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REVIEWS

De la Causalité à la Finalité: A Propos de la Turbulence. By A. FAVRE, H. GUITTON, J. GUITTON, A. LICHNEWOWICZ & E. WOLF. Maloine Editeau, 1988. 256 pp. 150 FF.

This extremely unusual book presents (in French) a global philosophical analysis of order and chaos, determinism, finality, and turbulence, resulting from an unprecedented interdisciplinary collaboration between all disciplines of the French Academy (Science, Literature, Political Sciences). The authors are well known for their contributions to 'turbulence' in Fluid Mechanics (Alexandre Favre), Pure Mathematics (André Lichnerowicz), Philosophy (Jean Guitton), Economics (Henri Guitton), and Biology (Etienne Wolf). Their aim is to illustrate through various examples how chaotic and unpredictable systems encountered in fluid mechanics, meteorology and oceanograpy, theoretical physics, economics, embryology or genetics, obey a global determinism principle, called throughout the book finality or 'téléonomie', after Jacques Monod's famous essay *Le hasard et la nécessité* (Chance and necessity).

The first chapter presents the methods, concepts and languages. It introduces a discussion on deterministic and disordered chaos, determinism and predictability, and stresses that unpredictability is not incompatible with determinism. Of course, I fully agree with this statement.

The second chapter is a quite general and classical presentation of transition and turbulence in fluid mechanics, with emphasis put on the role of spatio-temporal correlations. It is also demonstrated (pp. 71–73) that turbulent flows fulfill the conditions of determinism; although I believe the result must be true, I do not think the derivation given here is valid, since it mixes up arguments concerning the possibility of reproducing experimentally laminar flows under the same general conditions with arguments based on a statistical stability of turbulent flows. To me, determinism of turbulence would require a uniqueness theorem for the solutions of Navier–Stokes equations at arbitrary times; up to now, and since Leray's 1934 work, the theorem holds only up to a finite time. The end of the chapter is devoted to 'mass-weighted averages', introduced by Favre, which are now widely used for compressible turbulence modelling. The third chapter is a well-documented presentation of the physics and dynamics of the Earth's atmosphere and oceans and their mutual interactions. Turbulence is presented as a necessary regulating phenomenon, developing in order to allow thermal fluctuations and the redistribution of pollutants, thus permitting the development and preservation of life on the Earth. I do not know whether the CO_2 problem or the Antarctic ozone hole fit this optimistic teleonomic point of view.

The fourth chapter is devoted to physical theories (group theory, variation calculus, special and generalized relativity, statistical and quantum mechanics). I have some difficulties in reconciling this chapter with the general purpose of the book, but it is, by itself, extremely clear and pleasant to read. For instance, Einstein's interpretation of gravitational forces in terms of space–time curvature effects (p. 151) is nicely illustrated.

I have no great expertise in biology and economics, and do not think I can say anything sensible about the fifth chapter (focusing on embryology and on the DNA double helix structure) and the sixth (dealing with bifurcations and turbulence in economic science). I must confess I do not see how to apply 'turbulence' theories to systems which are, up to now, too complicated to allow a description by well-posed nonlinear equations such as the Navier–Stokes equations in fluid turbulence for instance.

Examples of coherent structures (order) emerging from the development of initially random fluctuations (chaos) are quite familiar in fluid mechanics and turbulence, and are to be found in mixing layers, wakes, boundary layers, thermally convective flows or dissipative structures of isotropic turbulence for instance. Some of these ideas have been used for a long time to explain the structure of the Universe, the emergence of life or the evolution of human societies. A new philosophy based on these concepts, which can be traced back to Epicure and Lucretius, as was nicely stressed by Michel Serres in *Naissance de la Physique dans le Texte de Lucrèce*, has appeared during the last decade, as attested for instance by the Stanford interdisciplinary conference on 'Order and Disorder' in 1982, or by Prigogine and Stengers' book on *The New Alliance between Science and Humanism*. What is new in the book under review is an attempt to present these ideas in a rigorous and systematic philosophical vocabulary. The result is a book which is difficult to read and, it seems to me, lacks the unity it is seeking for. But, as stressed by the authors, this is only the first step. *De la Casualité à la Finalité: à propos de la Turbulence* is a demanding but rewarding book, which points out stimulating questions concerning nonlinear physics and philosophy of sciences. Any (French-reading) researcher interested in these fields should see it.

MARCEL LESIEUR

Random Seas and Design of Maritime Structures. By YOSHIMI GODA. University of Tokyo Press, 1985. 323 pp. ¥7000 or $37.50 or £27.50.

This book by Dr Goda is a systematic treatment of random wave theory from the point of view of the engineer. It was first published in Japanese in October 1977: the present edition was revised and translated into English in 1985. The book consists of two parts. Part I is aimed at practising engineers who are looking for answers to their daily problems. It contains chapters on the statistical properties and spectral form of sea waves, the transformation of random waves by refraction, reflection and diffraction, the design of breakwaters and sea walls and hydraulic models of irregular waves. Part II, which is concerned with the theory of random waves, is of particular interest to readers of this Journal. It contains chapters on the statistical theory of sea waves and techniques of wave analysis, including the estimation of the directional wave spectrum. There are interesting sections on wave groups and nonlinearities in waves: subjects on which Dr Goda is an authority.

Some important references are made to sources in Japanese which are not accessible to most readers in the West. Other references to information are not accorded their original, Western, source. For example, the well-known cosine-power form for directional spreading and the cloverleaf wave buoy both originated from work at the National Institute of Oceanography (now the Institute of Oceanographic Sciences Deacon Laboratory) in the UK.

The book is written in a clear style with well-produced figures and tables. The engineer will appreciate the useful examples with worked solutions to problems. The book will appeal to engineers concerned with coastal wave problems and to the research worker interested in random wave theory and statistics.

J. A. EWING

Rheology of Materials and Engineering Structures. By Z. Sobotka. Elsevier, 1984. 552 pp. $125.

I found the title of this book a little misleading in that the work is primarily concerned with the rheology of viscoelastic solids and the deformation of viscoelastic structures. There is little here for the polymer scientist with only a dozen or so pages devoted to non-Newtonian fluids. The book is essentially a compilation of the author's extensive work in the field over some thirty years. In it the author adopts his own unconventional approach to the subject and this is reflected in the bibliography.

The first four chapters are concerned with the rheology of small deformations. The material response is described by analogue models in which the usual elements, springs and dashpots, are supplemented to model the response of plastic bodies and such abstractions, introduced by the author, as the supple body, the strain-hardening body and the uni-directional bond. Linear one-dimensional stress–strain relationships are developed for combinations of the elements of increasing complexity, representing a wide range of material responses. The extension to two and three dimensions is by means of models in which the resultant stresses and strains in a representative volume are weighted averages of the stresses and strains in the individual elements.

Nonlinear rheology is introduced in chapter five initially through the author's notion of equivalent stresses and strains. In the latter half of this chapter the reader is introduced to the usual definitions of finite strains and frame-indifferent time derivations. Chapter six is concerned with the series expansions of functionals of the stresses, strains and strain rates.

Chapter seven is entitled the rheological properties of materials but apart from the qualitative description of the Weissenberg climbing effect there is little on normal stress effects and elasticity in liquids. A large section of this chapter is concerned with modelling the rheological properties of concrete. In the final four chapters the author uses his theory of equivalent stresses and strains to analyse in detail the deformation of viscoelastic beams, plates, shells and frameworks.

R. S. Jones

Air–Sea Exchange of Heat and Moisture during Storms. By R. S. Bortkovskii. D. Reidel, 1987. 192 pp. Dfl185 or $74 or £50.75.

Can any natural phenomenon be imagined which presents a broader range of complex processes or, therefore, a greater challenge to unravel them than does the surface of the ocean during a storm? If so, it must be formidable! We are presented with a two-fluid system, dominated at large scale by gravitational forces and at small scales by surface tension, viscous and electrostatic forces. The interface between the fluids may be coated by a surface-active film. One of the fluids, the atmosphere, is in rapid relative motion and, in consequence, the (multiply connected) interface is distorted by waves with a broad range of scales and both fluids are highly turbulent, each containing parts of the (disconnected) interface in the form of interacting bubbles and spray droplets. Heat is exchanged by radiation, conduction and convection, involving both latent heat and evaporation which then, in turn, affects the salt content of the denser fluid, the ocean. There is, not surprisingly, little sound observational data on which to base a theoretical description.

Bortkovskii has made a valiant attempt to survey the phenomenon in this four-chapter monograph, first published in USSR in 1983 and now available in an English translation. First, perhaps oddly, he describes bubbles and spray. I think it might be more natural to begin with sea state, the waves and their relation to wind and other factors, but this he takes second. Rather little is said about the wave field and the onset of breaking, or of Langmuir circulation and wind rows. The monograph's title is directly addressed in Chapter three, where a detailed numerical model of spray droplets is developed and estimates derived of heat and mass transfer. The final chapter addresses the overall objective, an assessment of the importance of storms in the global exchange between the ocean and the atmosphere. Bortkovskii concludes that the effects of storms must be taken into account in climate models and this, alone, makes the monograph worthy of attention.

As might be guessed (and is inevitable given the state of knowledge), the discussion moves freely between the theoretical and the empirical, weaving a clever path through the intricacies of the subject and the various processes involved, towards the goal of global assessment. Readers hoping to find a clear statement of fundamentals will however be disappointed, and rarely are statistical estimates provided of the reliability of data shown in graphical form. Scatter plots are not always very helpful! The foundations of the exposition are weak, although not always through the author's fault.

The text is somewhat dour, with occasional flashes of incomprehensible phrasiology which perhaps the editor should have dealt with. For example, the description of wave breaking (p. 6), "In the 'plunging' type the tip of the wave, moving as a whole, passes the lower part of the wave, curling over and crashing downward into the downwind slope of the wave at some distance from the crest", is difficult to visualise or even relate to a sketch which is provided. We all know what it looks like, but description should add definition and clarity. The credibility of the reader is sometimes strained, for instance when being invited (p. 10) to accept the notion that an eddy diffusion coefficient is independent of both time and depth, '... since diffusion in a completely turbulent layer is being considered'. There is one, but only one, photograph (of the sea surface at a wind speed of 13 m s^{-1} – hardly a storm!), and more illustrations would have helped. I expected to find a discussion of the effect of rainfall, or precipitation other than spray, but none is provided.

In spite of these serious reservations, I did find the monograph to be a valuable and useful statement of the subject, particularly in providing a Soviet view and an extensive list of references. This is an important area of climate research and one which has advanced since the publication of Bortkovskii's original Russian text in 1983. His observation that the development of sound theoretical models will be possible only if more experimental data are available is, however, still true. The text is a timely and comprehensive review, and one which helps in the development of the subject.

S. A. THORPE