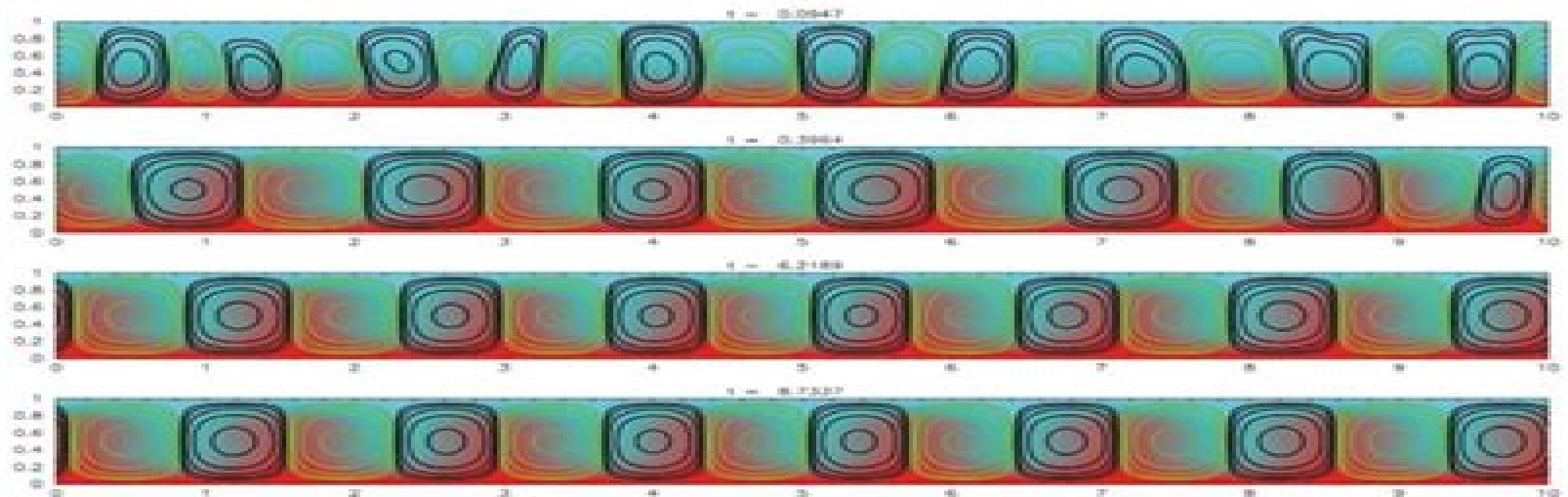


Michael Bestehorn

NON-EQUILIBRIUM THERMODYNAMICS

ENTROPY, HEAT AND MASS TRANSFER



Non Equilibrium Thermodynamics

Ilya Prigogine



Non Equilibrium Thermodynamics:

Non-equilibrium Thermodynamics Sybren Ruurds de Groot, Peter Mazur, 1984-01-01 Classic monograph treats the irreversible processes and phenomena of thermodynamics non equilibrium thermodynamics Covers statistical foundations and applications of the field with special chapters on fluctuation theory theory of stochastic processes kinetic theory of gases derivation of the Onsager reciprocal relations more 4 black and white illustrations Non-Equilibrium Thermodynamics Michael Bestehorn, 2024-06-04 Transport and diffusion processes are central in numerous scientific and technical applications Prominent examples are the temperature distribution in continuous media the flow of liquids or gases the dynamics of reaction diffusion systems or the concentration distributions in mixtures The theoretical and numerical description of these systems is based on partial differential equations The theory of non equilibrium thermodynamics provides a frame to derive these equations from basic conservation laws and first principles The first part of the textbook discusses the concept of equilibrium thermodynamics and its generalization to systems in local equilibrium Thermodynamic fluxes are defined and caused by generalized forces Finally linear relations the Onsager relations between fluxes and forces allow for a closed description In this way conservation equations for mass continuity momentum Euler or Navier Stokes and energy temperature are derived and solved analytically or numerically for several examples The second part is based on the kinetic gas theory describing a classical many particle system At the example of a perfect gas the conservation equations derived phenomenologically in the first part are thereby put on statistical grounds The textbook addresses advanced Bachelor or Master students of physics mechanical engineering and applied mathematics Aspects Of Non-equilibrium Thermodynamics: Lectures On Fundamentals And Methods Wolfgang Muschik, 1989-11-01 In six lectures aspects of modern non equilibrium thermodynamics of discrete systems as well as continuum theoretical concepts are represented Starting out with survey and introduction state spaces are defined the existence of internal energy is investigated and Clausius inequality including negative absolute temperature is derived by diagram technique Non equilibrium contact quantities such as contact temperature the dynamic analogue of thermostatic temperature and chemical potentials are phenomenologically defined and quantumstatistically founded Using Clausius inequality the existence of non negative entropy production is proved which allows to formulate a dissipation inequality in continuum thermodynamics The transition between thermodynamics of discrete systems and continuum thermodynamics with respect to contact quantities is considered Different possibilities of exploiting the dissipation inequality for getting constraints for constitutive equations are discussed Finally hyperbolic heat conduction in non extended thermodynamics is treated **Non-equilibrium Thermodynamics and Statistical Mechanics** Phil Attard, 2012-10-04 This title builds from basic principles to advanced techniques and covers the major phenomena methods and results of time dependent systems It is a pedagogic introduction a comprehensive reference manual and an original research monograph **Understanding Non-equilibrium Thermodynamics** Georgy Lebon, David

Jou, 2008-01-12 Our time is characterized by an explosion of information and by an acceleration of knowledge. A book cannot compete with the huge amount of data available on the Web. However, to assimilate all this information, it is necessary to structure our knowledge in a useful conceptual framework. The purpose of the present work is to provide such a structure for students and researchers interested by the current state of the art of non-equilibrium thermodynamics. The main features of the book are a concise and critical presentation of the basic ideas illustrated by a series of examples selected not only for their pedagogical value but also for the perspectives offered by recent technological advances. This book is aimed at students and researchers in physics, chemistry, engineering, material sciences and biology. We have been guided by two apparently antagonistic objectives: generality and simplicity. To make the book accessible to a large audience of non-specialists, we have decided about a simplified but rigorous presentation. Emphasis is put on the underlying physical background without sacrificing mathematical rigour, the several formalisms being illustrated by a list of examples and problems. Altogether, this work has been guided by the formula: Get more from the less, with the purpose to make a maximum of people aware of a maximum of knowledge from a minimum of basic tools. Besides being an introductory text, our objective is to present an overview as general as possible of the more recent developments in non-equilibrium thermodynamics, especially beyond the local equilibrium description.

Non-equilibrium Thermodynamics and the Production of Entropy Axel Kleidon, Ralph D. Lorenz, 2004-11-18 The present volume studies the application of concepts from non-equilibrium thermodynamics to a variety of research topics. Emphasis is on the Maximum Entropy Production (MEP) principle and applications to Geosphere-Biosphere couplings. Written by leading researchers from a wide range of backgrounds, the book presents a first coherent account of an emerging field at the interface of thermodynamics, geophysics and life sciences.

Non-Equilibrium Thermodynamics with Application to Solids W. Muschik, 2014-05-04 This book puts emphasis on developing the basic ideas behind the different approaches to non-equilibrium thermodynamics and on applying them to solids. After a survey about different approaches, an introduction to their common fundamentals is given in the first part. In the second part, the mechanical behavior of special materials such as viscoelasticity, viscoplasticity, viscoelastoplasticity and thermoplasticity are discussed. The third part is devoted to extended thermodynamics. The basic ideas, phenomenological as well as microscopical, are reviewed and applied to thermo- and viscoelastic materials. Electromagnetic solids showing dielectric relaxation such as ceramics showing electromagnetomechanical hysteresis and superconductivity are treated in the fourth part. In the last part, stability with regard to constitutive equations is investigated. Especially, stability of quasi-static processes and of elastic-plastic systems are discussed.

Non-equilibrium Thermodynamics and Physical Kinetics Halid Bikkın, Igor I. Lyapilın, 2021-08-02 This new edition covers contemporary directions of non-equilibrium statistical mechanics as well as classical methods of kinetics. Supplementary material on the non-equilibrium statistical operator (NSO) method for calculating kinetics coefficients describing spintronics is included in this new addition. This book is an easy-to-read text describing the fundamentals of the field.

Maximum

Dissipation Non-Equilibrium Thermodynamics and its Geometric Structure Henry W. Haslach Jr.,2011-01-15

Maximum Dissipation Non Equilibrium Thermodynamics and its Geometric Structure explores the thermodynamics of non equilibrium processes in materials The book develops a general technique created in order to construct nonlinear evolution equations describing non equilibrium processes while also developing a geometric context for non equilibrium thermodynamics Solid materials are the main focus in this volume but the construction is shown to also apply to fluids This volume also Explains the theory behind thermodynamically consistent construction of non linear evolution equations for non equilibrium processes Provides a geometric setting for non equilibrium thermodynamics through several standard models which are defined as maximum dissipation processes Emphasizes applications to the time dependent modeling of soft biological tissue Maximum Dissipation Non Equilibrium Thermodynamics and its Geometric Structure will be valuable for researchers engineers and graduate students in non equilibrium thermodynamics and the mathematical modeling of material behavior

Nonequilibrium Statistical Thermodynamics Bernard H. Lavenda,2019-04-17 This book develops in detail the statistical foundations of nonequilibrium thermodynamics based on the mathematical theory of Brownian motion Author Bernard H Lavenda demonstrates that thermodynamic criteria emerge in the limit of small thermal fluctuations and in the Gaussian limit where means and modes of the distribution coincide His treatment assumes the theory of Brownian motion to be a general and practical model of irreversible processes that are inevitably influenced by random thermal fluctuations This unifying approach permits the extraction of widely applicable principles from the analysis of specific models Arranged by argument rather than theory the text is based on the premises that random thermal fluctuations play a decisive role in governing the evolution of nonequilibrium thermodynamic processes and that they can be viewed as a dynamic superposition of many random events Intended for nonmathematicians working in the areas of nonequilibrium thermodynamics and statistical mechanics this book will also be of interest to chemical physicists condensed matter physicists and readers in the area of nonlinear optics

Non-Equilibrium Thermodynamics in Multiphase Flows Roberto Mauri,2012-11-08 Non equilibrium thermodynamics is a general framework that allows the macroscopic description of irreversible processes This book introduces non equilibrium thermodynamics and its applications to the rheology of multiphase flows The subject is relevant to graduate students in chemical and mechanical engineering physics and material science This book is divided into two parts The first part presents the theory of non equilibrium thermodynamics reviewing its essential features and showing when possible some applications The second part of this book deals with how the general theory can be applied to model multiphase flows and in particular how to determine their constitutive relations Each chapter contains problems at the end the solutions of which are given at the end of the book No prior knowledge of statistical mechanics is required the necessary prerequisites are elements of transport phenomena and on thermodynamics The style of the book is mathematical but nonetheless it remains very readable and anchored in the physical world rather than becoming too abstract Though it is up to

date and includes recent important developments there is a lot of classical material in the book albeit presented with unprecedented clarity and coherence The first six chapters are actually a very good introduction to the theory underlying many phenomena in soft matter physics beyond the focus on flow and transport of the later chapters of the book Prof Richard A L Jones FRS Pro Vice Chancellor for Research and Innovation University of Sheffield *Non-equilibrium Thermodynamics Of Heterogeneous Systems* Signe Kjelstrup, Dick Bedeaux, 2008-02-22 The purpose of this book is to encourage the use of non equilibrium thermodynamics to describe transport in complex heterogeneous media With large coupling effects between the transport of heat mass charge and chemical reactions at surfaces it is important to know how one should properly integrate across systems where different phases are in contact No other book gives a prescription of how to set up flux equations for transports across heterogeneous systems The authors apply the thermodynamic description in terms of excess densities developed by Gibbs for equilibrium to non equilibrium systems The treatment is restricted to transport into and through the surface Using local equilibrium together with the balance equations for the surface expressions for the excess entropy production of the surface and of the contact line are derived Many examples are given to illustrate how the theory can be applied to coupled transport of mass heat charge and chemical reactions in phase transitions at electrode surfaces and in fuel cells Molecular simulations and analytical studies are used to add insight *Non-equilibrium Thermodynamics* Andrea Di Vita, 2022-09-13 The importance of thermodynamics particularly its Second Principle to all branches of science in which systems with very large numbers of particles are involved cannot be overstated This book offers a panoramic view of non equilibrium thermodynamics Perhaps the two most attractive aspects of thermodynamic equilibrium are its stability and its independence from the specifics of the particular system involved Does an equivalent exist for non equilibrium thermodynamics Many researchers have tried to describe such stability in the same way that the Second Principle describes the stability of thermodynamic equilibrium and failed Most of them invoked either entropy or its production rate or some modified version of it In their efforts however those researchers have found a lot of useful stability criteria for far from equilibrium states These criteria usually take the form of variational principles in terms of the minimization or maximization of some quantity The aim of this book is to discuss these variational principles by highlighting the role of macroscopic quantities This book is aimed at a wider audience than those most often exposed to the criteria described i e undergraduates in STEM as well as the usual interested and invested professionals *Nonequilibrium Thermodynamics* Yasar Demirel, 2007-10-10 Natural phenomena consist of simultaneously occurring transport processes and chemical reactions These processes may interact with each other and lead to instabilities fluctuations and evolutionary systems This book explores the unifying role of thermodynamics in natural phenomena *Nonequilibrium Thermodynamics* Second Edition analyzes the transport processes of energy mass and momentum transfer processes as well as chemical reactions It considers various processes occurring simultaneously and provides students with more realistic analysis and modeling by accounting

possible interactions between them This second edition updates and expands on the first edition by focusing on the balance equations of mass momentum energy and entropy together with the Gibbs equation for coupled processes of physical chemical and biological systems Every chapter contains examples and practical problems to be solved This book will be effective in senior and graduate education in chemical mechanical systems biomedical tissue biological and biological systems engineering as well as physical biophysical biological chemical and biochemical sciences Will help readers in understanding and modelling some of the coupled and complex systems such as coupled transport and chemical reaction cycles in biological systems Presents a unified approach for interacting processes combines analysis of transport and rate processes Introduces the theory of nonequilibrium thermodynamics and its use in simultaneously occurring transport processes and chemical reactions of physical chemical and biological systems A useful text for students taking advanced thermodynamics courses

Non-equilibrium Thermodynamics Istvan Gyarmati, 2013-03-13 Although nearly three years have elapsed since the publication of this work in Hungarian it was decided to publish the English edition in the same form as the original apart from some minor modifications Since recent research has been directed to the development of an exact theory of non linear irreversible processes we suggest to readers interested in similar tasks such as the continuation of this book that they should study some new publications On the most general form of the Thermodynamic Integral Principle *Z phys Chem* 239 1968 133 and particularly On the Governing Principle of Dissipative Processes *Ann Phys* 7 1969 23 I have to thank my wife and Mr W F HEINZ for the translation of the very concise Hungarian text I also wish to express my gratitude to Dr L KARADI and Mr Gy VINCZE for reading the typescript with such care and to Mrs A R6SZLER who typed the manuscript with great patience I am deeply indebted to Professor ISTVAN SZABO for making this edition available so quickly and for including my work in the Engineering Science Library Finally I would like to express my thanks to Springer Verlag for the excellent edition and to the editorial staff for their readiness to meet my wishes

Nonlinear Nonequilibrium

Thermodynamics II Rouslan L. Stratonovich, 2013-11-11 This two volume work gives the first detailed coherent treatment of a relatively young branch of statistical physics nonlinear nonequilibrium and fluctuational dissipative thermodynamics This area of research has taken shape rather recently its development began in 1959 The earlier theory linear nonequilibrium thermodynamics is in principle a simple special case of the new theory Despite the fact that the title of the book includes the word nonlinear it also covers the results of linear nonequilibrium thermodynamics The presentation of the linear and nonlinear theories is done within a common theoretical framework that is not subject to the linearity condition The author hopes that the reader will perceive the intrinsic unity of this discipline the uniformity and generality of its constituent parts This theory has a wide variety of applications in various domains of physics and physical chemistry enabling one to calculate thermal fluctuations in various nonlinear systems The book is divided into two volumes Fluctuation dissipation theorems or relations of various types linear quadratic and cubic classical and quantum are considered in the first volume There one

encounters the Markov and non Markov fluctuation dissipation theorems FDTs theorems of the first second and third kinds Nonlinear FDTs are less known than their linear counterparts The present second volume of the book deals with the advanced theory It consists of four chapters The connection and interdependence of the material in the various chapters of both volumes are illustrated in the accompanying diagram

Nonequilibrium Thermodynamics Yasar Demirel, Vincent Gerbaud, 2018-11-24 Nonequilibrium Thermodynamics Transport and Rate Processes in Physical Chemical and Biological Systems Fourth Edition emphasizes the unifying role of thermodynamics in analyzing natural phenomena This updated edition expands on the third edition by focusing on the general balance equations for coupled processes of physical chemical and biological systems Updates include stochastic approaches self organization criticality ecosystems mesoscopic thermodynamics constructal law quantum thermodynamics fluctuation theory information theory and modeling the coupled biochemical systems The book also emphasizes nonequilibrium thermodynamics tools such as fluctuation theories mesoscopic thermodynamic analysis information theories and quantum thermodynamics in describing and designing small scale systems Provides a useful text for seniors and graduate students from diverse engineering and science programs Highlights the fundamentals of equilibrium thermodynamics transport processes and chemical reactions Expands the theory of nonequilibrium thermodynamics and its use in coupled transport processes and chemical reactions in physical chemical and biological systems Presents a unified analysis for transport and rate processes in various time and space scales Discusses stochastic approaches in thermodynamic analysis including fluctuation and information theories mesoscopic nonequilibrium thermodynamics constructal law and quantum thermodynamics

Beyond the Second Law Roderick C. Dewar, Charles H. Lineweaver, Robert K. Niven, Klaus Regenauer-Lieb, 2013-12-02 The Second Law a cornerstone of thermodynamics governs the average direction of dissipative non equilibrium processes But it says nothing about their actual rates or the probability of fluctuations about the average This interdisciplinary book written and peer reviewed by international experts presents recent advances in the search for new non equilibrium principles beyond the Second Law and their applications to a wide range of systems across physics chemistry and biology Beyond The Second Law brings together traditionally isolated areas of non equilibrium research and highlights potentially fruitful connections between them with entropy production playing the unifying role Key theoretical concepts include the Maximum Entropy Production principle the Fluctuation Theorem and the Maximum Entropy method of statistical inference Applications of these principles are illustrated in such diverse fields as climatology cosmology crystal growth morphology Earth system science environmental physics evolutionary biology and technology fluid turbulence microbial biogeochemistry plasma physics and radiative transport using a wide variety of analytical and experimental techniques Beyond The Second Law will appeal to students and researchers wishing to gain an understanding of entropy production and its central place in the science of non equilibrium systems both in detail and in terms of the bigger picture

Non-equilibrium Thermodynamics Of Heterogeneous Systems (Second Edition) Signe

Kjelstrup, Dick Bedeaux, 2020-08-27 This book utilizes non equilibrium thermodynamics to describe transport in complex heterogeneous media There are large coupling effects between transport of heat mass charge and chemical reactions at surfaces and it is important to know how one should properly integrate across systems where different phases are in contact There is no other book available today that gives a prescription of how to set up flux equations for transports across heterogeneous systems **Non-Equilibrium Statistical Mechanics** Ilya Prigogine, 2017-02-27 Groundbreaking monograph by Nobel Prize winner for researchers and graduate students covers Liouville equation anharmonic solids Brownian motion weakly coupled gases scattering theory and short range forces general kinetic equations more 1962 edition

Unveiling the Power of Verbal Beauty: An Emotional Sojourn through **Non Equilibrium Thermodynamics**

In a world inundated with monitors and the cacophony of instantaneous communication, the profound power and psychological resonance of verbal beauty often disappear into obscurity, eclipsed by the constant barrage of sound and distractions. However, set within the lyrical pages of **Non Equilibrium Thermodynamics**, a charming function of literary elegance that pulses with raw feelings, lies an remarkable journey waiting to be embarked upon. Written by a virtuoso wordsmith, this magical opus books readers on a mental odyssey, lightly revealing the latent potential and profound influence stuck within the complex web of language. Within the heart-wrenching expanse of the evocative analysis, we shall embark upon an introspective exploration of the book is main themes, dissect their interesting writing style, and immerse ourselves in the indelible effect it leaves upon the depths of readers souls.

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