Acoustic Metamaterials And Wave Control Frontier Research In Computation And Mechanics Of Materials

Acoustics and Vibration of Mechanical Structures—AVMS-2017
Wave Dynamics, Mechanics and Physics of Microstructured Metamaterials
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SINGH KASEY

Acoustics and Vibration of Mechanical Structures—AVMS-2017 World Scientific
This book delivers a comprehensive and up-to-date treatment of practical applications of metamaterials, structured media, and conventional porous materials. With increasing levels of urbanization, a growing demand for motorized transport, and inefficient urban planning, environmental noise exposure is rapidly becoming a pressing societal and health concern. Phononic and sonic crystals, acoustic metamaterials, and metasurfaces can revolutionize noise and vibration control and, in many cases, replace traditional porous materials for these applications. In this collection of contributed chapters, a group of international researchers reviews the essentials of acoustic wave propagation in metamaterials and porous absorbers with viscothermal losses, as well as the most recent advances in the design of acoustic metamaterial absorbers. The book features a detailed theoretical introduction describing commonly used modelling techniques such as plane wave expansion, multiple scattering theory, and the transfer matrix method. The following

chapters give a detailed consideration of acoustic wave propagation in viscothermal fluids and porous media, and the extension of this theory to non-local models for fluid saturated metamaterials, along with a description of the relevant numerical methods. Finally, the book reviews a range of practical industrial applications, making it especially attractive as a white book targeted at the building, automotive, and aeronautic industries.

Wave Dynamics, Mechanics and Physics of Microstructured Metamaterials Springer

This book presents a collection of chapters on the current problems of the theory of dynamical processes in generalized continua and structures, and has been compiled to commemorate the 70th birthday of Prof. Dmitry Indeitsev – a leading specialist in the field of dynamical processes in solids, fluids and structures. It discusses various applications related to Prof. Indeitsev's contributions, including various discrete and continuous dynamic models of structures and media, as well as a number of dynamical processes in generalized media.

Acoustic Waves in Periodic Structures, Metamaterials, and Porous Media Springer

Phononic crystals and acoustic metamaterials are heterogeneous materials that enable manipulation of elastic waves. An important characteristic of these heterogeneous systems is their ability to tailor the propagation of elastic waves due to the existence of band gaps -- frequency ranges of strong wave attenuation. In this Thesis, I report discoveries of three new types of band gaps: i) Band gaps induced by geometric frustration in periodic acoustic channel networks; ii) Band gap induced by high connectivity in periodic beam lattices; and iii) Topological band gaps in gyroscopic phononic crystals that protects one-way edge waves. The investigations presented here shed new light on the rich dynamic properties of phononic crystals and acoustic metamaterials, opening avenues for new strategies to control mechanical waves in elastic systems.

Automotive Acoustics Conference 2015 Springer Nature

Engineering practice has revealed that innovative technologies' structural applications require new design concepts related to developing materials with mechanical properties tailored for construction purposes. This would allow the efficient use of engineering materials. The efficiency can be understood in a simplified and heuristic manner as the optimization of performance and the proper combination of structural components, leading to the consumption of the least amount of natural resources. The solution to the eco-optimization problem, based on the adequate characterization of the materials, will enable implementing environmentally friendly engineering principles when the efficient use of advanced materials guarantees the required structural safety. Identifying fundamental relationships between the structure of advanced composites and their physical properties is the focus of this book. The collected articles explore the development of sustainable composites with valorized manufacturability corresponding to Industrial Revolution 4.0 ideology. The publications, amongst others, reveal that the application of nano-particles improves the mechanical performance of composite materials; heat-resistant aluminium composites ensure the safety of overhead power transmission lines; chemical additives can detect the impact of temperature on concrete structures. This book demonstrates that

construction materials' choice has considerable room for improvement from a scientific viewpoint, following heuristic approaches.

Handbook of Micromechanics and Nanomechanics CRC Press

The 3rd International Conference on Material Engineering and Manufacturing (ICMEM 2019) and the 4th International Conference on Materials Engineering and Nanotechnology (ICMEN 2019) were dedicated to new research developments and advances in the fields of material engineering, nanotechnology, and manufacturing technologies. We hope that the presented collection of scientific papers will be interesting and useful for many engineers and researchers.

Frontier Research in Computati

The purpose of this dissertation is to model, simulate and design metamaterials for underwater sound and elastic wave control. Water-based acoustic metamaterials usually suffer from low transmission due to the impedance mismatch with water; elastic metamaterials also suffer from this issue not only because of the impedance mismatch to the host medium, but also due to the multiple wave types existing simultaneously at the interface between the inclusions and the background matrix. This dissertation focuses on the theoretical modeling and computational design of broadband high transmission metamaterial devices. Several related topics are discussed. (1) A semi-analytical method for band diagram computation of three dimensional (3D) lattices is developed in this dissertation. It has significant applications in 3D pentamode metamaterial design. (2) Acoustic transmission through gratings of parallel plates displaying anisotropic inertia is also investigated. It is found that broadband impedance matching and total acoustic transmission can be achieved if the plane wave is incident at the so-called intromission angle ±[theta]i. (3) Elastic wave transmission through aligned parallel plates are studied theoretically by considering the coupling between different types of waves in elastic half-spaces and in the plates. The results are applied in the design and optimization of elastic metamaterials. (4) Elastic waves in fluid-saturated anisotropic double porosity medium of cubic symmetry is also investigated as an extension to Biot's theory of poroelasticity. A third dilatational wave is predicted in a double porosity fluid-saturated gyroid structure and demonstrated using finite element (FEM) simulations. The second part of the dissertation focuses on several novel devices for manipulating acoustic and elastic waves. Metallic metamaterial unit cells of the hexagonal lattice type are employed to mimic the quasi-static acoustic properties of water, and to provide a certain range of index for gradient index (GRIN) metamaterial design. The advantage of such a metamaterial element is that it has in-plane isotropy and only allows one propagating mode within the frequency range of interest. (5) A flat GRIN lens is designed by tuning the unit cells to obey a modified hyperbolic secant index profile, such that a normally incident plane wave transmits through the lens efficiently and focuses at a single point. The side lobe suppression and aberration reduction abilities of the GRIN lens are demonstrated in both simulations and in underwater experiments (carried out by colleagues at the University of Texas at Austin). (6) An elastic shell based metamaterial element, which provides a wider range of index at the quasi-static regime, is

adopted in the design of a conformal lens for converting a monopole source to highly directional plane wave beams. The required bulk modulus and density distributions are derived using conformal transformation acoustics mapping from a unit circle to a triangle. The mapping function is adjustable which allows energy radiating preferentially into different directions. Two collimation devices are designed using fluid-saturated shells and demonstrated using full wave FEM simulations. (7) A novel class of elastic metamaterial composed of "effective plates" are introduced to design high transmission devices for elastic waves. Several devices for focusing SV-wave, splitting P- and SV-waves, and asymmetric transmission are designed and demonstrated using full wave FEM simulations.

Physics and Engineering Explorations Springer Nature

This volume provides an overview of the recent advances in the field of paper microfluidics, whose innumerable research domains have stimulated considerable efforts to the development of rapid, cost-effective and simplified point-of-care diagnostic systems. The book is divided into three parts viz. theoretical background of paper microfluidics, fabrication techniques for paper-based devices, and broad applications. Each chapter of the book is self-explanatory and focuses on a specific topic and its relation to paper microfluidics and starts with a brief description of the topic’s physical background, essential definitions, and a short story of the recent progress in the relevant field. The book also covers the future outlook, remaining challenges, and emerging opportunities. This book shall be a tremendous up-to-date resource for researchers working in the area globally.

A Practitioner's Handbook for Sound Intensity Springer

In the last few decades, metamaterials have revolutionized the ways in which waves are controlled, and applied in physics and practical situations. The extraordinary properties of metamaterials, such as their locally resonant structure with deep subwavelength band gaps and their ranges of frequency where propagation is impossible, have opened the way to a host of applications that were previously unavailable. Acoustic metamaterials have been able to replace traditional treatments in several sectors, due to their better performance in targeted and tunable frequency ranges with strongly reduced dimensions. This is a training book composed of nine chapters written by experts in the field, giving a broad overview of acoustic metamaterials and their uses. The book is divided into three parts, covering the state-of-the-art, the fundamentals and the real-life applications of acoustic metamaterials.

Advanced Materials Springer Nature

This book provides an in-depth analysis as well as an overview of phononic crystals. This book discusses numerous techniques for the analysis of phononic crystals and covers, among other material, sonic and ultrasonic structures, hypersonic planar structures and their characterization, and novel applications of phononic crystals. This is an ideal book for those working with micro and nanotechnology, MEMS (microelectromechanical systems), and acoustic devices. This book also: Presents an introduction to the fundamentals and properties of phononic crystals Covers simulation techniques for the analysis of phononic crystals Discusses sonic and ultrasonic, hypersonic and planar, and three-dimensional phononic crystal structures Illustrates how phononic crystal structures are being deployed in communication

systems and sensing systems

Bianisotropy in Passive Acoustic Metamaterials World Scientific

Metamaterials are composite materials whose dynamic microstructure results in macroscopically observable properties beyond those available in nature. The emergence of metamaterials has enabled unprecedented control of electromagnetic, elastodynamic, and acoustic wave propagation and has led to technologies including invisibility cloaks, super- and hyper-lenses, and subwavelength bandgaps. These effects are made possible through the hidden degrees of freedom afforded by the dynamic microstructure. Analytically, the macroscopically observed parameters are the result of a dynamic homogenization procedure using weighted field averages over a representative volume element of the composite. After performing the homogenization procedure, constitutive relations reveal the dependencies between macroscopic fields and metamaterial properties. Recent research has demonstrated that dynamic homogenization results in constitutive relations that are coupled, which is not the case for most traditional materials. This general effect is well-known in electromagnetism and is known as bianisotropy, but the analogous effect in elastodynamics and acoustics was discovered more recently and is also often referred to as Willis coupling. However, most current homogenization schemes are modeled to determine macroscopic properties in the same form as traditional materials and therefore do not account for coupled constitutive relations. Additionally in the absence of embedded sources, metamaterial parameters are non-unique, which allows for macroscopic descriptions that only include traditional parameters or traditional parameters and coupling parameters. For acoustic metamaterials, the traditional properties are density and compressibility. The additional coupling parameters result in macroscopic momentum density and volume strain fields that are coupled due to both being dependent on macroscopic acoustic particle velocity and pressure fields. This dissertation explores the analogs between bianisotropy in electromagnetism, elastodynamics, and acoustics and the consequences of neglecting these effects on the physical interpretation of acoustic metamaterial parameters. The analogs are used to provide a qualitative understanding of the origin of coupling parameters, and a multiple scattering homogenization procedure is derived to demonstrate coupling due to asymmetry and nonlocal effects. Additionally, the restrictions of causality, passivity, and reciprocity on acoustic metamaterial parameters are derived, and it is demonstrated that macroscopic descriptions that neglect bianisotropy in one-dimensional acoustic metamaterials do not in general satisfy these restrictions.

Generalized Models and Non-classical Approaches in Complex Materials 1 ScholarlyEditions

Metamaterials have attracted enormous interests from both physics and engineering communities in the past 20 years, owing to their powerful ability in manipulating electromagnetic waves. However, the functionalities of traditional metamaterials are fixed at the time of fabrication. To control the EM waves dynamically, active components are introduced to the meta-atoms, yielding active metamaterials. Recently, a special kind of active metamaterials, digital coding and programmable metamaterials, are proposed, which can achieve dynamically controllable

functionalities using field programmable gate array (FPGA). Most importantly, the digital coding representations of metamaterials set up a bridge between the digital world and physical world, and allow metamaterials to process digital information directly, leading to information metamaterials. In this Element, we review the evolution of information metamaterials, mainly focusing on their basic concepts, design principles, fabrication techniques, experimental measurement and potential applications. Future developments of information metamaterials are also envisioned.

Advances in Nonlinear Dynamics John Wiley & Sons

As an emerging interdisciplinary field, acoustic metamaterials have generated increasing interests for diverse engineering applications, from noise and vibration alleviation to super-resolution imaging. The book starts with a simple mass-in-mass chain model to illustrate the concept of negative mass due to internal resonance and its impact on wave transmission. The practical transformation theory for controlling acoustic waves is explained. Pentamode acoustic metamaterials and related cloaking design are also included. Finally, the book ends up with the sub-diffraction-limited acoustic imaging based on metamaterials. This comprehensive title gives a broad overview on different aspects of acoustic metamaterials with a balance of theory and experiment. It is not only a collection of the authors' original works to these interesting topics, but also the main achievements in this field. Researchers, academics, professionals and graduate students in the fields of mechanical engineering, condensed matter physics, new materials, applied physics, and general readers of noise and vibration controls, will find this exciting book to be an indispensible reference material.

The Rise of Smart Cities CRC Press

Requiring no advanced knowledge of wave propagation, An Introduction to Metamaterials and Waves in Composites focuses on theoretical aspects of metamaterials, periodic composites, and layered composites. The book gives novices a platform from which they can start exploring the subject in more detail. After introducing concepts related to elasticity, acoustics, and electrodynamics in media, the text presents plane wave solutions to the equations that describe elastic, acoustic, and electromagnetic waves. It examines the plane wave expansion of sources as well as scattering from curved interfaces, specifically spheres and cylinders. The author then covers electrodynamic, acoustic, and elastodynamic metamaterials. He also describes examples of transformations, aspects of acoustic cloaking, and applications of pentamode materials to acoustic cloaking. With a focus on periodic composites, the text uses the Bloch-Floquet theorem to find the effective behavior of composites in the quasistatic limit, presents the quasistatic equations of elastodynamic and electromagnetic waves, and investigates Brillouin zones and band gaps in periodic structures. The final chapter discusses wave propagation in smoothly varying layered media, anisotropic density of a periodic layered medium, and quasistatic homogenization of laminates. This book provides a launch pad for research into elastic and acoustic metamaterials. Many of the ideas presented have yet to be realized experimentally—the book encourages readers to explore these ideas and bring them to technological maturity.

Advances in Machine Learning Research and Application: 2011 Edition Springer

Manufacturing Techniques for Materials: Engineering and Engineered provides a cohesive and comprehensive overview of the following: (i) prevailing and emerging trends, (ii) emerging developments and related technology, and (iii) potential for the commercialization of techniques specific to manufacturing of materials. The first half of the book provides the interested reader with detailed chapters specific to the manufacturing of emerging materials, such as additive manufacturing, with a valued emphasis on the science, technology, and potentially viable practices specific to the manufacturing technique used. This section also attempts to discuss in a lucid and easily understandable manner the specific advantages and limitations of each technique and goes on to highlight all of the potentially viable and emerging technological applications. The second half of this archival volume focuses on a wide spectrum of conventional techniques currently available and being used in the manufacturing of both materials and resultant products. Manufacturing Techniques for Materials is an invaluable tool for a cross-section of readers including engineers, researchers, technologists, students at both the graduate level and undergraduate level, and even entrepreneurs.

An Introduction to Metamaterials and Waves in Composites Springer

This book is to provide readers with up-to-date advances in applied and interdisciplinary engineering science and technologies related to nonlinear dynamics, vibration, control, robotics, and their engineering applications, developed in the most recent years. All the contributed chapters come from active scholars in the area, which cover advanced theory & methods, innovative technologies, benchmark experimental validations and engineering practices. Readers would benefit from this state-of-the-art collection of applied nonlinear dynamics, in-depth vibration engineering theory, cutting-edge control methods and technologies, and definitely find stimulating ideas for their on-going R&D work. This book is intended for graduate students, research staff and scholars in academics, and also provides useful hand-up guidance for professional and engineers in practical engineering missions.

Theory and Design of Acoustic Metamaterials Butterworth-Heinemann

This book is the first of 2 special volumes dedicated to the memory of Gérard Maugin. Including 40 papers that reflect his vast field of scientific activity, the contributions discuss non-standard methods (generalized model) to demonstrate the wide range of subjects that were covered by this exceptional scientific leader. The topics range from micromechanical basics to engineering applications, focusing on new models and applications of well-known models to new problems. They include micro–macro aspects, computational endeavors, options for identifying constitutive equations, and old problems with incorrect or non-satisfying solutions based on the classical continua assumptions.

Negative Refraction, Imaging, Lensing and Cloaking Cambridge University Press

Bringing together contributions on a diverse range of topics, this text explores the relationship between discrete and continuum mechanics as a tool to model new and complex metamaterials. Providing a comprehensive bibliography and historical review of

the field, it covers mechanical, acoustic and pantographic metamaterials, discusses Naive Model Theory and Lagrangian discrete models, and their applications, and presents methods for pantographic structures and variational methods for multidisciplinary modeling and computation. The relationship between discrete and continuous models is discussed from both mathematical and engineering viewpoints, making the text ideal for those interested in the foundation of mechanics and computational applications, and innovative viewpoints on the use of discrete systems to model metamaterials are presented for those who want to go deeper into the field. An ideal text for graduate students and researchers interested in continuum approaches to the study of modern materials, in mechanical engineering, civil engineering, applied mathematics, physics, and materials science.

Shock Mitigation and Wave Control Using Elastic Metamaterial Structures John Wiley & Sons

This book is a collection of papers presented at Acoustics and Vibration of Mechanical Structures 2017 – AVMS 2017 – highlighting the current trends and state-of-the-art developments in the field. It covers a broad range of topics, such as noise and vibration control, noise and vibration generation and propagation, the effects of noise and vibration, condition monitoring and vibration testing, modeling, prediction and simulation of noise and vibration, environmental and occupational noise and vibration, noise and vibration attenuators, as well as biomechanics and bioacoustics. The book also presents analytical, numerical and experimental techniques for evaluating linear and non-linear noise and vibration problems (including strong nonlinearity). It is primarily intended for academics, researchers and professionals, as well as PhD students in various fields of the acoustics and vibration of mechanical structures.

Information Metamaterials MDPI

Advances in Machine Learning Research and Application: 2011 Edition is a ScholarlyEditions™ eBook that delivers timely, authoritative, and comprehensive information about Machine Learning. The editors have built Advances in Machine Learning Research and Application: 2011 Edition on the vast information databases of ScholarlyNews.™ You can expect the information about Machine Learning in this eBook to be deeper than what you can access anywhere else, as well as consistently reliable, authoritative, informed, and relevant. The content of Advances in Machine Learning Research and Application: 2011 Edition has been produced by the world’s leading scientists, engineers, analysts, research institutions, and companies. All of the content is from peer-reviewed sources, and all of it is written, assembled, and edited by the editors at ScholarlyEditions™ and available exclusively from us. You now have a source you can cite with authority, confidence, and credibility. More information is available at http://www.ScholarlyEditions.com/.

Sonic and Photonic Crystals CRC Press

Sound-Power Flow: A practitioner's handbook for sound intensity is a guide for practitioners and research scientists in different areas of acoustical science. There are three fundamental quantities in acoustics: sound pressure, sound particle velocity, and sound intensity. This book is about sound intensity and demonstrates the advantages and uses of acoustical sensing compared with other forms of sensing. It describes applications

such as: measuring total sound power; directional hearing of humans and mammals; echolocation; measuring sound-power flow in ducts; and uses of non-contact, focused, high-frequency, pulse-echo ultrasonic probes. This book presents computational approaches using standard mathematics, and relates these to the measurement of sound-power flow in air and water. It also uses linear units rather than logarithmic units – this making computation in acoustics simpler and more accessible to advanced mathematics and computing. The book is based on work by the author and his associates at General Motors, the University of Mississippi, and Sonometrics.