

# WAVEFRONTS AND RAYS AS CHARACTERISTICS AND ASYMPTOTICS

Second Edition

Andrej Bóna

Michael A. Slawinski



World Scientific

# Wavefronts And Rays As Characteristics And Asymptotics

**Barbara Romanowicz, Adam  
Dziewonski**



## **Wavefronts And Rays As Characteristics And Asymptotics:**

**Wavefronts and Rays as Characteristics and Asymptotics** Andrej Bona, Michael A. Slawinski, 2011 This textbook incorporated with many illuminating examples and exercises is aimed at graduate students of physical sciences and engineering The purpose is to provide a background of physics and underlying mathematics for the concept of rays filling the gap between mathematics and physics textbooks for a coherent treatment of all topics The authors emphasis and extremely good presentation of the theory of characteristics which defines the rays accentuate the beauty and versatility of this theory To this end the rigour of the formulation by a pure mathematician s standards is downplayed to highlight the physical meaning and to make the subject accessible to a wider audience The authors describe in detail the theory of characteristics for different types of differential equations the applications to wave propagation in different types of media and the phenomena such as caustics

**Wavefronts And Rays As Characteristics And Asymptotics (Third Edition)** Andrej Bona, Michael A Slawinski, 2020-09-24 Characteristics and asymptotics of partial differential equations play an important role in mathematical physics since they lead to insightful solutions of complex problems that might not be solvable otherwise They constitute however a difficult subject and the purpose of this book with its additions and refinements that led to its third edition is to present this subject in an accessible manner without decreasing the rigor As any method characteristics and asymptotics have their limitations This important issue is addressed in the last chapter where we discuss caustics which must be understood in applications of the method and which constitute a fertile ground for further mathematical research The book is both a research reference and a textbook Its careful and explanatory style which includes numerous exercises with detailed solutions makes it an excellent textbook for senior undergraduate and graduate courses as well as for independent studies Six appendices are provided which form a self contained course on applied mathematics and can be used as a textbook on its own

**Wavefronts And Rays As Characteristics And Asymptotics (2nd Edition)** Michael A Slawinski, Andrej Bona, 2014-12-30 This textbook incorporated with many illuminating examples and exercises is aimed at graduate students of physical sciences and engineering The purpose is to provide a background of physics and underlying mathematics for the concept of rays filling the gap between mathematics and physics textbooks for a coherent treatment of all topics The authors emphasis and extremely good presentation of the theory of characteristics which defines the rays accentuate the beauty and versatility of this theory To this end the rigour of the formulation by a pure mathematician s standards is downplayed to highlight the physical meaning and to make the subject accessible to a wider audience The authors describe in detail the theory of characteristics for different types of differential equations the applications to wave propagation in different types of media and phenomena such as caustics

*Waves And Rays In Seismology: Answers To Unasked Questions* Michael A Slawinski, 2016-07-28 The author dedicates this book to readers who are concerned with finding out the status of concepts statements and hypotheses and with clarifying and rearranging them in a logical order It is

thus not intended to teach tools and techniques of the trade but to discuss the foundations on which seismology and in a larger sense the theory of wave propagation in solids is built. A key question is why and to what degree can a theory developed for an elastic continuum be used to investigate the propagation of waves in the Earth which is neither a continuum nor fully elastic. But the scrutiny of the foundations goes much deeper: material symmetry, effective tensors, equivalent media, the influence or rather the lack thereof of gravitational and thermal effects and the rotation of the Earth are discussed *ab initio*. The variational principles of Fermat and Hamilton and their consequences for the propagation of elastic waves, causality, Noether's theorem and its consequences on conservation of energy and conservation of linear momentum are but a few topics that are investigated in the process to establish seismology as a science and to investigate its relation to subjects like realism and empiricism in natural sciences, to the nature of explanations and predictions and to experimental verification and refutation.

*Waves And Rays In Elastic Continua (Fourth Edition)* Michael A Slawinski, 2020-09-24

Seismology as a branch of mathematical physics is an active subject of both research and development. Its reliance on computational and technological advances continuously motivates the developments of its underlying theory. The fourth edition of *Waves and Rays in Elastic Continua* responds to these needs. The book is both a research reference and a textbook. Its careful and explanatory style which includes numerous exercises with detailed solutions makes it an excellent textbook for the senior undergraduate and graduate courses as well as for an independent study. Used in its entirety the book could serve as a sole textbook for a year long course in quantitative seismology. Its parts however are designed to be used independently for shorter courses with different emphases. The book is not limited to quantitative seismology; it can serve as a textbook for courses in mathematical physics or applied mathematics.

*Waves And Rays In Elastic Continua (3rd Edition)* Michael A Slawinski, 2014-12-15

The present book which is the third significantly revised edition of the textbook originally published by Elsevier Science emphasizes the interdependence of mathematical formulation and physical meaning in the description of seismic phenomena. Herein we use aspects of continuum mechanics, wave theory and ray theory to explain phenomena resulting from the propagation of seismic waves. The book is divided into three main sections: Elastic Continua, Waves and Rays, and Variational Formulation of Rays. There is also a fourth part which consists of appendices. In Elastic Continua we use continuum mechanics to describe the material through which seismic waves propagate and to formulate a system of equations to study the behaviour of such a material. In Waves and Rays we use these equations to identify the types of body waves propagating in elastic continua as well as to express their velocities and displacements in terms of the properties of these continua. To solve the equations of motion in anisotropic inhomogeneous continua we invoke the concept of a ray. In Variational Formulation of Rays we show that in elastic continua a ray is tantamount to a trajectory along which a seismic signal propagates in accordance with the variational principle of stationary traveltime. Consequently many seismic problems in elastic continua can be conveniently formulated and solved using the calculus of variations. In the Appendices we describe

two mathematical concepts that are used in the book namely homogeneity of a function and Legendre's transformation This section also contains a list of symbols Asymptotic and Hybrid Methods in Electromagnetics I. Andronov, F. Molinet, D. Bouche, 2005-07-18 Asymptotic methods provide considerable physical insight and understanding of diffraction mechanisms and are very useful in the design of electromagnetic devices such as radar targets and antennas However difficulties can arise when trying to solve problems using multipole and asymptotic methods together such as in radar cross-section objects This new book offers a solution to this problem by combining these approaches into hybrid methods therefore creating high demand for both understanding and learning how to apply asymptotic and hybrid methods to solve diffraction problems

**On Foundations Of Seismology: Bringing Idealizations Down To Earth** James Robert Brown, Michael A Slawinski, 2017-04-27 I can wholeheartedly recommend this book students researchers college and university science professors and readers of The Leading Edge I also recommend it to all those who want to enrich their own experience of practicing and teaching science with some carefully considered soul searching on how it all fits together in the human story of figuring things out It is written throughout with precise and careful language prudently paced carefully crafted eloquently enunciated and playfully illuminated The Leading Edge This remarkable collaboration between a mathematical physicist and a science philosopher concerns foundational and conceptual issues in seismology Their aim is to present mathematical physical and philosophical topics in a clear and concise manner They provide an extensive philosophical discussion of the methods of science and show how seismology fits in They explain with care and precision the basic structure of seismology which is built on classical continuum mechanics Not only do they explain how various models work in seismology they also include an extensive discussion of the nature of models and idealizations Physics Avoidance Mark Wilson, 2017-10-20 Mark Wilson presents a series of explorations of our strategies for understanding the world Physics avoidance refers to the fact that we frequently cannot reason about nature in the straightforward manner we anticipate but must seek alternative policies that allow us to address the questions we want answered in a tractable way Within both science and everyday life we find ourselves relying upon thought processes that reach useful answers in opaque and roundabout manners Conceptual innovators are often puzzled by the techniques they develop when they stumble across reasoning patterns that are easy to implement but difficult to justify But simple techniques frequently rest upon complex foundations a young magician learns how to execute a card guessing trick without understanding how its progressive steps squeeze in on a proper answer As we collectively improve our inferential skills in this gradually evolving manner we often wander into unfamiliar explanatory landscapes in which simple words encode physical information in complex and unanticipated ways Like our juvenile conjurer we fail to recognize the true strategic rationales underlying our achievements and may turn instead to preposterous rationalizations for our policies We have learned how to reach better conclusions in a more fruitful way but we remain baffled by our own successes At its best philosophical reflection illuminates the natural developmental processes that generate these

confusions and explicates their complexities But current thinking within philosophy of science and language works to opposite effect by relying upon simplistic conceptions of cause law of nature possibility and reference that ignore the strategic complexities in which these concepts become entangled within real life usage To avoid these distortions better descriptive tools are wanted The nine new essays within this volume illustrate this need for finer discriminations through a range of revealing cases of both historical and contemporary significance     *Singular Perturbations and Asymptotics* Richard E. Meyer, Seymour V. Parter, 2014-05-10 Mathematics Research Center Symposia and Advanced Seminar Series *Singular Perturbations and Asymptotics* covers the lectures presented at an Advanced Seminar on Singular Perturbation and Asymptotics held in Madison Wisconsin on May 28 30 1980 under the auspices of the Mathematics Research Center of the University of Wisconsin Madison The book focuses on the processes methodologies reactions and principles involved in singular perturbations and asymptotics including boundary value problems equations perturbations water waves and gas dynamics The selection first elaborates on basic concepts in the analysis of singular perturbations limit process expansions and approximate equations and results on singularly perturbed boundary value problems Discussions focus on quasi linear and nonlinear problems semilinear systems water waves expansion in gas dynamics asymptotic matching principles and classical perturbation analysis The text then takes a look at multiple solutions of singularly perturbed systems in the conditionally stable case and singular perturbations stochastic differential equations and applications The book ponders on connection problems in the parameterless case general connection formula problem for linear differential equations of the second order and turning point problems for ordinary differential equations of hydrodynamic type Topics include the comparison equation method boundary layer flows compound matrix method asymptotic solution of the connection formula problem and higher order equations The selection is a valuable source of information for researchers interested in singular perturbations and asymptotics     **Singularities of Caustics and Wave Fronts** Vladimir Arnold, 2013-12-01 One service mathematics has rendered the Et moi si j'avait su comment en revenir human race It has put common sense back je n'y serais point aile Jules Verne where it belongs on the topmost shelf next to the dusty canister labelled discarded non The series is divergent therefore we may be sense Erie T. Bell able to do something with it O Heaviside Mathematics is a tool for thought A highly necessary tool in a world where both feedback and non linearities abound Similarly all kinds of parts of mathematics serve as tools for other parts and for other sciences Applying a simple rewriting rule to the quote on the right above one finds such statements as One service topology has rendered mathematical physics One service logic has rendered computer science One service category theory has rendered mathematics All arguably true And all statements obtainable this way form part of the *raison d'être* of this series     Surveys in Applied Mathematics Joseph B. Keller, David W. McLaughlin, George C. Papanicolaou, 2013-12-21 Partial differential equations play a central role in many branches of science and engineering Therefore it is important to solve problems involving them One aspect of solving a partial differential

equation problem is to show that it is well posed i.e. that it has one and only one solution and that the solution depends continuously on the data of the problem. Another aspect is to obtain detailed quantitative information about the solution. The traditional method for doing this was to find a representation of the solution as a series or integral of known special functions and then to evaluate the series or integral by numerical or by asymptotic methods. The shortcoming of this method is that there are relatively few problems for which such representations can be found. Consequently the traditional method has been replaced by methods for direct solution of problems either numerically or asymptotically. This article is devoted to a particular method called the ray method for the asymptotic solution of problems for linear partial differential equations governing wave propagation. These equations involve a parameter such as the wavelength which is small compared to all other lengths in the problem. The ray method is used to construct an asymptotic expansion of the solution which is valid near 0 or equivalently for  $k \rightarrow \infty$ . I A near infinity

**An Introduction to Geometrical Physics** Aldrovandi Ruben, Pereira Jose Geraldo, 2016-10-07 This book focuses on the unifying power of the geometrical language in bringing together concepts from many different areas of physics ranging from classical physics to the theories describing the four fundamental interactions of Nature: gravitational, electromagnetic, strong nuclear and weak nuclear. The book provides in a single volume a thorough introduction to topology and differential geometry as well as many applications to both mathematical and physical problems. It is aimed as an elementary text and is intended for first year graduate students. In addition to the traditional contents of books on special and general relativity, this book discusses also some recent advances such as de Sitter invariant special relativity, teleparallel gravity and their implications in cosmology for those wishing to reach a higher level of understanding.

**Treatise on Geophysics**, 2015-04-17 Treatise on Geophysics Second Edition is a comprehensive and in depth study of the physics of the Earth beyond what any geophysics text has provided previously. Thoroughly revised and updated, it provides fundamental and state of the art discussion of all aspects of geophysics. A highlight of the second edition is a new volume on Near Surface Geophysics that discusses the role of geophysics in the exploitation and conservation of natural resources and the assessment of degradation of natural systems by pollution. Additional features include new material in the Planets and Moon, Mantle Dynamics, Core Dynamics, Crustal and Lithosphere Dynamics, Evolution of the Earth and Geodesy volumes. New material is also presented on the uses of Earth gravity measurements. This title is essential for professionals, researchers, professors and advanced undergraduate and graduate students in the fields of Geophysics and Earth system science. Comprehensive and detailed coverage of all aspects of geophysics. Fundamental and state of the art discussions of all research topics. Integration of topics into a coherent whole. *Fifth International Conference on Mathematical and Numerical Aspects of Wave Propagation* Alfredo Bermudez, 2000-01-01 This conference was held in Santiago de Compostela, Spain, July 10-14, 2000. This volume contains papers presented at the conference covering a broad range of topics in theoretical and applied wave propagation in the general areas of acoustics, electromagnetism and elasticity. Both direct and

inverse problems are well represented This volume along with the three previous ones presents a state of the art primer for research in wave propagation The conference is conducted by the Institut National de Recherche en Informatique et en Automatique with the cooperation of SIAM      **Asymptotic Methods in Electromagnetics** Daniel Bouche, Frederic Molinet, Raj Mittra, 2012-12-06 Numerically rigorous techniques for the computation of electromagnetic fields diffracted by an object become computationally intensive if not impractical to handle at high frequencies and one must resort to asymptotic methods to solve the scattering problem at short wavelengths The asymptotic methods provide closed form expansions for the diffracted fields and are also useful for eliciting physical interpretations of the various diffraction phenomena One of the principal objectives of this book is to discuss the different asymptotic methods in a unified manner Although the book contains explicit formulas for computing the field diffracted by conducting or dielectric coated objects it also provides the mathematical foundations of the different methods and explains how they are interrelated

**Fundamentals of Acoustics** Michel Bruneau, 2013-03-01 The central theme of the chapters is acoustic propagation in fluid media dissipative or non dissipative homogeneous or nonhomogeneous infinite or limited placing particular emphasis on the theoretical formulation of the problems considered      **Energy Methods in Dynamics** Khanh Chau Le, Lu Trong Khiem Nguyen, 2014-07-08 Energy Methods in Dynamics is a textbook based on the lectures given by the first author at Ruhr University Bochum Germany Its aim is to help students acquire both a good grasp of the first principles from which the governing equations can be derived and the adequate mathematical methods for their solving Its distinctive features as seen from the title lie in the systematic and intensive use of Hamilton's variational principle and its generalizations for deriving the governing equations of conservative and dissipative mechanical systems and also in providing the direct variational asymptotic analysis whenever available of the energy and dissipation for the solution of these equations It demonstrates that many well known methods in dynamics like those of Lindstedt Poincare Bogoliubov Mitropolsky Kolmogorov Arnold Moser KAM Wentzel Kramers Brillouin WKB and Whitham are derivable from this variational asymptotic analysis This second edition includes the solutions to all exercises as well as some new materials concerning amplitude and slope modulations of nonlinear dispersive waves      **The Devil in the Details** Robert W. Batterman, 2001-11-29 Robert Batterman examines a form of scientific reasoning called asymptotic reasoning arguing that it has important consequences for our understanding of the scientific process as a whole He maintains that asymptotic reasoning is essential for explaining what physicists call universal behavior With clarity and rigor he simplifies complex questions about universal behavior demonstrating a profound understanding of the underlying structures that ground them This book introduces a valuable new method that is certain to fill explanatory gaps across disciplines      Seismology and Structure of the Earth Barbara Romanowicz, Adam Dziewonski, 2010-04-20 Treatise on Geophysics Seismology and Structure of the Earth Volume 1 provides a comprehensive review of the state of knowledge on the Earth's structure and earthquakes It addresses various aspects of structural

seismology and its applications to other fields of Earth sciences The book is organized into four parts The first part principally covers theoretical developments and seismic data analysis techniques from the end of the nineteenth century until the present with the main emphasis on the development of instrumentation and its deployment The second part reviews the status of knowledge on the structure of the Earth's shallow layers starting with a global review of the Earth's crustal structure The third part focuses on the Earth's deep structure divided into its main units the upper mantle the transition zone and upper mantle discontinuities the D region at the base of the mantle and the Earth's core The fourth part comprises two chapters which discuss constraints on Earth structure from fields other than seismology mineral physics and geodynamics Self contained volume starts with an overview of the subject then explores each topic with in depth detail Extensive reference lists and cross references with other volumes to facilitate further research Full color figures and tables support the text and aid in understanding Content suited for both the expert and non expert

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