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REVIEWS

Turbulence Bidimensionnelle, *Journal de Mécanique Théorique et Appliquée, Vol. 2* (*numéro spéciale*). Gauthier-Villars, 1983. 292 pp. FF 162.00.

Two-dimensional turbulence serves as a prototype for many geophysical, plasma, and laboratory flows. These include planetary-scale geophysical flows, MHD flows constrained by strong external magnetic fields, and shear layers created behind splitter plates. Interest in this domain is, thus, considerably more than academic. This edition of *Journal de Mécanique* is devoted to an exposition and review of the field. The twelve papers contain a balance of theoretical discussions (closures and stability concepts), laboratory experiments, and numerical simulations. In addition, there are new experimental, theoretical, and numerical results. Several papers are reviews, written with care and containing appendices, so that the novice may become acquainted with both known results and mathematical techniques.

The volume begins with a short introduction to the subject by M. Lesieur, indicating first those flows in which two-dimensional idealizations may be profitable: rotating flows, MHD flows, mixing layers, and stably stratified flows. It contains a brief exposition of the concepts of inverse cascade, negative turbulent viscosity and enstrophy cascade, presented from the perspective of two-point closure.

The final paper of the volume – that of Larcheveque – is perhaps most related to the first, at least as far as its reliance on closure is concerned. Larcheveque examines in analytic detail the problem of dispersion of pairs of particles convected by two-dimensional turbulence. Her results give interesting analytic details, many of which cannot be surmised by analogy with three-dimensional turbulence. Nor can they be reproduced from simple dimensional analysis of two-dimensional flows.

The paper by Hopfinger, Griffith & Mory gives a careful analysis of laboratory experiments in rapidly rotating liquids. The experiments show clear evidence of energy-scale increasing and associated vortex pairing. The paper reports new results at larger Reynolds numbers, although inertial-range information is only briefly and qualitatively discussed.

Legras & Ghil study a low-order spectral model discussing the issue of chaos in two-dimensional flow. Their model consists of a spherical, low-order, spectral simulation of the equivalent barotropic model (of the quasi-geostrophic equations). The topographic effects of continentality are included at the lowest non-trivial level. As the strength of nonlinearity increases, their model displays a transition from stationary flow to periodic and then to chaotic flow typical of low-order spectral models: it is not shown, however, that their 25-mode truncated model adequately represents the structure of the flows. The paper contains an extended appendix nicely describing Hopf bifurcations and other essentials necessary for the study of chaotic systems.

The degree to which two-dimensional turbulence and its simple generalizations (geostrophic turbulence) correspond to atmospheric and oceanographic flows is examined in detail by McWilliams. The article contains a critical discussion of those conditions needed for simple concepts (such as two-dimensional and quasi-geostrophic turbulence) to be useful idealizations for geophysical flows. McWilliams also gives a relatively complete account of references applying geophysical turbulence concepts to planetary and oceanographic flows.

The paper by Browand & Ho contains a complete review of the mixing-layer experiments, a domain that is only quasi-two-dimensional, but which – the authors argue – may be invoked to understand the large scales during the initial phase. Two other articles – those of Huerre and Corcos – are devoted to this topic; Huerre studies the effects of solid walls (via finite-amplitude perturbation theory), and Corcos incorporates the effects of three-dimensionality. The numerical simulations of Corcos concerning the growth of streamwise vorticity and the pairing of vortices shows interesting verisimilitude, despite the quasi-linearity of the numerical calculations.

Two articles are devoted to two-dimensional MHD flows. [J.] Sommeria presents experimental results in mercury constrained by a strong transverse magnetic field. His results for the quasi-two-dimensional energy spectrum ($t^{-2}k^{-3}$) may encourage closure theorists; however, results reported later in this volume suggest that strictly two-dimensional flows have sufficient intermittency to preclude the kind of near-Gaussianity needed for such a spectrum. The article by Frisch, Pouquet, Sulem & Meneguzzi reviews numerical results for two-dimensional MHD turbulence. They also have new results at the highest resolution reported in this volume (512×512). Their work illustrates the value of such calculations in discovering new physics of the flow. Of importance here is the fact that the specific nonlinearities at small scales rule out – at these scales – simple closures that assume a near-Gaussian moment behaviour.

P. & C. Sulem present a review of mathematical results for two-dimensional inviscid flow. The major question addressed is whether the two-dimensional Euler equations have solutions whose vorticity remains bounded in cases in which the initial value is so bounded. The question is important in a practical sense: if true, it would suggest that dissipationless two-dimensional flows may be relevant idealizations of high-Reynolds-number two-dimensional flows. The condition is true for the simplest two-dimensional flows, but they show that it is not so for the Kelvin–Helmholtz problem. The presentation is aimed at the non-specialist, despite the use of technical estimates of norms for the vorticity magnitude. Other questions (for example, Do such theorems exist for two-dimensional convection?) are not discussed.

Basdevant & Sadourney discuss new sub-grid-scale methods specifically designed for two-dimensional flows, in which the presence of coherent structures is allowed. Their innovation, the method of anticipated tourbillion (the term anticipated vorticity seems the English expression now in vogue), allows for dissipation of enstrophy, without any dissipation of energy. It is an ingenious proposal, which appears a more logical basis for problems with boundaries than methods based on 'hyper viscosities' now popular in ocean-basin calculations (R. Salmon, private communication), although two technical questions come to mind: Is Galilean invariance strictly preserved? Do other methods (for example, that proposed by Lesieur and Sadourney, based on an earlier proposal of Kraichnan) yield essentially the same result, at least in a slowly evolving context, where near energy conservation is expected?

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Shorter Notices

Principles of Fluid Mechanics. By Jan F. Kreider. Allyn and Bacon Inc., 1985. 609 pp. £41.85.

This book is designed for an engineer's first course in fluid dynamics. Areas introduced include laminar internal and external flows, turbulent flows, compressible flows, fluid machinery and flow measurement. Numerous examples and problems are presented, amongst which are short computer programs and problems suitable for computation. The Navier–Stokes equations are intentionally not formally developed since only simplified forms are used.

Finite Elements in Fluids, Vol. VI. Edited by R. H. Gallagher, G. F. Carey, J. T. Oden and O. C. Zienkiewicz. Wiley, 1985. 358 pp. £42.50.

This volume contains eighteen selected articles which were presented at the Fifth International Conference on Finite Elements and Flow Problems held in Austin, Texas, during January 1984, exactly a decade after the meeting held in Swansea that initiated the series. During that period, there has been a development of the mathematical understanding of variational methods and finite-element approximation theory to the extent that many of the fundamental issues related to formulation and methodology are now well established. In the present volume the first few chapters are concerned with techniques for treating viscous and compressible flow problems. There follow several chapters which are specifically related to viscous flow computation. These include topics that range from the analysis of new elements to the development of continuation techniques for higher-Reynolds-number flows. The remaining chapters include applications to such diverse topics as oil recovery simulation, the extrusion of viscoelastic liquids, the growth of semiconductor crystals and shock-tube dynamics. Throughout, the advantages of the finite-element method in local mesh refinement and the treatment of boundary conditions on arbitrarily shaped boundaries are in evidence. However, one might note that turbulent-flow modelling is notable by its absence.

Diffusion. By E. L. Cussler. Cambridge University Press, 1985. 525 pp. £15.00 or $24.95.

This is a paperback edition of a text for students of chemical engineering and chemistry and biology which was first published in 1984. As is indicated by the sub-title, 'Mass transfer in fluid systems', the book is concerned with more than molecular diffusion. Mass transfer by convection and mass transfer across interfaces are discussed. The interaction of molecular diffusion and fluid convection is not analysed in all such cases; instead the mass transfer is represented in terms of a coefficient whose values are to be determined empirically. The book aims at being practical and helpful, and provides a great deal of detailed specific information about the dispersion of solutes or contaminants in moving fluids. It is written in a disarmingly modest style which students should find encouraging, but like many other books which avoid deductive analysis and physical reasoning it makes the subject seem rather complicated. In his desire to make undemanding statements the author sometimes goes too far, as on the first page where we find: 'In gases, diffusion progresses at a rate of about 10 cm in a minute; in liquids its rate is about 0.05 cm/min.'