Nonlinear Waves

Nonlinear Wave and Plasma Structures in the Auroral and Subauroral Geospace presents a comprehensive examination of the self-consistent processes leading to multiscale electromagnetic and plasma structures in the magnetosphere and ionosphere near the plasmapause, particularly in the auroral and subauroral geospace. It utilizes simulations and a large number of relevant in situ measurements conducted by the most recent satellite missions, as well as ground-based optical and radar observations to verify the conclusions and analysis. Including several case studies of observations related to prominent geospacer events, the book also provides experimental and numerical results throughout the chapters to further enhance understanding of how the same physical mechanisms produce different phenomena at different regions of the near-Earth space environment. Additionally, the comprehensive description of mechanisms responsible for space weather effects will give readers a broad foundation of wave and particle processes in the near-Earth magnetosphere. As such, Nonlinear Wave and Plasma Structures in the Auroral and Subauroral Geospace Nonlinear Wave and Plasma Structures in the Auroral and Subauroral Geospace is a cutting-edge reference for space physicists looking to better understand plasma physics in geospace. Presents a unified approach to wave and particle phenomena occurring in the auroral and subauroral geospace Summarizes the most current theoretical concepts related to the generation of the large-scale electric field near the plasmapause by flows of hot plasma from the reconnection site Includes case studies of the observations related to the most "famous events during the last 20 years as well as a large number of experimental and numerical results illustrated throughout the text

The Boussinesq equation is the first model of surface waves in shallow water that considers the nonlinearity and the dispersion and their interaction as a reason for wave stability known as the Boussinesq paradigm. This balance bears solitary waves that behave like quasi-particles. At present, there are some Boussinesq-like equations. The prevalent part of the known analytical and numerical solutions, however, relates to the 1d case while for multidimensional cases, almost nothing is known so far. An exclusion is the solutions of the Kadomtsev-Petviashvili equation. The difficulties originate from the lack of known analytic initial conditions and the nonintegrability in the multidimensional case. Another problem is which kind of nonlinearity will keep the temporal stability of localized solutions. The system of coupled nonlinear Schroedinger equations known as well as the vector Schroedinger equation is a soliton supporting dynamical system. It is considered as a model of light propagation in Kerr isotropic media. Along with that, the phenomenology of the equation opens a prospect of investigating the quasi-particle behavior of the interacting solitons. The initial polarization of the vector Schroedinger equation and its evolution evolves from the vector nature of the model. The existence of exact (analytical) solutions usually is rendered to simpler models, while for the vector Schroedinger equation such solutions are not known. This determines the role of the numerical schemes and approaches. The vector Schroedinger equation is a spring-board for combining the reduced integrability and conservation laws in a discrete level. The experimental observation and measurement of ultrashort pulses in waveguides is a hard job and this is the reason and stimulus to create mathematical models for computer simulations, as well as reliable algorithms for treating the governing equations. Along with the nonintegrability, one more problem appears here - the multidimensionality and necessity to split and linearize the operators in the appropriate way.

Presents in a systematic and unified manner the ray method, in its various forms, for studying nonlinear wave propagation in situations of physical interest, essentially fluid dynamics and plasma physics.

Nonlinear physics is a well-established discipline in physics today, and this book offers a comprehensive account of the basic soliton theory and its applications. Although primarily mathematical, the theory for nonlinear phenomena in practical environment

Non-Linear Waves in Dispersive Media

Linear and Nonlinear Waves

Nonlinear Waves in Integrable and Non-integrable Systems

Nonlinear Waves, Solitons and Chaos

Spectral and Dynamical Stability of Nonlinear Waves

"Waves and Structures in Nonlinear Nondispersive Media: General Theory and Applications to Nonlinear Acoustics" is devoted completely to nonlinear structures. The general theory is given here in parallel with mathematical models. Many concrete examples illustrate the general analysis of Part I. Part II is devoted to applications to nonlinear acoustics, including specific nonlinear models and exact solutions, physical mechanisms of nonlinearity, sawtooth-shaped wave propagation, self-action phenomena, nonlinear resonances and engineering application (medicine, nondestructive testing, geophysics, etc.). This book is designed for graduate and postgraduate students studying the theory of nonlinear waves of various physical nature. It may also be useful as a handbook for engineers and researchers who encounter the necessity of taking nonlinear wave effects into account of their work. Dr. Gurbatov S.N. is the head of Department, and Vice Rector for Research of Nizhny Novgorod State University. Dr. Rudenko O.V. is the Full member of Russian Academy of Sciences, the head of Department at Moscow University and Professor at BTH (Sweden). Dr. Saichev A.I. is the Professor at the Faculty of Radiophysics of Nizhny Novgorod State University, Professor of ETH Zürich.

TIlis volume contains the contributions to the Euromech Colloquium No. 241 on Nonlinear Waves in Active Media at the Institute of Cybernetics of the Estonian Academy of Sciences, Tallinn, Estonia, USSR, September 27-30, 1988. The Co-chairmen of the Euromech Colloquium felt that it would be a good service to the community to publish these proceedings. First, the topic itself dealing with various wave processes with energy influx is extremely interesting and attracted a much larger number of participants than usual - a clear sign of its importance to the scientific community. Second, Euromech No. 241 was actually the first Euromech Colloquium held in the Soviet Union and could thus be viewed as a milestone in the extending scientific contacts between East and West. At the colloquium 50 researchers working in very different branches of sci ence met to lecture on their results and to discuss problems of common interest. An introductory paper by I. Engelbrecht presents the common motivation and background of the topics covered. Altogether 36 speakers presented their lectures, of which 30 are gathered here. The remaining six papers which will appear elsewhere are listed on page X. In addition, three contributions by authors who could not attend the colloquium are included. The two lectures given by A.S. Mikhailov, V.S. Davydov and V.S. Zykov are here published as one long paper.

The book details a few of the novel methods developed in the last few years for studying various aspects of nonlinear wave systems. The introductory chapter provides a general overview, thematically linking the objects described in the book. Two chapters are devoted to wave systems possessing resonances with linear frequencies (Chapter 2) and with nonlinear frequencies (Chapter 3). In the next two chapters modulation instability in the KdV-type of equations is studied using rigorous mathematical methods (Chapter 4) and its possible connection to freak waves is investigated (Chapter 5). The book goes on to demonstrate how the choice of the Hamiltonian (Chapter 6) or the Lagrangian (Chapter 7) framework allows us to gain a deeper insight into the properties of a specific wave system. The final chapter discusses problems encountered when attempting to verify the theoretical predictions using numerical or laboratory experiments. All the chapters are illustrated by ample constructive examples demonstrating the applicability of these novel methods and approaches to a wide class of evolutionary dispersive PDEs, e.g. equations from Benjamin-Oro, Boussinesq, Hasegawa-Mima, KdV-type, Klein-Gordon, NLS-type, Serre, Shamel , Whitham and Zakharov. This makes the book interesting for professionals in the fields of nonlinear physics, applied mathematics and fluid mechanics as well as students who are studying these subjects. The book can also be used as a basis for a one-semester lecture course in applied mathematics or mathematical physics.

The second edition of a highly successful book on nonlinear waves, solitons and chaos.

Homogenization and Asymptotic Approaches

Nonlinear Periodic Waves and Their Modulations

Ray Methods for Nonlinear Waves in Fluids and Plasmas

Theory, Computer Simulation, Experiment

Nonlinear Wave Processes in Acoustics

Linear and Nonlinear WavesJohn Wiley & Sons

Non-Linear Waves in Dispersive Media introduces the theory behind such topic as the gravitational waves on water surfaces. Some limiting cases of the theory, wherein proof of an asymptotic class is necessary and generated, are also provided. The first section of the book discusses the notion of linear approximation. This discussion is followed by some samples of dispersive media. Examples of stationary waves are also examined. The book proceeds with a discussion of waves of envelopes. The concept behind this subject is from the application of the methods of geometrical optics to non-linear theory. A section on non-linear waves with slowly varying parameters is given at the end of the book, along with a discussion of the evolution of electro-acoustic waves in plasma with negative dielectric permittivity. The gravitational waves on fluid surfaces are presented completely. The text will provide valuable information for physicists, mechanical engineers, students, and researchers in the field of optics, acoustics, and hydrodynamics.

Based in part on a lecture course, this book gives an authoritative and up-to-date overview of recent research on the behaviour of waves in crystalline solids. It covers aspects of plasticity, fracture, and nonlinear wave propagation.

Travelling wave processes and wave motion are of great importance in many areas of mechanics, and nonlinearity also plays a decisive role there. The basic mathematical models in this area involve nonlinear partial differential equations, and predictability of behaviour of wave phenomena is of great importance. Beside fluid dynamics and gas dynamics, which have long been the traditional nonlinear scienes, solid mechanics is now taking an ever increasing account of nonlinear effects. Apart from plasticity and fracture mechanics, nonlinear elastic waves have been shown to be of great importance in many areas, such as the study of impact, nondestructive testing and seismology. These lectures offer a thorough account of the fundamental theory of nonlinear deformation waves, and in the process offer an up to date account of the current state of research in the theory and practice of nonlinear waves in solids.

Nonlinear Wave Dynamics

Structure And Dynamics Of Nonlinear Waves In Fluids: Proceedings Of The Iutam/isimm Symposium

Dynamical Systems and Nonlinear Waves in Plasmas

Nonlinear Wave and Plasma Structures in the Auroral and Subauroral Geospace

A Course on Nonlinear Waves

Waves are essential phenomena in most scientific and engineering disciplines, such as electromagnetism and optics, and different mechanics including fluid, solid, structural, quantum, etc. They appear in linear and nonlinear systems. Some can be observed directly and others are not. The features of the waves are usually described by solutions to either linear or nonlinear partial differential equations, which are fundamental to the students and researchers.Generic equations, describing wave and pulse propagation in linear and nonlinear systems, are introduced and analyzed as initial/boundary value problems. These systems cover the general properties of non-dispersive and dispersive, uniform and non-uniform, with/without dissipations. Methods of analyses are introduced and illustrated with analytical solutions. Wave-wave and wave-particle interactions ascribed to the nonlinearity of media (such as plasma) are discussed in the final chapter.This interdisciplinary textbook is essential reading for anyone in above mentioned disciplines. It was prepared to provide students with an understanding of waves and methods of solving wave propagation problems. The presentation is self-contained and should be read without difficulty by those who have adequate preparation in classic mechanics. The selection of topics and the focus given to each provide essential materials for a lecturer to cover the bases in a linear/nonlinear wave course.

This book addresses the peculiarities of nonlinear wave propagation in waveguides and explains how the stratification depends on the waveguide and confinement. An example of this is an optical fibre that does not allow light to pass through a density jump. The book also discusses propagation in the nonlinear regime, which is characterized by a specific waveform and amplitude, to demonstrate so-called solitonic behaviour. In this case, a wave may be strongly localized, and propagates with a weak change in shape. In the waveguide case there are additional contributions of dispersion originating from boundary or asymptotic conditions. Offering concrete guidance on solving application problems, this essentially (more than twice) expanded second edition includes various aspects of guided propagation of nonlinear waves as well as new topics like solitonic behaviour of one-mode and multi-mode excitation and propagation and plasma waveguides, propagation peculiarities of electromagnetic waves in metamaterials, new types of dispersion, dissipation, electromagnetic waveguides, planetary waves and plasma waves interaction.The key feature of the solitonic behaviour is based on Coupled KdV and Coupled NS systems. The systems are derived in this book and solved numerically with the proof of stability and convergence. The domain wall dynamics of ferromagnetic microwaveguides and Bloch waves in nano-waveguides are also included with some problems of magnetic momentum and charge transport.

The outcome of a conference held in East Carolina University in June 1982, this book provides an account of developments in the theory and application of nonlinear waves in both fluids and plasmas. Twenty-two contributors from eight countries here cover all the main fields of research, including nonlinear water waves, K-dV equations, solitions and inverse scattering transforms, stability of solitary waves, resonant wave interactions, nonlinear evolution equations, nonlinear wave phenomena in plasmas, recurrence phenomena in nonlinear wave systems, and the structure and dynamics of envelope solitions in plasmas.

Leading scientists discuss the most recent physical and experimental results in the physics of Bose-Einstein condensate theory, the theory of nonlinear lattices (including quantum and nonlinear lattices), and nonlinear optics and photonics. Classical and quantum aspects of the dynamics of nonlinear waves are considered. The contributions focus on the Gross-Pitaevskii equation and on the quantum nonlinear Schrödinger equation. Recent experimental results on atomic condensates and hydrogen bonded systems are reviewed. Particular attention is given to nonlinear matter waves in periodic potential.

Generalized Korteweg-de Vries, Nonlinear Schrödinger, Wave and Schrödinger Maps

Linear And Nonlinear Wave Propagation

Impact of Inhomogeneity and Accompanying Effects

Nonlinear Waves in Elastic Media

Nonlinear Waves in Elastic Crystals

Big Nate is the star goalie of his school's soccer team, and he is tasked with defending his goal and saving the day against Jefferson Middle School, their archrival.

This is an introductory book about nonlinear waves. It focuses on two properties that various different wave phenomena have in common, the "nonlinearity" and "dispersion", and explains them in a style that is easy to understand for first-time students. Both of these properties have important effects on wave phenomena. Nonlinearity, for example, makes the wave lean forward and leads to wave breaking, or enables waves with different wavenumber and frequency to interact with each other and exchange their energies. Dispersion, for example, sorts irregular waves containing various wavelengths into gentler wavetrains with almost uniform wavelengths as they propagate, or cause a difference between the propagation speeds of the wave waveform and the wave energy. Many phenomena are introduced and explained using water waves as an example, but this is just a tool to make it easier to draw physical images. Most of the phenomena introduced in this book are common to all nonlinear and dispersive waves. This book focuses on understanding the physical aspects of wave phenomena, and requires very little mathematical knowledge. The necessary minimum knowledges about Fourier analysis, perturbation method, dimensional analysis, the governing equations of water waves, etc. are provided in the text and appendices, so even second- or third-year undergraduate students will be able to fully understand the contents of the book and enjoy the fan of nonlinear wave phenomena without relying on other books.

For more than 200 years, the Fourier Transform has been one of the most important mathematical tools for understanding the dynamics of linear wave trains. Nonlinear Ocean Waves and the Inverse Scattering Transform presents the development of the nonlinear Fourier analysis of measured space and time series, which can be found in a wide variety of physical settings including surface water waves, internal waves, and equatorial Rossby waves. This revolutionary development will allow hyperfast numerical modelling of nonlinear waves, greatly advancing our understanding of oceanic surface and internal waves. Nonlinear Fourier analysis is based upon a generalization of linear Fourier analysis referred to as the inverse scattering transform, the fundamental building block of which is a generalized Fourier series called the Riemann theta function. Elucidating the art and science of implementing these functions in the context of physical and time series analysis is the goal of this book. Presents techniques and methods of the inverse scattering transform for data analysis Geared toward both the introductory and advanced reader venturing further into mathematical and numerical analysis Suitable for classroom teaching as well as research

The need for tsunami research and analysis has grown dramatically following the devastating tsunami of December 2004, which affected Southern Asia. This book pursues a detailed theoretical and mathematical analysis of the fundamentals of tsunamis, especially the evolution and dynamics of tsunamis and other great waves. Of course, it includes specific measurement results from the 2004 tsunami, but the emphasis is on the nature of the waves themselves and their links to nonlinear phenomena.

Physics of Nonlinear Waves

Nonlinear Ocean Waves and the Inverse Scattering Transform

An Introductory Course

Nonlinear Waves in Inhomogeneous and Hereditary Media

The aim of this book is to give a self-contained introduction to the mathe matical analysis and physical explanations of some basic nonlinear wave phe nomena. This volume grew out of lecture notes for graduate courf;!es which I gave at the University of Alberta, the University of Saskatchewan, ·and Texas A&M University. As an introduction it is not intended to be exhaustive iQ its choice of material, but rather to convey to interested readers a basic; yet practical, methodology as well as some of the more important results obtained since the 1950's. Although the primary purpose of this volume is to serve as a textbook, it should be useful to anyone who wishes to understand or conduct research into nonlinear waves. Here, for the first time, materials on X-ray crystallography and the forced Korteweg-de Vries equation are incorporated naturally into a textbook on non linear waves. Another characteristic feature of the book is the inclusion of four symbolic calculation programs written in MATHEMATICA. They emphasize outcomes rather than numerical methods and provide certain symbolic and nu merical results related to solitons. Requiring only one or two commands to run, these programs have user-friendly interfaces. For example, to get the explicit expression of the 2-soliton of the Korteweg-de Vries equation, one only needs to type in soliton[2] when using the program solipac.m.

The first part of the book provides an introduction to key tools and techniques in dispersive equations: Strichartz estimates, bilinear estimates, modulation and adapted function spaces, with an application to the generalized Korteweg-de Vries equation and the Kadomtsev-Petviashvili equation. The energy-critical nonlinear Schrödinger equation, global solutions to the defocusing problem, and scattering are the focus of the second part. Using this concrete example, it walks the reader through the induction on energy technique, which has become the essential methodology for tackling large data critical problems. This includes refined/inverse Strichartz estimates, the existence and almost periodicity of minimal blow up solutions, and the development of long-time Strichartz inequalities. The third part describes wave and Schrödinger maps. Starting by building heuristics about multilinear estimates, it provides a detailed outline of this very active area of geometric/dispersive PDE. It focuses on concepts and ideas and should provide graduate students with a stepping stone to this exciting direction of research.

Now in an accessible paperback edition, this classic work is just as relevant as when it first appeared in 1974, due to the increased use of nonlinear waves. It covers the behavior of waves in two parts, with the first part addressing hyperbolic waves and the second addressing dispersive waves. The mathematical principles are presented along with examples of specific cases in communications and specific physical fields, including flood waves in rivers, waves in glaciers, traffic flow, sonic booms, blast waves, and ocean waves from storms.

This unique book aims to treat a class of nonlinear waves that are reflected from the boundaries of media of finite extent. It involves both standing (unforced) waves and resonant oscillations due to external periodic forcing. The waves are both hyperbolic and dispersive. To achieve this aim, the book develops the necessary understanding of linear waves and the mathematical techniques of nonlinear waves before dealing with nonlinear waves in bounded media. The examples used come mainly from gas dynamics, water waves and viscoelastic waves.

General Theory and Applications to Nonlinear Acoustics

Dispersive Equations and Nonlinear Waves

Nonlinear Waves In Bounded Media: The Mathematics Of Resonance

Introduction to the Mathematical Physics of Nonlinear Waves

Linear and Nonlinear Waves in Microstructured Solids

This symposium brought together mechanicians, physicists and applied mathematicians to discuss the interdisciplinary topic of nonlinear wave motion, which displays effects that give rise to a multitude of unanswered questions. Nonlinear waves in fluids in particular display all the prominent nonlinear phenomena such as chaos, turbulence and pattern formation. Amongst the topics emphasized in these proceedings are: travelling fronts, solitary waves and periodic waves (dissipative and conservative); temporal and spatial asymptotics of perturbations of waves; bifurcations, stability and local dynamics of waves; interaction between different waves, and between waves and the mean flow; wave breaking, nonlinear effects on focussing and diffraction; modulation and envelope equations (their derivation and validity); and numerical and experimental results.

This IMA Volume in Mathematics and its Applications MICROLOCAL ANALYSIS AND NONLINEAR WAVES is based on the proceedings of a workshop which was an integral part of the 1988- 1989 IMA program on "Nonlinear Waves". We thank Michael Beals, Richard Melrose and Jeffrey Rauch for organizing the meeting and editing this proceedings volume. We also take this opportunity to thank the National Science Foundation whose financial support made the workshop possible. A vner Friedman Willard Miller, Jr. PREFACE Microlocal analysis is natural and very successful in the study of the propagation of linear hyperbolic waves. For example consider the initial value problem Pu = f E e'(RHd), supp f C {t ;::: O} u = 0 for t

This book uses asymptotic methods to obtain simple approximate analytic solutions to various problems within mechanics, notably wave processes in heterogeneous materials. Presenting original solutions to common issues within mechanics, this book builds upon years of research to demonstrate the benefits of implementing asymptotic techniques within mechanical engineering and material science. Focusing on linear and nonlinear wave phenomena in complex micro-structured solids, the book determines their global characteristics through analysis of their internal structure, using homogenization and asymptotic procedures, in line with the latest thinking within the field. The book ' s cutting-edge methodology can be applied to optimal design, non-destructive control and in deep seismic sounding, providing a valuable alternative to widely used numerical methods. Using case studies, the book covers topics such as elastic waves in nonhomogeneous materials, regular and chaotic dynamics based on continualisation and discretization and vibration localization in 1D Linear and Nonlinear lattices. The book will be of interest to students, research engineers, and professionals specialising in mathematics and physics as well as mechanical and civil engineering.

This book unifies the dynamical systems and functional analysis approaches to the linear and nonlinear stability of waves. It synthesizes fundamental ideas of the past 20+ years of research, carefully balancing theory and application. The book isolates and methodically develops key ideas by working through illustrative examples that are subsequently synthesized into general principles. Many of the seminal examples of stability theory, including orbital stability of the KdV solitary wave, and asymptotic stability of viscous shocks for scalar conservation laws, are treated in a textbook fashion for the first time. It presents spectral theory from a dynamical systems and functional analytic point of view, including essential and absolute spectra, and develops general nonlinear stability results for dissipative and Hamiltonian systems. The structure of the linear eigenvalue problem for Hamiltonian systems is carefully developed, including the Krein signature and related stability indices. The Evans function for the detection of point spectra is carefully developed through a series of frameworks of increasing complexity. Applications of the Evans function to the Orientation index, edge bifurcations, and large domain limits are developed through illustrative examples. The book is intended for first or second year graduate students in mathematics, or those with equivalent mathematical maturity. It is highly illustrated and there are many exercises scattered throughout the text that highlight and emphasize the key concepts. Upon completion of the book, the reader will be in an excellent position to understand and contribute to current research in nonlinear stability.

Nonlinear Waves in Active Media

Waveguide Propagation of Nonlinear Waves

International Series of Monographs in Natural Philosophy

Complexity and Simplicity

Microlocal Analysis and Nonlinear Waves

The theory of nonlinear wave equations in the absence of shocks began in the 1960s. Despite a great deal of recent activity in this area, some major issues remain unsolved, such as sharp conditions for the global existence of solutions with arbitrary initial data, and the global phase portrait in the presence of periodic solutions and traveling waves. This book, based on lectures presented by the author at George Mason University in January 1989, seeks to present the sharpest results to date in this area. The author surveys the fundamental qualitative properties of the solutions of nonlinear wave equations in the absence of boundaries and shocks. These properties include the existence and regularity of global solutions, strong and weak singularities, asymptotic properties, scattering theory and stability of solitary waves. Wave equations of hyperbolic, Schrodinger, and KdV type are discussed, as well as the Yang-Mills and the Vlasov-Maxwell equations. The book offers readers a broad overview of the field and an understanding of the most recent developments, as well as the status of some important unsolved problems. Intended for mathematicians and physicists interested in nonlinear waves, this book would be suitable as the basis for an advanced graduate-level course.

Nonlinear Waves in Integrable and Nonintegrable Systems presents cutting-edge developments in the theory and experiments of nonlinear waves. Its comprehensive coverage of analytical and numerical methods for nonintegrable systems is the first of its kind. This book is intended for researchers and graduate students working in applied mathematics and various physical subjects where nonlinear wave phenomena arise (such as nonlinear optics, Bose-Einstein condensates, and fluid dynamics).

This text considers models of different "acoustic" media as well as equations and behavior of finite-amplitude waves. It also considers the effects of nonlinearity, dissipation, dispersion, and for two- and three-dimensional problems, reflection and diffraction on the evolution and interaction of acoustic beams.

At the end of the twentieth century, nonlinear dynamics turned out to be one of the most challenging and stimulating ideas. Notions like bifurcations, attractors, chaos, fractals, etc. have proved to be useful in explaining the world around us, be it natural or artificial. However, much of our everyday understanding is still based on linearity, i. e. on the additivity and the proportionality. The larger the excitation, the larger the response-this seems to be carved in a stone tablet. The real world is not always reacting this way and the additivity is simply lost. The most convenient way to describe such a phenomenon is to use a mathematical term-nonlinearity. The importance of this notion, i. e. the importance of being nonlinear is nowadays more and more accepted not only by the scientific community but also globally. The recent success of nonlinear dynamics is heavily biased towards temporal characterization widely using nonlinear ordinary differential equations. Nonlinear spatio-temporal processes, i. e. nonlinear waves are seemingly much more complicated because they are described by nonlinear partial differential equations. The richness of the world may lead in this case to coherent structures like solitons, kinks, breathers, etc. which have been studied in detail. Their chaotic counterparts, however, are not so explicitly analysed yet. The wavebearing physical systems cover a wide range of phenomena involving physics, solid mechanics, hydrodynamics, biological structures, chemistry, etc.

An Introduction

New Approaches to Nonlinear Waves

Waves and Structures in Nonlinear Nondispersive Media

Nonlinear Waves

Nonlinear Wave Equations

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.

This book formulates the kinematical conservation laws (KCL), analyses them and presents their applications to various problems in physics. Finally, it addresses one of the most challenging problems in fluid dynamics: finding successive positions of a curved shock front. The topics discussed are the outcome of collaborative work that was carried out mainly at the Indian Institute of Science, Bengaluru, India. The theory presented in the book is supported by referring to extensive numerical results. The book is organised into ten chapters. Chapters 1 – 4 offer a summary of and briefly discuss the theory of hyperbolic partial differential equations and conservation laws. Formulation of equations of a weakly nonlinear wavefront and those of a shock front are briefly explained in Chapter 5, while Chapter 6 addresses KCL theory in space of arbitrary dimensions. The remaining chapters examine various analyses and applications of KCL equations ending in the ultimate goal-propagation of a three-dimensional curved shock front and formation, propagation and interaction of kink lines on it.

Although the mathematical theory of nonlinear waves and solitons has made great progress, its applications to concrete physical problems are rather poor, especially when compared with the classical theory of linear dispersive waves and nonlinear fluid motion. The Whitham method, which describes the combining action of the dispersive and nonlinear effects as modulations of periodic waves, is not widely used by applied mathematicians and physicists, though it provides a direct and natural way to treat various problems in nonlinear wave theory. Therefore it is topical to describe recent developments of the Whitham theory in a clear and simple form suitable for applications in various branches of physics.This book develops the techniques of the theory of nonlinear periodic waves at elementary level and in great pedagogical detail. It provides an introduction to a Whitham's theory of modulation in a form suitable for applications. The exposition is based on a thorough analysis of representative examples taken from fluid mechanics, nonlinear optics and plasma physics rather than on the formulation and study of a mathematical theory. Much attention is paid to physical motivations of the mathematical methods developed in the book. The main applications considered include the theory of collisionless shock waves in dispersive systems and the nonlinear theory of soliton formation in modulationally unstable systems. Exercises are provided to amplify the discussion of important topics such as singular perturbation theory, Riemann invariants, the finite gap integration method, and Whitham equations and their solutions.

Dynamical systems and Nonlinear Waves in Plasmas is written in a clear and comprehensible style to serve as a compact volume for advanced postgraduate students and researchers working in the areas of Applied Physics, Applied Mathematics, Dynamical Systems, Nonlinear waves in Plasmas or other nonlinear media. It provides an introduction to the background of dynamical systems, waves, oscillations and plasmas. Basic concepts of dynamical systems and phase plane analysis for the study of dynamical properties of nonlinear waves in plasmas are presented. Different kinds of waves in plasmas are introduced. Reductive perturbative technique and its applications to derive different kinds of nonlinear evolution equations in plasmas are discussed. Analytical wave solutions of these nonlinear evolution equations are presented using the concept of bifurcation theory of planar dynamical systems in a very simple way. Bifurcations of both small and arbitrary amplitudes of various nonlinear acoustic waves in plasmas are presented using phase plots and time-series plots. Super nonlinear waves and its bifurcation behaviour are discussed for various plasma systems. Multiperiodic, quasiperiodic and chaotic motions of nonlinear plasma waves are discussed in presence of external periodic force. Multistability of plasma waves is investigated. Stable oscillation of plasma waves is also presented in dissipative plasmas. The book is meant for undergraduate and postgraduate students studying plasma physics. It will also serve a reference to the researchers, scientists and faculties to pursue the dynamics of nonlinear waves and its properties in plasmas. It describes the concept of dynamical systems and is useful in understanding exciting features, such as solitary wave, periodic wave, supernonlinear wave, chaotic, quasiperiodic and coexisting structures of nonlinear waves in plasmas. The concepts and approaches, discussed in the book, will also help the students and professionals to study such features in other nonlinear media.

Propagation of Multidimensional Nonlinear Waves and Kinematical Conservation Laws

Nonlinear Waves in Solids

Nonlinear Waves: Classical and Quantum Aspects

Nonlinear Waves and Dissipative Effects

Tsunami and Nonlinear Waves

Although nonlinear waves occur in nearly all branches of physics and engi neering, there is an amazing degree of agreement about the fundamental con cepts and the basic paradigms. The underlying unity of the theory for linearized waves is already well-established, with the importance of such universal concepts as group velocity and wave superposition. For nonlinear waves the last few decades have seen the emergence of analogous unifying comcepts. The pervasiveness of the soliton concept is amply demonstrated by the ubiquity of such models as the Korteweg-de Vries equation and the nonlinear Schrodinger equation. Similarly, there is a universality in the study of wave-wave interactions, whether determin istic or statistical, and in the recent developments in the theory of wave-mean flow interactions. The aim of this text is to present the basic paradigms of weakly nonlinear waves in fluids. This book is the outcome of a CISM Summer School held at Udine from September 20-24, 2004. . Like the lectures given there the text covers asymptotic methods for the derivation of canonical evolution equations, such as the Kortew- de Vries and nonlinear Schrodinger equations, descriptions of the basic solution sets of these evolution equations, and the most relevant and compelling applica tions. These themes are interlocked, and this will be demonstrated throughout the text . The topics address any fluid flow application, but there is a bias towards geophysical fluid dynamics, reflecting for the most part the areas where many applications have been found.

The collection of papers contained in this volume, the authors of which attended Euromech 270, provides a useful contribution to the study of nonlinear dissipative wave propagation.

Nonlinear Waves in Fluids: Recent Advances and Modern Applications