J. Fluid Mech. (2001), *vol.* 447, *pp.* 409–411.
Printed in the United Kingdom

BOOK REVIEWS

Evolution of Spontaneous Structures in Dissipative Continuous Systems. Edited by F. H. Busse & S. C. Müller. Springer, 1998. 583 pp. ISBN 3-540-65154-3. DM 139.90.

J. Fluid Mech. **447**, 2001, DOI: 10.1017/S0022112001216875

Pattern formation occurs in many systems in nature. Classic examples involve fluid instabilities driven by buoyancy, vibration or shear, but there are many others involving, for instance, electric or magnetic fields, chemical reactions, biological systems and even granular materials. While the physics of each problem may be different, there is enough mathematical similarity that a general nonlinear theory of pattern formation, or spontaneous formation of structure, has developed.

This edited volume aims to demonstrate, by providing numerous examples, that the common mathematical language of pattern formation can fruitfully be used to interpret the transition from order to disorder in a wide variety of physical systems. The book originated as part of a six-year programme on the 'Evolution of Spontaneous Structures in Dissipative Continuous Systems', funded by the Deutsche Forschungsgemeinschaft, and the intention was to review the current state of the field using the projects in the research programme as examples. Many, but not all, of the contributors to the volume were part of the programme, but not all projects were included in the volume.

The book is made up of two main parts. The first fifth or so is a review article 'Mathematical tools for pattern formation' by Dangelmayer and Kramer, providing the background mathematical structure for the remainder of the volume. There are two main streams within the mathematical theory, and which one is relevant depends crucially on the symmetry of the physical system under consideration. Closed experimental systems, or numerical calculations posed in periodic domains, will result in finite sets of ordinary differential equations (ODEs), the range of validity of which decreases as the size of the system increases. Open-flow experiments, or calculations performed in large (strictly speaking, infinite) domains, result in sets of partial differential equations (PDEs), typically of the Ginzburg–Landau type. This dichotomy is reflected in the structure of the first review article: the first half discusses pattern-forming transitions in systems that have discrete or circular symmetries, and the second discusses the real and complex Ginzburg–Landau equation in one and two dimensions, and related equations.

The second, and much larger, part of the book touches on many important areas of pattern formation in fluid mechanical and related problems. In each chapter the authors describe their recent work and, to a greater or lesser extent, review the work of other researchers. The topics covered include: the Taylor–Couette system and others characterized by an axisymmetric experimental setup; binary fluid convection; pattern formation with through-flow; coherent structure formation in open flows; theoretical and experimental aspects of pattern formation in the Faraday wave experiment in both small and large containers; pattern formation in the presence of inhomogeneities in the background state; pattern formation in electrically driven smectic and nematic liquid crystals; spiral wave formation during surface catalysed and auto-catalytic chemical reactions; pattern formation in charge carriers in semi-conductors; pattern formation in granular materials; generation of magnetic fields in a laboratory dynamo; and the self-organised patterns of the slime-mould *Dictyostelium discoideum.* Many of the articles combine theoretical, numerical and experimental aspects and have lengthy lists of references.

Overall, the book is a remarkable achievement, bringing together as it does so many of the strands of research in so many different fields of physics and mathematics, and managing to present a digestible mixture of experiment and theory in almost every article. The quality of the individual articles is good overall but varies: some have been written as general reviews of the field, and so should be useful to a wide audience, while others are more restricted in scope and will have a shorter shelf-life. The review of developments in the Faraday wave experiment, by Müller, Friedrich and Papathanassiou, is particularly useful to me, but other readers will find interest in other places. I also thought it interesting to see the relative position of theory and experiment in different fields: in the Faraday problem, for instance, quantitative comparisons between the nonlinear theory and the observed experimental pattern are possible, while in electroconvection, even the linear theory is too difficult owing to the large number of material parameters.

The part of the book I find the least satisfying is the introductory review of the mathematical background: the scope is broad, but not enough space has been given to the review to do the topics justice, and many of the technical ideas need more explanation to make them intelligible. But I also think that an opportunity has been missed. As mentioned above, the first half of the review deals with finite-dimensional dynamics (ODEs) and the second with infinite-dimensional dynamics (PDEs) – there is much current interest in the boundary between these two, relevant to pattern formation in large but finite boxes. This would have been an ideal place for an exploration of topics such as the formation of quasi-patterns, which have orientational but not translational order.

The back cover states that the book 'addresses researchers but it could also be used as a text for graduate work'. I agree with the first part of this but not the second, though of course individual articles could be useful to those starting out in this field.

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Statistical Theory and Modeling for Turbulent Flows. By P. A. Durbin & B. A. Petterson-Reif. Wiley, 2001. 285 pp. ISBN 0471 497444. £29.95.

J. Fluid Mech. **447**, 2001, DOI: 10.1017/S0022112001226871

Turbulence is of course of great technological importance because of the large effects it has on the flows in which it occurs. The prediction of these effects in a flow of interest is one of the primary concerns of applied fluid dynamicists, and it is often the case that the uncertainties in a fluid dynamic calculation are dominated by uncertainties in the turbulence models. Therefore, one can argue that for many students of fluid dynamics, Reynolds-averaged turbulence models, their approximations and limitations are of most relevance in the study of turbulence.

In this context, the new book *Statistical Theory and Modelling for Turbulent Flows* by Durbin and Petterson-Reif is a particularly welcome addition to the turbulence literature. This text is designed to explain, motivate and occasionally debunk current techniques for the Reynolds-averaged (one-point) modelling of turbulent flows. Most of the material in the text will be accessible to graduate students with a basic background in fluid mechanics and mathematics. But the authors' compilation of and insight into the literature of one-point Reynolds-averaged turbulence modelling will be valuable to the turbulence research community as well.

The book is organized in three parts, with distinctly different goals and subject matter. Part I is a presentation of fundamentals, including mathematical and statistical background, the Reynolds-averaged description of turbulence and the phenomenology and structure of turbulent flows. The discussion of turbulence phenomena is in places a bit cursory. For example, the logarithmic layer in wall-bounded shear layers is discussed in the context of a mixing-length description of the eddy viscosity, with only a brief mention of the overlap region and intermediate asymptotics. Similar comments apply to the treatment of free shear flows and turbulence structure. Thus, the first part of the book is not a comprehensive treatment of the topics covered. Rather, it appears calculated to provide the student with the background needed to approach single-point modelling closures, which is the subject of the second part.

In part II, which is the heart of the book, the authors provide an insightful exposition of a variety of commonly used turbulence models. Examples of each major class of model (e.g. one- and two-equation, eddy viscosity, Reynolds stress) are discussed, as are their ranges of validity. The discussion here is refreshingly frank. The weaknesses and shortcomings of the models are presented, often with cogent explanations of the physical reasons why the models fail in certain situations. For example, there is a nice explanation of the difficulties that the k–ϵ model encounters very near a wall. Throughout, it is pointed out that tuning of model constants to match specific cases is generally not a useful approach, since this does not address the underlying problems with the models.

The third and final part of the book is devoted to the spectral theory of homogeneous turbulence. While this topic is often the focus of an introduction to turbulence, in this book it is included primarily for completeness. As with the phenomenology in part I, the coverage here is not comprehensive. Indeed important topics such as the Kármán–Howarth equations and the Kolmogorov 4/5 law are absent. However, the authors' treatment gives the student a starting point for a deeper study of turbulence theory.

In summary, this book is not as comprehensive or deep a treatment of turbulence as one might like for some purposes, but it is an excellent introduction for those interested in Reynolds-averaged (one-point) turbulence modelling. It will be valuable to students beginning their study of turbulence. However, the book will also be of value to all of those interested in turbulence modelling, because of its comprehensive and insightful compilation of current one-point modelling techniques, and its extensive references to the turbulence modelling literature.

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