



# Nonlinear Waves

**S.S. Shen**



## **Nonlinear Waves :**

**Linear and Nonlinear Waves** G. B. Whitham, 2011-10-18 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 **Nonlinear Waves in Integrable and Non-integrable Systems** Jianke Yang, 2010-12-02 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 New Approaches to Nonlinear Waves Elena Tobisch, 2015-08-19 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 Nonlinear Waves in Solids A. Jeffrey, J. Engelbrecht, 2014-05-04 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 sciences 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 Waves, Solitons and Chaos* Eryk Infeld, George Rowlands, 2000-07-13 This revised and updated second edition of a highly successful book is the only text at this level to embrace a universal approach to three major developments in classical physics namely nonlinear waves solitons and chaos The authors now include new material on biology and laser theory and go on to discuss important recent developments such as soliton metamorphosis A comprehensive treatment of basic plasma and fluid configurations and instabilities is followed by a study of the relevant nonlinear structures Each chapter concludes with a set of problems This text will be particularly valuable for students taking courses in nonlinear aspects of physics In general it will be of value to final year undergraduates and beginning graduate students studying fluid dynamics plasma physics and applied mathematics

*Nonlinear Waves: A Geometrical Approach* Petar Radoev Popivanov, Angela Slavova, 2018-11-16 This volume provides an in depth treatment of several equations and systems of mathematical physics describing the propagation and interaction of nonlinear waves as different modifications of these the KdV equation Fornberg Whitham equation Vakhnenko equation Camassa Holm equation several versions of the NLS equation Kaup Kupershmidt equation Boussinesq paradigm and Manakov system amongst others as well as symmetrizable quasilinear hyperbolic systems arising in fluid dynamics Readers not familiar with the complicated methods used in the theory of the equations of mathematical physics functional analysis harmonic analysis spectral theory topological methods a priori estimates conservation laws can easily be acquainted here with different solutions of some nonlinear PDEs written in a sharp form waves with their geometrical visualization and their interpretation In many cases explicit solutions waves having specific physical interpretation solitons kinks peakons ovals loops rogue waves are found and their interactions are studied and geometrically visualized To do this classical methods coming from the theory of ordinary differential equations the dressing method Hirota s direct method and the method of the simplest equation are introduced and applied At the end the paradiifferential approach is used This volume is self contained and equipped with simple proofs It contains many exercises and examples arising from the applications in mechanics physics optics and quantum mechanics      *Physics of Nonlinear Waves* Mitsuhiro Tanaka, 2019-12-18 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

*Tsunami and Nonlinear Waves* Anjan Kundu, 2007-06-19 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 **Nonlinear Waves** Lokenath Debnath, 1983-12-30

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 solitons 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 solitons in plasmas

**Advances in Nonlinear Waves** Lokenath Debnath, 1984 Nonlinear Waves: Classical and Quantum Aspects Fatkhulla Abdullaev, Vladimir V. Konotop, 2006-03-02 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 **Nonlinear Waves in Fluids: Recent Advances and Modern Applications** Roger

Grimshaw, 2007-03-23 Although nonlinear waves occur in nearly all branches of physics and engineering there is an amazing degree of agreement about the fundamental concepts 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 concepts The pervasiveness of the soliton concept is amply demonstrated by the ubiquity of such models as the Korteweg de Vries equation and the nonlinear Schrödinger equation Similarly there is a universality in the study of wave wave interactions whether deterministic 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 Korteweg-de Vries and nonlinear Schrödinger equations, descriptions of the basic solution sets of these evolution equations and the most relevant and compelling applications. 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.

***Nonlinear Waves in Elastic Media*** A.G. Kulikovskii, Elena I. Sveshnikova, 2021-06-30. *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.

***A Course on Nonlinear Waves*** S.S. Shen, 2012-12-06. The aim of this book is to give a self-contained introduction to the mathematical analysis and physical explanations of some basic nonlinear wave phenomena. This volume grew out of lecture notes for graduate courses which I gave at the University of Alberta, the University of Saskatchewan, and Texas A&M. It presents a practical methodology as well as some of the more important results obtained since the 1950s. 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 nonlinear 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 numerical 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`.

***Ray Methods for Nonlinear Waves in Fluids and Plasmas*** Marcelo Anile, P. Pantano, G. Russo, J. Hunter, 1993-05-04. 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 Ocean Waves and the Inverse Scattering***

**Transform** Alfred Osborne, 2010-04-07 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

**Nonlinear Waves in Solid State Physics** A.D.

Boardman, M. Bertolotti, T. Twardowski, 2012-12-06 This book is based on the contributions to the 17th International School of Materials Science and Technology entitled Nonlinear Waves in Solid State Physics This was held as a NATO Advanced Study Institute at the Ettore Majorana Centre in Erice Sicily between the 1st and 15 July 1989 and attracted almost 100 participants from over 20 different countries The book covers the fundamental properties of nonlinear waves in solid state materials dealing with both theory and experiment The aim is to emphasise the methods underpinning the important new developments in this area The material is organised into subject areas that can broadly be classified into the following groups the theory of nonlinear surface and guided waves in self focusing magnetic and non magnetic materials nonlinear effects at interfaces nonlinear acoustoelectronic and surface acoustic waves Lagrangian and Hamiltonian formulations of nonlinear problems nonlinear effects in optical fibres resonance phenomena and nonlinear integrated optics The chapters have been grouped together according to these classifications as closely as possible but it should be borne in mind that although there is much overlap of ideas each chapter is essentially independent of the others We would like to acknowledge the sponsorship of the NATO Scientific Affairs Division the European Physical Society the National Science Foundation of the USA the European Research Office the Italian Ministry of Education the Italian Ministry of Scientific and Technological Research the Sicilian Regional Government and the Ugo Bordononi Foundation

Spectral and Dynamical Stability of Nonlinear Waves

Todd Kapitula, Keith Promislow, 2013-06-06 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 Networks** Felix Ali Mehmeti, 1994-09-27 The main topic of this text is the well posedness locally in time of quasilinear wave equations on one dimensional networks with linear transmission conditions Such problems arise for example in the modelling of transversal vibrations of networks of strings The setting serves as a model case for the systematic study with T Kato's theory of the phenomenon of nonlinear compatibility conditions arising if we desire regular solutions This phenomenon is bound to occur always if we combine hyperbolic evolution with all kinds of coupling conditions We explain the connections of the results to a concept for the description of complicated interactions between media of possibly varying space dimension with time evolution previously developed by the author A strategy for physical legitimations of linear mechanical coupling models the systematic derivation of physical laws and of the asymptotics of frequencies of eigenmodes are outlined As applications of this interaction concept small vibrations of membranes with conic boundary points and a membrane string coupling are considered

*Introduction to Nonlinear Fluid-Plasma Waves* B.K Shivamoggi, 2012-12-06 A variety of nonlinear effects occur in a plasma First there are the wave steepening effects which can occur in any fluid in which the propagation speed depends upon the wave amplitude In a dispersive medium this can lead to classes of nonlinear waves which may have stationary solutions like solitons and shocks Because the plasma also acts like an inherently nonlinear dielectric resonant interactions among waves lead to exchange of energy among them Further an electromagnetic wave interacting with a plasma may parametrically excite other waves in the plasma A large amplitude Langmuir wave undergoes a modulational instability which arises through local depressions in plasma density and the corresponding increases in the energy density of the wave electric field Whereas a field collapse occurs in two and three dimensions in a one dimensional case spatially localized stationary field structures called Langmuir solitons can result Many other plasma waves like upper hybrid waves lower hybrid waves etc can also undergo a modulational instability and produce localized field structures A new type of nonlinear effect comes into play when an electromagnetic wave propagating through a plasma is strong enough to drive the electrons to relativistic speeds This leads to a propagation of an electromagnetic wave in a normally overdense plasma and



the coupling of the electromagnetic wave to a Langmuir wave in the plasma The relativistic mass variation of the electrons moving in an intense electromagnetic wave can also lead to a modulational instability of the latter

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