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REVIEWS

Turbulence: A Tentative Dictionary. Edited by P. TABELING & O. CARDOSO. Plenum Press, 1994. 149 pp. ISBN 0-306-44998-6. $65.

It is rather adventurous to write a dictionary for a language that does not exist. The appropriate vocabulary and grammar of turbulence are still broadly unknown. However, the subject is filled with a multitude of concepts and technical terms that can be esoteric and quite disconcerting to the neophyte. This book is a *tentative* dictionary because it is the concepts and techniques involved in current approaches to turbulence that are often tentative. But it is also a tentative dictionary because it is incomplete. A more appropriate title may have been: Turbulence: A Physicist's Tentative Dictionary. This is because the reader will not find in this dictionary entries concerned with turbulent mixing, turbulence in multi-phase flows, transition to turbulence, modelling of turbulence, and industrial or environmental aspects of turbulence. The contents of this dictionary are organized alphabetically; however I feel that they fall under the following broad categories:

Obtention and Analysis of 3-D fluid turbulence data

This category covers the entries Extended self-similarity by Ciliberto, Hot-wire anemometry by Tsinober, Numerical simulations (direct) by Brachet, Probability density functions by Castaing, Structure function (in 3-D turbulence) by Gagne & Villermeaux, Velocity filaments by Couder, Douady & Cadot, and Wavelet analysis (of single-point turbulence data) by Arnéodo, Bacry & Muzy.

In these entries one can also read about structure functions (longitudinal or lateral, of even or odd order, Kolmogorov scaling and the Kolmogorov equation), multifractal analysis and singularity spectra, log-normal distributions and stretched exponential tails, the asymmetry of pressure and other histograms, invariant geometrical statistical relations, visualization with microbubbles, stretching and roll-up of layer-shaped shear regions and vortex breakdown.

2-D fluid turbulence

This heading covers the entries Decaying two-dimensional turbulence by Young, Experiments on 2-D turbulence (laboratory) by Tabeling, Numerical simulations of two-dimensional flows (turbulence and vortices) by Legras, and Statistical approach (to 2-D turbulence) by Pomeau.

These entries also include references to and discussions of Hamiltonian point-vortex dynamics, vortex merging, filamentation and stripping, hyperviscosity, robust invariants, quasi-two-dimensional flows, the Rossby number and the Taylor–Proudman theorem, the Hartmann number, coherent structures/vortices and negative temperatures, power laws for the decay process, forward, inverse and double cascade, and the maximization of the mixing entropy.

Intermittency and spatio-temporal chaos

This is a broad category which covers the entries Experiments in 1-D turbulence by Daviaud, Experiments on spatiotemporal chaos (in two dimensions) by Gollub, Intermittency (random cascade models, multifractality and large deviations) by Frisch, Optical turbulence by Newell & Zakharov, Phase turbulence by Chaté & Manneville, Predictability (in turbulence) by Paladin, Jensen & Vulpiani, Rayleigh–Bénard turbulent convection by Tilgner, Belmonte & Libchaber and Spatio-temporal intermittency by Chaté & Manneville.

These entries also include introductory mention or discussion of supercritical and subcritical transition to turbulence, strong and weak turbulence, spatio-temporal defects, amplitude, phase and defect mediated turbulence, the Rayleigh and Nusselt numbers, the Faraday, Küppers–Lortz, printer's and convective instabilities, the complex Ginzburg–Landau, Kuramoto–Sivashinski, forced-damped nonlinear Schrödinger and Kardar–Parisi–Zhang equations, dispersive chaos, low-dimensional and extensive chaos, Lyapunov exponents, electroconvecting nematics, directed percolation, thermal boundary layers, multiplicative random cascade models, large deviations, multifractality and negative dimensions.

Fundamentals

I chose to group under this heading the three remaining, though quite disparate, entries: Scaling in hydrodynamics where Kadanoff contrasts three different ways in which scaling is used in fluid mechanics (dimensional analysis leading to dimensionless numbers such as the Reynolds or Rayleigh numbers, similarity solutions and inertial range scaling), Shear flows (turbulent) where Van Atta contrasts different turbulent shear flows and briefly discusses local isotropy and Singularities (and turbulence) where Dombre & Pumir discuss the possibilities of finite time singularities in the Euler and Navier–Stokes equations.

Referring to 3-D fluid turbulence, Van Atta remarks in his entry's introduction: 'Each different kind of flow invariably introduces new effects and turbulence structures peculiar to itself, prompting the common observation that there is no single "*turbulence problem*" *per se*, there are only turbulent *flows* and each one is a different problem'. In spite of a perhaps meagre number of entries, this dictionary's outlook is in fact broader: it is a dictionary of the different turbulence problems that are encountered in different systems described mathematically by different partial differential equations (PDE) or systems of ordinary differential equations (ODE). In the world of PDEs and ODEs the Navier–Stokes equation and Navier–Stokes turbulence are but only one example. Nevertheless, it turns out that all entries in this dictionary gravitate around a few common themes, and it may be interesting to find that these central themes are intermittency, order/coherence and disorder.

By and large, most entries are informative, clearly written, contain a suitable introductory reference list and are even sometimes stimulating. With all its perhaps unavoidable limitations, this is a useful book, in particular for a doctoral student who wants to take his bearings.

J. C. Vassilicos

Macrotransport Processes. By H. Brenner & D. A. Edwards. Butterworth-Heinemann, 1993. 714 pp. £60.

The authors present an elegant theory of dispersion, inspired by the foundational work of G. I. Taylor and the method of moments developed by Aris, both in the mid-fifties. It provides a comprehensive effective-medium theory of transport phenomena in heterogeneous systems by rigorously analysing the random walk of a Brownian tracer through the microcontinuum. This analytical aspect is a distinguishing feature in comparison with the homogenization and statistical or volume-averaging theories. The book is principally aimed at engineers cognisant of conventional theories of transport phenomena and armed with a strong background in mathematical techniques. Readers able to follow the analysis will tend to find it unnecessarily lengthy and somewhat repetitive as the various dispersive situations are catalogued.

The application of macrotransport theory requires the existence of at least one 'global' coordinate, which is unbounded and enables the long-time limit to be properly achieved. A Brownian tracer particle is introduced at time $t = 0$ and the convective–diffusion equation for the probability function P describing its possible position at later times is written down. Two types of moment are then introduced successively. The local moments P_0, $\boldsymbol{P}_m (m \geqslant 1)$ are moments with respect to the global space and hence functions of t and the local coordinates. The total or global moments M_0, $\boldsymbol{M}_m$ are integrals over the local space of P_0, $\boldsymbol{P}_m$ and therefore depend on t only. The asymptotically linear behaviour of $\boldsymbol{M}_1$ and $\boldsymbol{M}_2$ determines the mean tracer velocity $\bar{\boldsymbol{U}}^*$ and the dispersion dyadic $\bar{\boldsymbol{D}}^*$, to which there are both molecular and convective contributions. The latter is neatly determined, according to a key aspect of the theory, by the $\boldsymbol{B}$-field, which depends on the local coordinates and is identified as arising from the time-independent contribution to the asymptotic behaviour of $\boldsymbol{P}_1$.

The book is divided into three parts. After an introduction, the basic concepts of macrotransport theory are described in chapter 2 in the context of dispersion of a solute within Poiseuille flow. Chapters 3 and 4 provide the core of the text, in which the macrotransport paradigm is constructed in turn for 'continuous' and 'discontinuous' systems, with the latter being particularly designated as spatially periodic systems, i.e. model porous media or laminated materials. Chapters 5–8 extend the theory to surface transport processes including adsorption, time periodic flows, hydrodynamic coupling in which particle shape effects are included by additional local coordinates, and the remarkable generalization to chemically reactive solutes. Turning from species to non-material dispersion phenomena, chapters 10 and 11 discuss heat and momentum. Finally, selected foundations of macrotransport theory are addressed in chapters 12 and 13, namely, the derivations of the Smoluchowski equation from the finer scale Fokker–Planck equation and the macrotransport paradigm from the primitive Langevin equation. There are reading lists and exercises for each chapter and the book concludes with a full bibliography and with both author and subject indices.

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