

Dissipative Structures and Weak Turbulence

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in: *Chaos — The Interplay Between Stochastic and Deterministic Behaviour*
P. Garbaczewski *et al* eds.,
Springer Lecture Notes in Physics, vol. 457
pp. 257-272 (Springer, 1995)

Abstract

We present a brief overview of the current understanding of temporal and spatio-temporal chaos, both termed *weak turbulence* according to the context [1]. The process which allows one to reduce the primitive problem to a low-dimensional dynamical system is discussed. It turns out to be appropriate as long as *confinement effects* are sufficiently strong to freeze the space dependence of unstable modes, hence temporal chaos only. Otherwise modulated patterns arise, yielding genuine space-time chaos. The corresponding theory rests on *envelope equations* providing a useful framework for weak turbulence in a globally super-critical setting. *Spatio-temporal intermittency* analyzed next is the relevant scenario in the sub-critical case. Finally, the connection with hydrodynamic turbulence and the more general relevance of some of the ideas developed here are examined.

1 On the 'nature' of turbulence

Turbulence presents itself as a wildly fluctuating flow regime the understanding of which is important for many fields of basic and applied research, as its mixing and transfer properties are strongly enhanced with respect to their molecular counterparts. Following the suggestion of Landau [2]a, one can think of turbulence as resulting from a superposition of an infinite number of oscillation modes (Fig. 1, top), the randomness of the regime arising from the absence of knowledge of the initial phase of each mode. However, as stressed originally by Ruelle and Takens [2]b, this idea of a mere superposition is in some sense too linear. In fact, nonlinear interactions among a small number of modes generically yield chaotic behavior characterized by a decay of correlations that more appropriately describes a turbulent regime (Fig. 1, bottom) [3].

The main consequence of this remark is to place the problem of the transition to turbulence into the mathematical setting of the theory of dynamical systems, i.e. systems of ordinary

Dissipative Structures And Weak Turbulence

**P. Colinet (Pierre.), Jean Claude
Legros, Manuel G. Velarde**



Dissipative Structures And Weak Turbulence:

Dissipative Structures and Weak Turbulence, 2014-06-28 Dissipative Structure and Weak Turbulence provides an understanding of the emergence and evolution of structures in macroscopic systems This book discusses the emergence of dissipative structures Organized into 10 chapters this book begins with an overview of the stability of a fluid layer with potentially unstable density stratification in the field of gravity This text then explains the theoretical description of the dynamics of a given system at a formal level Other chapters consider several examples of how such simplified models can be derived complicating the picture progressively to account for other phenomena This book discusses as well the theory and experiments on plain Rayleigh Bnard convection by setting first the theoretical frame and deriving the analytical solution of the marginal stability problem The final chapter deals with building a bridge between chaos as studied in weakly confined systems and more advanced turbulence in the most conventional sense This book is a valuable resource for physicists

Lectures on Non-linear Plasma Kinetics Vadim N. Tsytovich, 2012-12-06 Lectures on Non linear Plasma Kinetics is an introduction to modern non linear plasma physics showing how many of the techniques of modern non linear physics find applications in plasma physics and how in turn the results of this research find applications in astrophysics Emphasis is given to explaining the physics of nonlinear processes and the radical change of cross sections by collective effects The author discusses new nonlinear phenomena involving the excitation of coherent nonlinear structures and the dynamics of their random motions in relation to new self organization processes He also gives a detailed description of applications of the general theory to various research fields including the interaction of powerful radiation with matter controlled thermonuclear research etc

The Dynamics of Modulated Wave Trains A. Doelman, 2009 The authors investigate the dynamics of weakly modulated nonlinear wave trains For reaction diffusion systems and for the complex Ginzburg Landau equation they establish rigorously that slowly varying modulations of wave trains are well approximated by solutions to the Burgers equation over the natural time scale In addition to the validity of the Burgers equation they show that the viscous shock profiles in the Burgers equation for the wave number can be found as genuine modulated waves in the underlying reaction diffusion system In other words they establish the existence and stability of waves that are time periodic in appropriately moving coordinate frames which separate regions in physical space that are occupied by wave trains of different but almost identical wave number The speed of these shocks is determined by the Rankine Hugoniot condition where the flux is given by the nonlinear dispersion relation of the wave trains The group velocities of the wave trains in a frame moving with the interface are directed toward the interface Using pulse interaction theory the authors also consider similar shock profiles for wave trains with large wave number that is for an infinite sequence of widely separated pulses The results presented here are applied to the FitzHugh Nagumo equation and to hydrodynamic stability problems

Chemical Waves and Patterns Raymond Kapral, K. Showalter, 2012-12-06 The concept of macroscopic waves and patterns developing from chemical reaction

coupling with diffusion was presented apparently for the first time at the Main Meeting of the Deutsche Bunsengesellschaft für Angewandte Physikalische Chemie held in Dresden Germany from May 21 to 24 1906 Robert Luther Director of the Physical Chemistry Laboratory in Leipzig read his paper on the discovery and analysis of propagating reaction diffusion fronts in autocatalytic chemical reactions [1, 2] He presented an equation for the velocity of these new waves $V = kDC / (1 + 2kDC)$ and asserted that they might have features in common with propagating action potentials in nerve cell axons During the discussion period a skeptic in the audience voiced his objections to this notion It was none other than the great physical chemist Walther Nernst who believed that nerve impulse propagation was far too rapid to be akin to the propagating fronts He was also not willing to accept Luther's wave velocity equation without a derivation Luther stood his ground saying his equation was a simple consequence of the corresponding differential equation He described several different autocatalytic reactions that exhibit propagating fronts recommending gelling the solution to prevent convection and even presented a demonstration the autocatalytic permanganate oxidation of oxalate was carried out in a test tube with the image of the front projected onto a screen for the audience

Spontaneous Formation of Space-Time Structures and Criticality T. Riste, David Sherrington, 2012-12-06 This volume contains the proceedings of a NATO Advanced Study Institute held at Geilo Norway between 2-12 April 1991 This institute was the eleventh in a series held biannually at Geilo on the subject of phase transitions It was intended to capture the latest ideas on self-organized patterns and criticality The Institute brought together many lecturers students and active researchers in the field from a wide range of NATO and non NATO countries The main financial support came from the NATO Scientific Affairs Division but additional support was obtained from the Norwegian Research Council for Science and the Humanities NAVF and Institutt for energi teknikk The organizers would like to thank all these contributors for their help in promoting an exciting and rewarding meeting and in doing so are confident that they echo the appreciation of all the participants In cooperative equilibrium systems physical states are described by spatio-temporal correlation functions The intimate connection between space and time correlations is especially apparent at the critical point the second order phase transition where the spatial range and the decay time of the correlation function both become infinite The salient features of critical phenomena and the history of the development of this field of science are treated in the first chapter of this book

Physics Briefs, 1992

Structure, Energetics and Dynamics of the Corona and the Heliosphere During the Rising Phase of the 23rd Solar Cycle S. Gibson, Steven T. Suess, 2002

Engineering Applications of Dynamics of Chaos W. Szemplinska-Stupnicka, H. Troger, 2014-05-04 The treatment of chaotic dynamics in mathematics and physics during last two decades has led to a number of new concepts for the investigation of complex behavior in nonlinear dynamical processes The aim of the CISM course Engineering Applications of Dynamics of Chaos of which this is the proceedings volume was to make these concepts available to engineers and applied scientists possessing only such modest knowledges in mathematics which are usual for engineers for example graduating

from a Technical University The contents of the articles contributed by leading experts in this field cover not only theoretical foundations and algorithmic and computational aspects but also applications to engineering problems In the first article an introduction into the basic concepts for the investigation of chaotic behavior of dynamical systems is given which is followed in the second article by an extensive treatment of approximative analytical methods to determine the critical parameter values describing the onset of chaos The important relation between chaotic dynamics and the phenomenon of turbulence is treated in the third article by studying instabilities various fluid flows In this contribution also an introduction into interesting phenomenon of pattern formation is given The fourth and fifth articles present various applications to nonlinear oscillations including roll motions of ships rattling oscillations in gear boxes tumbling oscillations of satellites flutter motions of fluid carrying pipes and vibrations of robot arms In the final article a short treatment of hyperchaos is given

Nonlinear Dynamics of Surface-Tension-Driven Instabilities P. Colinet (Pierre.), Jean Claude Legros, Manuel G. Velarde, 2001-08-15 This book provides the reader with a progressive and complete insight into a vast field of nonlinear physics While the introductory first chapter describes nonlinear dissipative structures at a general level in fluid mechanics as well as in other fields the second chapter contains a summary of the derivation of basic equations with emphasis on boundary conditions prevailing at interfaces Chapter 3 is devoted to linear stability analyses and identification of basic instability modes The weakly nonlinear theories are presented in Chapter 4 monotonic instabilities Chapter 5 oscillatory instabilities and Chapter 6 multiple bifurcations Finally results on strongly nonlinear surface tension driven convection and transitions to interfacial turbulence are contained in Chapter 7

Speech Coding and Synthesis W. Bastiaan Kleijn, Kuldeep K. Paliwal, 1995 Hardbound The fields of speech coding and synthesis have developed rapidly over the last decade Text to text speech systems now produce reasonable quality speech and currently available speech coders can transmit good quality speech at below 10kb/s This in combination with the ever increasing speed of microprocessors and signal processing hardware has resulted in a large number of practical applications These applications in turn have stimulated research and the number of papers published on speech coding and synthesis have proliferated rapidly Reflecting periodically on such developments have inspired the publication of this book Topics such as the effect of cross channel errors on coded speech and the determination of a proper pitch contour for synthesized speech are included Both readers unfamiliar with the fields of speech coding and speech synthesis as well as those already working within the areas will find the book of interest

Advances in Chemical Physics, Volume 91 Ilya Prigogine, Stuart A. Rice, 1958 The Advances in Chemical Physics series provides the chemical physics and physical chemistry fields with a forum for critical authoritative evaluations of advances in every area of the discipline Filled with cutting edge research reported in a cohesive manner not found elsewhere in the literature each volume of the Advances in Chemical Physics series serves as the perfect supplement to any advanced graduate class devoted to the study of chemical physics

Nonlinear and Turbulent Processes in Physics R. Z. Sagdeev, 1984 Nonlinear Effects in

Plasma Physics, Astrophysics, and Elementary Particle Theory R. Z. Sagdeev,1984 *Journal of Physics A* ,2002 Focuses on fundamental mathematical and computational methods underpinning physics Relevant to statistical physics chaotic and complex systems classical and quantum mechanics classical and quantum integrable systems and classical and quantum field theory **Innovations in DNA Analysis Device Technology** Madhavi Krishnan,2004 **Proceedings** ,2001
Proceedings of the Ninth Symposium on Energy Engineering Sciences ,1991 Bulletin of the Russian Academy of Sciences ,2005 Journal de Physique ,1992 *Il Nuovo cimento della Società italiana di fisica* ,1992

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