to the problems of wave propagation in newly developed metamaterials micro and nanostructures and porous media In this part the interested reader will find important and fundamental results on electromagnetic wave propagation in media with negative refraction index and electromagnetic imaging in devices based on the materials The third part of the book is devoted to the problems of wave propagation in elastic and piezoelectric media In the fourth part the works on the problems of wave propagation in plasma are collected The fifth sixth and seventh parts are devoted to the problems of wave propagation in media with chemical reactions in nonlinear and disperse media respectively And finally in the eighth part of the book some experimental methods in wave propagations are considered It is necessary to emphasize that this book is not a textbook It is important that the results combined in it are taken from the desks of researchers Therefore I am sure that in this book the interested and actively working readers scientists engineers and students will find many interesting results and new ideas

Nonlinear Waves in Elastic Media A.G. Kulikovskii, Elena I. Sveshnikova, 1995-08-31 Nonlinear Waves in Elastic Media explores the theoretical results of one dimensional nonlinear waves including shock waves in elastic media It is the first book to provide an in depth and comprehensive presentation of the nonlinear wave theory while taking anisotropy effects into account The theory is completely worked out and draws on 15 years of research by the authors one of whom also wrote the 1965 classic Magnetohydrodynamics Nonlinear Waves in Elastic Media emphasizes the behavior of quasitransverse waves and analyzes arbitrary discontinuity disintegration problems illustrating that the solution can be non unique a surprising result The solution is shown to be especially interesting when anisotropy and nonlinearity effects interact even in small amplitude waves In addition the text contains an independent mathematical chapter describing general methods to study hyperbolic systems expressing the conservation laws The theoretical results described in Nonlinear Waves in Elastic Media allow for the first time discovery and interpretation of many new peculiarities inherent to the general problem of discontinuous solutions and

so provide a valuable resource for advanced students and researchers involved with continuum mechanics and partial differential equations

Wave Propagation Giorgio Ferrarese, 2011-03-30

Static and Dynamic Problems of Nanobeams and Nanoplates Snehashish Chakraverty, Laxmidhar Behera, 2016

This book will deal with different sections associated with bending buckling and vibration of nanobeams and nanoplates along with systematic description of handling the complexities when nanoscales are considered The introduction includes basic ideas concerned with nanostructures the algorithms and iterations followed in numerical methods and introduction to beam and plate theories in conjunction with nonlocal elasticity theory applied in nanostructures Next the investigation of nanobeams and nanoplates subjected to different sets of boundary conditions based on various nonlocal theories will be included The varieties of physical and geometrical parameters that influence the bending buckling and vibration mechanisms will be summarized Finally effect of environments such as thermal environment Winkler Pasternak elastic foundations and non uniformity etc on the buckling and vibration mechanisms will be illustrated

*Wave Propagation in Dissipative Materials* B.D. Coleman, M.H. Gurtin, R.I. Herrera, C. Truesdell, 2012-12-06

Common experience reveals two basic aspects of wave propagation First while preserving their identity and travelling at definite speeds sounds finally die out Second weak sounds may combine to form strong noises Theories of acoustic propagation have succeeded in representing these aspects of experience separately but never combined as in nature The classical theories of sound in perfect fluids and elastic solids easily yield common speeds of propagation for plane infinitesimal disturbances but no damping Moreover within EULER S theory of the perfect fluid or its generalization the GREEN KIRCHHOFF KELVIN theory of finite elasticity weak waves may grow stronger and become shock waves which propagate according to more complicated but equally definite principles Effects of internal damping are easily added for theories of infinitesimal deformation but for finite motions a dead end was reached about sixty years ago Indeed in 1901 DUHEM proved that according to the NAVIER STOKES theory of fluids acceleration waves and waves of higher order cannot exist and for shock waves he claimed a similar result which has since been shown to be valid subject to certain qualifications So as to save the phenomena of sound and noise as was necessary if the NAVIER STOKES theory was to deserve the place proposed for it as a refinement upon EULER S theory DUHEM introduced the concept of quasi wave a region of rapid but continuous transition

*Wave Propagation in Elastic Media with Micro/Nano-Structures* G. L. Huang, 2010

**Wave Propagation in Elastic Media with Micro Nano Structures**

**Wave Propagation in Materials for Modern Applications** Andrey Petrin, 2010-01-01

In the recent decades there has been a growing interest in micro and nanotechnology The advances in nanotechnology give rise to new applications and new types of materials with unique electromagnetic and mechanical properties This book is devoted to the modern methods in electrodynamics and acoustics which have been developed to describe wave propagation in these modern materials and nanodevices The book consists of original works of leading scientists in the field of wave propagation who produced new theoretical and experimental methods in the research

field and obtained new and important results The first part of the book consists of chapters with general mathematical methods and approaches to the problem of wave propagation A special attention is attracted to the advanced numerical methods fruitfully applied in the field of wave propagation The second part of the book is devoted to the problems of wave propagation in newly developed metamaterials micro and nanostructures and porous media In this part the interested reader will find important and fundamental results on electromagnetic wave propagation in media with negative refraction index and electromagnetic imaging in devices based on the materials The third part of the book is devoted to the problems of wave propagation in elastic and piezoelectric media In the fourth part the works on the problems of wave propagation in plasma are collected The fifth sixth and seventh parts are devoted to the problems of wave propagation in media with chemical reactions in nonlinear and disperse media respectively And finally in the eighth part of the book some experimental methods in wave propagations are considered It is necessary to emphasize that this book is not a textbook It is important that the results combined in it are taken from the desks of researchers Therefore I am sure that in this book the interested and actively working readers scientists engineers and students will find many interesting results and new ideas



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In a fast-paced digital era where connections and knowledge intertwine, the enigmatic realm of language reveals its inherent magic. Its capacity to stir emotions, ignite contemplation, and catalyze profound transformations is nothing short of extraordinary. Within the captivating pages of **Wave Propagation In Nanostructures Nonlocal Continuum Mechanics Formulations Nanoscience And Technology** a literary masterpiece penned with a renowned author, readers embark on a transformative journey, unlocking the secrets and untapped potential embedded within each word. In this evaluation, we shall explore the book's core themes, assess its distinct writing style, and delve into its lasting impact on the hearts and minds of those that partake in its reading experience.

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web arsène lupin french pronunciation ʁɑsɛn lypɛ is a fictional gentleman thief and master of disguise created in 1905 by french writer maurice leblanc the character was first introduced in a series of short stories serialized in the magazine je sais tout the first story the arrest of arsène lupin was published on 15 july 1905

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