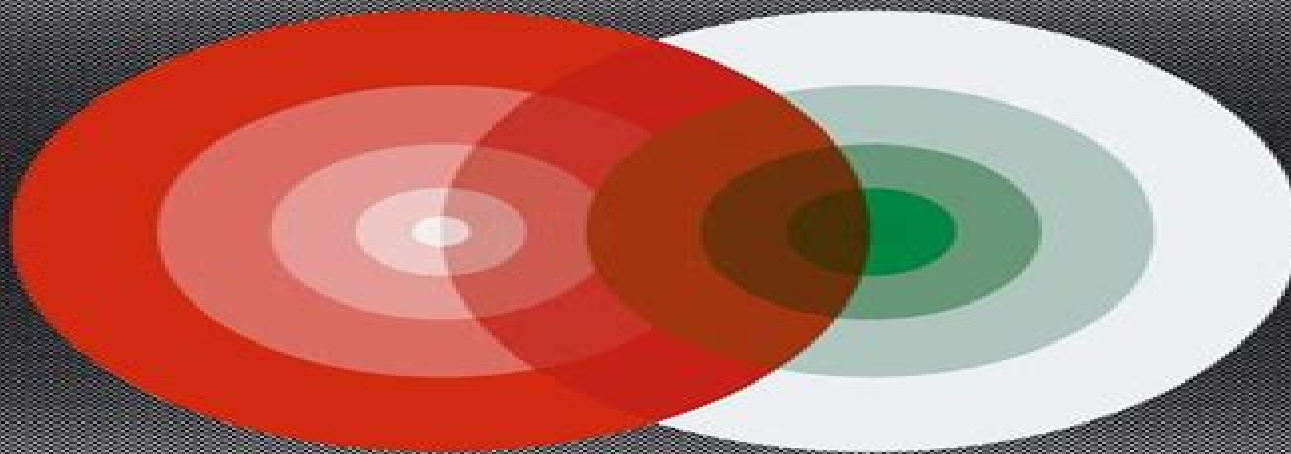


# **Generalized Thermodynamics**

**The Thermodynamics of Irreversible Processes and  
Generalized Hydrodynamics**

by  
**Byung Chan Eu**

**Kluwer Academic Publishers**



**Fundamental Theories of Physics**

# Generalized Thermodynamics The Thermodynamics Of Irreversible Processes And Generalized Hydrodynamics

**Jean-Laurent Puebe**



## **Generalized Thermodynamics The Thermodynamics Of Irreversible Processes And Generalized Hydrodynamics:**

Generalized Thermodynamics Byung Chan Eu, 2002-07-31 This monograph presents from the viewpoint of continuum mechanics a newly emerging field of irreversible thermodynamics in which linear irreversible thermodynamics are extended to the nonlinear regime and macroscopic phenomena far removed from equilibrium are studied in a manner consistent with the laws of thermodynamics The tool to develop this thermodynamic theory of irreversible processes are the generalized thermodynamics which also extends the classical hydrodynamics of Navier Stokes and Fourier to nonlinear irreversible processes On the basis of mathematically rigorous representations of the first and the second law of thermodynamics phenomenological theory continuum mechanics deductions are made from the thermodynamic laws of R Clausius and Lord Kelvin and by this continuum mechanics theories are formulated for macroscopic irreversible processes occurring far removed from equilibrium Non equilibrium thermodynamics are developed for thermodynamic functions The macroscopic irreversible processes studied include global irreversible processes as well as local hydrodynamic processes at an arbitrary degree of removal from equilibrium Applications of the theories cover global irreversible processes simple flows of non Newtonian and non Fourier fluids shock waves of monatomic and diatomic gases rarefied gas dynamics ultrasonic wave absorption and dispersion of monatomic and diatomic gases electrochemical processes neural networks of chemical reactors microflows etc Variational principles in irreversible thermodynamics and contact manifolds in thermodynamics are also discussed This monograph will be of interest to condensed matter physicists chemical physicists biophysicists mechanical and aerospace engineers and specialists and graduate students in the fields of irreversible thermodynamics and non equilibrium statistical mechanics

**Generalized Thermodynamics** Byung Chan Eu, 2006-04-11 Despite a long history of almost 180 years stretching back to the times of Carnot and later Clausius and Lord Kelvin amongst others following him the subject of thermodynamics has not as yet seen its full maturity in the sense that the theory of irreversible processes has remained incomplete The works of L Onsager J Meixner I Prigogine on the thermodynamics of linear irreversible processes are in effect the early efforts toward the desired goal of giving an adequate description of irreversible processes but their theory is confined to near equilibrium phenomena The works in recent years by various research workers on the extension of the aforementioned thermodynamic theory of linear irreversible processes are further efforts toward the goal mentioned The present work is another of such efforts and a contribution to the subject of generalizing the thermodynamics of reversible processes namely equilibrium thermodynamics to that of irreversible processes non equilibrium thermodynamics without being restricted to linear irreversible processes In this context the terms far moved from equilibrium is often used in the literature and such states of macroscopic systems and non linear irreversible phenomena in them are the objects of interest in this work The thermodynamics of processes either reversible or irreversible is a continuum mechanical theory of matter and energy and their exchange between different parts of the system and as such it makes no direct reference to the

molecules constituting the substance under consideration      *Kinetic Theory of Nonequilibrium Ensembles, Irreversible Thermodynamics, and Generalized Hydrodynamics* Byung Chan Eu, 2016-08-02 This book presents the fundamentals of irreversible thermodynamics for nonlinear transport processes in gases and liquids as well as for generalized hydrodynamics extending the classical hydrodynamics of Navier Stokes Fourier and Fick Together with its companion volume on relativistic theories it provides a comprehensive picture of the kinetic theory formulated from the viewpoint of nonequilibrium ensembles in both nonrelativistic and in Vol 2 relativistic contexts Theories of macroscopic irreversible processes must strictly conform to the thermodynamic laws at every step and in all approximations that enter their derivation from the mechanical principles Upholding this as the inviolable tenet the author develops theories of irreversible transport processes in fluids gases or liquids on the basis of irreversible kinetic equations satisfying the H theorem They apply regardless of whether the processes are near to or far removed from equilibrium or whether they are linear or nonlinear with respect to macroscopic fluxes or thermodynamic forces Both irreversible Boltzmann and generalized Boltzmann equations are used for deriving theories of irreversible transport equations and generalized hydrodynamic equations which rigorously conform to the tenet All observables described by the so formulated theories therefore also strictly obey the tenet      **Challenges to The Second Law of Thermodynamics** Vladislav Capek, Daniel P. Sheehan, 2005-02-15 The second law of thermodynamics is considered one of the central laws of science engineering and technology For over a century it has been assumed to be inviolable by the scientific community Over the last 10 20 years however more than two dozen challenges to it have appeared in the physical literature more than during any other period in its 150 year history The number and variety of these represent a cogent threat to its absolute status This is the first book to document and critique these modern challenges Written by two leading exponents of this rapidly emerging field it covers the theoretical and experimental aspects of principal challenges In addition unresolved foundational issues concerning entropy and the second law are explored This book should be of interest to anyone whose work or research is touched by the second law      **Extended Thermodynamics Systems** Stanislaw Sieniutycz, Peter Salamon, 1992-01-01 This multiauthored volume sketches the applications of nonequilibrium thermodynamics to complex systems These are characterized by an involved form of the Gibbs equation and include systems such as solutions of macromolecules magnetic hysteresis bodies viscoelastic fluids polarizable media fluids under stresses and in the presence of essential nonstationarities and high temperature gradients As a rule the so called internal variables and or dissipative fluxes are essential in the thermodynamic description of such systems      Transport in Transition Regimes Ben Abdallah Naoufel, Anton Arnold, Pierre Degond, Irene M. Gamba, Robert T. Glassey, C. David Levermore, Christian Ringhofer, 2012-12-06 IMA Volumes 135 Transport in Transition Regimes and 136 Dispersive Transport Equations and Multiscale Models focus on the modeling of processes for which transport is one of the most complicated components This includes processes that involve a wide range of length scales over different spatio temporal regions of the problem ranging

from the order of mean free paths to many times this scale Consequently effective modeling techniques require different transport models in each region The first issue is that of finding efficient simulations techniques since a fully resolved kinetic simulation is often impractical One therefore develops homogenization stochastic or moment based subgrid models Another issue is to quantify the discrepancy between macroscopic models and the underlying kinetic description especially when dispersive effects become macroscopic for example due to quantum effects in semiconductors and superfluids These two volumes address these questions in relation to a wide variety of application areas such as semiconductors plasmas fluids chemically reactive gases etc

*Fluid Mechanics* Jean-Laurent Puebe, 2013-03-01 This book examines the phenomena of fluid flow and transfer as governed by mechanics and thermodynamics Part 1 concentrates on equations coming from balance laws and also discusses transportation phenomena and propagation of shock waves Part 2 explains the basic methods of metrology signal processing and system modeling using a selection of examples of fluid and thermal mechanics

*Quantum Measure Theory* J. Hamhalter, 2013-03-14 This book is the first systematic treatment of measures on projection lattices of von Neumann algebras It presents significant recent results in this field One part is inspired by the Generalized Gleason Theorem on extending measures on the projection lattices of von Neumann algebras to linear functionals Applications of this principle to various problems in quantum physics are considered hidden variable problem Wigner type theorems decoherence functional etc Another part of the monograph deals with a fascinating interplay of algebraic properties of the projection lattice with the continuity of measures the analysis of Jauch Piron states independence conditions in quantum field theory etc These results have no direct analogy in the standard measure and probability theory On the theoretical physics side they are instrumental in recovering technical assumptions of the axiomatics of quantum theories only by considering algebraic properties of finitely additive measures states on quantum propositions

**Deformed Spacetime** Fabio Cardone, Roberto Mignani, 2007-09-04 This volume provides a detailed discussion of the mathematical aspects and physical applications of a new geometrical structure of space time based on a generalization deformation of the usual Minkowski space as supposed to be endowed with a metric whose coefficients depend on the energy This new five dimensional scheme Deformed Relativity in Five Dimensions DR5 represents a true generalization of the usual Kaluza Klein KK formalism

*Introduction to Soliton Theory: Applications to Mechanics* Ligia Munteanu, Stefania Donescu, 2006-07-06 This monograph is planned to provide the application of the soliton theory to solve certain practical problems selected from the fields of solid mechanics fluid mechanics and biomechanics The work is based mainly on the authors research carried out at their home institutes and on some specified significant results existing in the published literature The methodology to study a given evolution equation is to seek the waves of permanent form to test whether it possesses any symmetry properties and whether it is stable and solitonic in nature Students of physics applied mathematics and engineering are usually exposed to various branches of nonlinear mechanics especially to the soliton theory The soliton is regarded as an

entity a quasi particle which conserves its character and interacts with the surroundings and other solitons as a particle It is related to a strange phenomenon which consists in the propagation of certain waves without attenuation in dissipative media This phenomenon has been known for about 200 years it was described for example by the Joule Verne s novel Les histoires de Jean Marie Cabidoulou d Hetzel but its detailed quantitative description became possible only in the last 30 years due to the exceptional development of computers The discovery of the physical soliton is attributed to John Scott Russell In 1834 Russell was observing a boat being drawn along a narrow channel by a pair of horses Classical Electromagnetic Theory Jack Vanderlinde,2006-01-17 In questions of science the authority of a thousand is not worth the humble reasoning of a single individual Galileo Galilei physicist and astronomer 1564 1642 This book is a second edition of Classical Electromagnetic Theory which derived from a set of lecture notes compiled over a number of years of teaching electromagnetic theory to fourth year physics and electrical engineering students These students had a previous exposure to electricity and magnetism and the material from the first four and a half chapters was presented as a review I believe that the book makes a reasonable transition between the many excellent elementary books such as Griffith s Introduction to Electrodynamics and the obviously graduate level books such as Jackson s Classical Electrodynamics or Landau and Lifshitz Electrodynamics of Continuous Media If the students have had a previous exposure to Electromagnetic theory all the material can be reasonably covered in two semesters Neophytes should probably spend a semester on the first four or five chapters as well as depending on their mathematical background the Appendices B to F For a shorter or more elementary course the material on spherical waves waveguides and waves in anisotropic media may be omitted without loss of continuity

Reading Bohr: Physics and Philosophy Arkady Plotnitsky,2006-11-15 Reading Bohr Physics and Philosophy offers a new perspective on Niels Bohr s interpretation of quantum mechanics as complementarity and on the relationships between physics and philosophy in Bohr s work which has had momentous significance for our understanding of quantum theory and of the nature of knowledge in general Philosophically the book reassesses Bohr s place in the Western philosophical tradition from Kant and Hegel on Physically it reconsiders the main issues at stake in the Bohr Einstein confrontation and in the ongoing debates concerning quantum physics It also devotes greater attention than in most commentaries on Bohr to the key developments and transformations of his thinking concerning complementarity Most significant among them were those that occurred first under the impact of Bohr s exchanges with Einstein and second under the impact of developments in quantum theory itself both quantum mechanics and quantum field theory The importance of quantum field theory for Bohr s thinking has not been adequately addressed in the literature on Bohr to the considerable detriment to our understanding of the history of quantum physics Filling this lacuna is one of the main contributions of the book which also enables us to show why quantum field theory compels us to move beyond Bohr without however simply leaving him behind **Cosmological Pattern of Microphysics in the Inflationary Universe** Maxim Y. Khlopov,Sergei G. Rubin,2013-03-20 Modern cosmology

is a quickly developing field of research. New technical devices and tools supply the community with new experimental data measured with high accuracy. The self-consistent explanation of these data needs theoretical models that are based on hypothetical predictions of particle theory. In their turn, such predictions imply cosmology for their probe. Specific studies of the cosmological consequences of particle theory, linking them to their observable signatures, are actual. This boiling kettle of theoretical research and experimental efforts produces ideas that will be preserved for following generations. The aim of this book is to acquaint the reader with some of these ideas, offering nontrivial ways to probe the physical basis of modern cosmology. An extensive review of the newest ideas in modern cosmology, e.g. related with the development of the M-brane theory, lies beyond the scope of our book, which is aimed at providing a firmly established system of probes for these ideas, linking their predictions to their possible experimental test. We use the framework of an inflationary paradigm to reveal the phenomena that can shed light on the physical origin of the observed Universe, of its matter content and large-scale structure. The crucial role of quantum fluctuations in creation of our Universe and in possible features reflecting cosmological impact of microphysics is discussed. These features are shown to be accessible to experimental test in the near future.

**Relativity and the Dimensionality of the World** Vesselin Petkov, 2007-10-08. All physicists would agree that one of the most fundamental problems of the 21st century physics is the dimensionality of the world. In the four-dimensional world of Minkowski or Minkowski spacetime, the most challenging problem is the nature of the temporal dimension. In Minkowski spacetime, it is merely one of the four dimensions, which means that it is entirely given like the other three spatial dimensions. If the temporal dimension were not given in its entirety and only one constantly changing moment of it existed, Minkowski spacetime would be reduced to the ordinary three-dimensional space. But if the physical world represented by Minkowski spacetime is indeed four-dimensional, with time being the fourth dimension, then such a world is drastically different from its image based on our perceptions. Minkowski four-dimensional world is a block Universe, a frozen world in which nothing happens, since all moments of time are given at once, which means that physical bodies are four-dimensional worldtubes containing the whole histories in time of the three-dimensional bodies of our everyday experience. The implications of a real Minkowski world for physics itself and especially for our world view are enormous. The main focus of this volume is the question: is spacetime nothing more than a mathematical space which describes the evolution in time of the ordinary three-dimensional world, or is it a mathematical model of a real four-dimensional world with time entirely given as the fourth dimension? It contains fourteen invited papers which either directly address the main question of the nature of spacetime or explore issues related to it.

*Factorization Method in Quantum Mechanics* Shi-Hai Dong, 2007-04-01. This book introduces the factorization method in quantum mechanics at an advanced level, with the aim of putting mathematical and physical concepts and techniques like the factorization method, Lie algebras, matrix elements and quantum control at the reader's disposal. For this purpose, the text provides a comprehensive description of the factorization method and its wide applications.

in quantum mechanics which complements the traditional coverage found in quantum mechanics textbooks

**The Universe of Fluctuations** B. G. Sidharth, 2006-03-30 The Universe of Fluctuations The Architecture of Spacetime and the Universe is a path breaking work which proposes solutions to the impasse and crisis facing fundamental physics and cosmology It describes a cosmological model based on fuzzy spacetime that has correctly predicted a dark energy driven acceleration of our expanding universe with a small cosmological constant at a time when the popular belief was quite the contrary It describes how the Universe is made up of an underpinning of Planck oscillators in a Quantum Vacuum This leads to amongst other things a characterization of gravitation as being distributional over the entire Universe thereby providing an answer to a puzzle brought to light by Weinberg years ago and since overlooked There is also a simple formula for the mass spectrum of all known elementary particles based on QCD dynamics Many other interesting ramifications and experimental tests for the future are also discussed This apart there is a brief survey of some of the existing theories The book is accessible to junior and senior researchers in High Energy Physics and Cosmology as well as the serious graduate student in Physics

Precisely Predictable Dirac Observables Heinz Otto Cordes, 2007-01-10 In this book we are attempting to offer a modification of Dirac's theory of the electron we believe to be free of the usual paradoxes so as perhaps to be acceptable as a clean quantum mechanical treatment While it seems to be a fact that the classical mechanics from Newton to Einstein's theory of gravitation offers a very rigorous concept free of contradictions and able to accurately predict motion of a mass point quantum mechanics even in its simplest cases does not seem to have this kind of clarity Almost it seems that everyone of its fathers had his own wave equation For the quantum mechanical 1 body problem with vanishing potentials let us focus on 3 different wave equations I The Klein Gordon equation  $\nabla^2 \psi - \frac{1}{c^2} \frac{\partial^2 \psi}{\partial t^2} = 0$  Laplacian  $\nabla^2 \psi = 0$  This equation may be written as  $\nabla^2 \psi = 0$  Here it may be noted that the operator  $\nabla^2$  has a well defined positive square root as unbounded self adjoint positive operator of the Hilbert space  $H^1(\mathbb{R}^3)$

**Relativity in Rotating Frames** G. Rizzi, M.L. Ruggiero, 2013-03-09 Even if the subject is a long standing one this is the first monograph on this field On the one hand this book is intended to give a rather wide review on this field both in a historical and pedagogical perspective on the other hand it aims at critically re-examining and discussing the most controversial issues For instance according to some authors the celebrated Sagnac effect is a disproof of the theory of relativity applied to rotating frames according to others it is an astonishing experimental evidence of the relativistic theory In order to give the reader a deeper insight into this research field the contributing authors discuss their opinions on the main subjects in an enthralling virtual round table in this way the reader can get a direct comparison of the various viewpoints on the most controversial and interesting topics This is particularly expedient since the differences in the various approaches are often based upon subtleties that can be understood only by a direct comparison of the underlying hypotheses

**Classical and Relativistic Rational Extended Thermodynamics of Gases** Tommaso Ruggeri, Masaru Sugiyama, 2021-04-22 Rational extended thermodynamics RET is the theory that is applicable to



nonequilibrium phenomena out of local equilibrium It is expressed by the hyperbolic system of field equations with local constitutive equations and is strictly related to the kinetic theory with the closure method of the hierarchies of moment equations The book intends to present in a systematic way new results obtained by RET of gases in both classical and relativistic cases and it is a natural continuation of the book Rational Extended Thermodynamics beyond the Monatomic Gas by the same authors published in 2015 However this book addresses much wider topics than those of the previous book Its contents are as follows RET of rarefied monatomic gases and of polyatomic gases a simplified RET theory with 6 fields being valid far from equilibrium RET where both molecular rotational and vibrational modes exist mixture of gases with multi temperature The theory is applied to several typical topics sound waves shock waves etc and is compared with experimental data From a mathematical point of view RET can be regarded as a theory of hyperbolic symmetric systems of which it is possible to conduct a qualitative analysis The book represents a valuable resource for applied mathematicians physicists and engineers offering powerful models for many potential applications such as reentering satellites into the atmosphere semiconductors and nanoscale phenomena

Chemical Thermodynamics: With Examples For Nonequilibrium Processes

Byung Chan Eu, Mazen Al-ghoul, 2010-08-06 Thermodynamics is an ever evolving subject This book aims to introduce to advanced undergraduate students and graduate students the fundamental ideas and notions of the first and second laws of thermodynamics in a manner unavailable in the usual textbooks on the subject of thermodynamics For example it treats the notions of unavailable work compensated and uncompensated heats and dissipation which make it possible to formulate the thermodynamic laws in more broadened forms than those in the conventional treatment of equilibrium thermodynamics It thus strives to prepare students for more advanced subjects of irreversible processes which are encountered in our everyday scientific activities In addition it also aims to provide them with functional and practical knowledge of equilibrium chemical thermodynamics of reversible processes in real fluids It discusses temperature work and heat thermodynamic laws equilibrium conditions and thermodynamic stability thermodynamics of reversible processes in gases and liquids in surfaces chemical equilibria reversible processes in electrolyte solutions and dielectrics in static electric and magnetic fields A couple of examples for irreversible processes associated with fluid flows and chemical pattern formation and wave propagations are discussed as examples for applications of broader treatments of the thermodynamic laws in the realm of irreversible phenomena

## **Generalized Thermodynamics The Thermodynamics Of Irreversible Processes And Generalized Hydrodynamics**

Book Review: Unveiling the Power of Words

In a global driven by information and connectivity, the power of words has are more evident than ever. They have the ability to inspire, provoke, and ignite change. Such could be the essence of the book **Generalized Thermodynamics The Thermodynamics Of Irreversible Processes And Generalized Hydrodynamics**, a literary masterpiece that delves deep into the significance of words and their effect on our lives. Written by a renowned author, this captivating work takes readers on a transformative journey, unraveling the secrets and potential behind every word. In this review, we will explore the book is key themes, examine its writing style, and analyze its overall impact on readers.

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