J. Fluid Mech. (1980), *vol.* **98**, *part* 4, *pp.* 856–861
Printed in Great Britain

REVIEWS

Sound Transmission Through a Fluctuating Ocean. Edited by S. M. FLATTÉ. Cambridge University Press, 1979. 299 pp. £17.50 (hardback).

Research on the scattering of a radiation field by a randomly fluctuating continuum went through a high point in activity, and in controversy, during the sixties. The specific application was the scattering of electromagnetic signals by atmospheric turbulence. Most of the controversy centred around two questions: What measures of the statistics of the radiation field are most conveniently determined in physical experiments and most conveniently incorporated in theories? How does one derive theories that properly incorporate multiple scatter effects, as well as the effects of diffraction?

By the close of the decade the controversy and the activity on these fundamental questions largely ceased. The central role of the multipoint statistical moments, termed coherence functions in the propagation literature, was recognized by increasing numbers of researchers; techniques had been developed for deriving theories, in the form of differential equations, governing these statistical moments; specific equations had been written on the second- and fourth-order moments, the most crucial moments for discussing experiments; and studies were frequently reported treating the analysis and the solution of these equations in specific applications. Research in the nineteen seventies has addressed the need to solve the governing field equations on the second- and fourth-order moments. These efforts included analytic solutions achieved for idealized experiments, and the need for general numerical algorithms for addressing realistic experiments. Also, in the seventies, the specific application shifted away from the scattering of laser beams in the atmosphere to the scattering of acoustic signals in the ocean. While in principle the applications are the same, three factors make an ocean acoustic experiment different in detail. The wavelengths of the acoustic signal for the experiments of interest are large compared to the previous application; the dynamic process that gives rise to the fluctuating continuum is different in the ocean acoustic application; and the ocean is an inhomogeneous and a highly anisotropic propagation medium. While the first two factors make the ocean acoustic experiment differ from the previous application in degree, the last factor can make it differ in kind. Incorporation of medium inhomogeneity and anisotropy introduces additional length scales that need to be parametrized in additional non-dimensional ratios. The theories reported in the optical literature are 'structurally' homogeneous and isotropic. One can, of course, introduce a degree of inhomogeneity or of anisotropy into the model in a parametric fashion; but this incorporation results in quasi-homogeneous and quasi-isotropic formulations. Finally, a general appreciation of the mathematical identity of the scattering by a randomly inhomogeneous continuum and the quantized motion of a particle in a randomly perturbed potential field, as well as a duality between a radiative transport theory and the equation governing the two-point coherence function, was achieved during the seventies. While this appreciation has not greatly altered the general flow of the development of theories, it has introduced new techniques that could prove useful in solving specific problems.

0022-1120/80/0405-1240 $00.35

The book edited by S. M. Flatté is an outgrowth of three summer studies, in 1974, 1975 and 1976, of the 'Jason' group. The participants of the studies are all highly distinguished and respected scientists, although none contributed significantly to the aforementioned literature. Not surprisingly, then, the Jason studies did not draw very heavily on the studies reported in this literature, although most of the fundamental conclusions reached have their counterparts. Noteworthy, in the discussion of scattering by a statistically homogeneous and isotropic refractive-index field, is an emphasis on the formalism of Feynman path integrals. While the introduction of the formalism to the continuum scattering problem is not entirely original to this book, R. Dashen has followed the approach further and with more success than had previous investigators. To be regretted, in their treatment of scattering by a homogeneous and isotropic continuum, is the prominence given to the Rytov approximation and a reliance on an assumption that the refractive index fluctuations satisfy gaussian statistics. The latter assumption would be difficult to justify and is unnecessary, as alternative derivations of the fundamental results have demonstrated.

The principal message of the book, however, is that sound propagation in the ocean differs significantly from electromagnetic propagation in the atmosphere, for the reasons mentioned previously. There would appear to be general agreement that the dynamic process which gives rise to the refractive index fluctuations which dominate the scattering of acoustic signals is the existence of internal waves. The first part of the text describes the ocean environment and argues, persuasively, for this view. This reviewer is not an oceanographer, but found the treatment to be logically constructed and lucidly written. The stratification of the ocean, which results in an inherent medium inhomogeneity and anisotropy, is emphasized. Indeed, it is the presence of the inhomogeneity and anisotropy of the ocean that would appear to be the reason for the existence of this book. The discussions of basic sound propagation are clearly secondary in importance. Unfortunate, in this reviewer's opinion, is an assumption, the validity of which is largely unaddressed, that one can incorporate the effects of both refraction, due to the medium inhomogeneity, and of the medium anisotropy in a parametric fashion. The lack of any discussion of a possibly more significant role of either of the complicating factors is quite surprising, since the need to identify natural length scales and to collect them in suitably chosen non-dimensional parameters is stressed in discussing scattering by a homogeneous and isotropic medium. (This is the point of the Λ, Φ diagrams scattered throughout the text.) The medium inhomogeneity and anisotropy, of course, introduce additional length scales that need be suitably parametrized for a fundamental discussion of these factors. For example, in its most elementary form the anisotropy of the ocean requires one to introduce at least two lengths, one for a horizontal direction (l_H) and one for the vertical (l_V). The presence of two medium lengths requires the introduction of an anisotropy ratio; an appropriate ratio is readily demonstrated to be $\alpha = kl_V^2/l_H$, k being the signal wavenumber. All the results of this text are limited to experiments in which this ratio is large relative to unity. Further, most if not all of the physical experiments discussed satisfy $\alpha \gg 1$. Choosing an $l_V = 100$ m and an $l_H = 7000$ m, values sometimes argued by the Jason group for the open sea, this ratio equals unity for $f = 167$ Hz and increases with increasing frequency.

The significance of small values of α on the two-point statistics is well documented in the acoustics literature. Indeed, an appropriate theory for discussing this aspect of the problem is presented in the text, in the form of a radiative transport theory. The authors, however, do not use this theory directly, but derive from it an equation on the two-point coherence function. Unfortunately, the derivation presented is marred by a number of misprints that hide the importance of the anisotropy ratio. A carefully constructed derivation clearly demonstrates that the final result is valid only for $\alpha \gg 1$.

How will this text be received? This reviewer believes that it will enjoy a flurry of interest among acousticians and oceanographers occasioned by the prestige of the authors and the absence of any other attempt to treat ocean-acoustic fluctuation experiments comprehensively, as much as by the novelty of the path integral formalism and the emphasis on internal waves as the relevant dynamic process that gives rise to the scattering. Time and the availability of more experimental data, principally at lower frequencies, will, however militate for the need for scattering models which incorporate the ocean's anisotropy and inhomogeneity in a more systematic manner. This reviewer thinks that a convenient presentation of these scattering models will be differential equations, written on the statistical moments of the radiation field, analogous to those available in the optical literature since the late sixties, but properly generalized so as to enable the incorporation of the medium anisotropy and inhomogeneity. As noted above, a reasonably rigorously derived equation governing the two-point coherence function and incorporating the newer complications is available. To my knowledge, however, no equation has appeared which is the analogue of the four-point moment equation that has been studied in the optical literature. The derivation of this equation and the development of computer codes for implementing the several equations are areas of active study.

J. J. McCoy

Fundamental Mechanics of Fluids. By I. G. Currie. McGraw-Hill, 1974. 441 pp. $22.50.

Fluid Mechanics. By Ruth H. Rogers. Routledge & Kegan Paul, 1978. 322 pp. £9.75.

Both these textbooks are intended to give, in from 30 to 50 lectures, a broad introduction to fluid mechanics for students of engineering and physics. (Currie also mentions chemists, and Rogers adds mathematicians.) The two books naturally have much in common, but the differences are remarkable.

Currie's book is attractively designed, with wide margins and a typeface that is pleasant to read. By contrast, Rogers' book has been typed with an ordinary typewriter, so that right margins are unjustified, subscripts and exponents are full-size numerals, and the reader sometimes has trouble distinguishing text, tables, captions, and exercises.

Both authors regard turbulence as outside their scope. Rogers goes further, and effectively restricts attention to one-dimensional and plane motions, so that three-dimensional and axisymmetric flows are not represented, even by the familiar potential flow past a sphere. She is also more limited than Currie in other ways; for example, there is nothing on low Reynolds numbers (except a dimensional

0022-1120/80/0404-1240 $00.35

analysis) or on plane subsonic and supersonic flows. Within those limits, however, Rogers writes very carefully, using simple physical analogies and avoiding complicating details, sometimes at the risk of oversimplification. Currie gives (except for an unfortunate misinterpretation of Kelvin's vortex theorem on page 52) a balanced account of most of what a worker in the subject would regard as the essentials of fluid mechanics.

Lamb managed with line drawings in his *Hydrodynamics* (6th edn, Cambridge University Press, 1957); but most contemporary authors feel the need for a few photographs, and the choice may be revealing. Rogers uses just four photographs, all drawn from nature; and three are devoted to water waves (the Severn bore and the wave patterns of a flock of ducks and a flock of minesweepers). That is evidently where her heart lies, for surface waves is a topic on which she is more thorough than Currie. He gives instead laboratory photographs of flow past a flat plate, a disk, a cone, and a snowmobile! – betraying his interest in the aerodynamics of vehicles.

Currie's book, perhaps augmented by some discussion of turbulence, would serve well as the text for an American first-year graduate course. Rogers' book, being more limited in scope and elementary in its style, would be less suitable for that purpose.

M. VAN DYKE

SHORTER NOTICES

Dynamics and Instability of Fluid Interfaces. Edited by T. S. SØRENSEN. Springer, 1979. 315 pp. DM 32,—.

An international conference with this title was held in Copenhagen in May 1978, and this addition to the publisher's series of Lecture Notes in Physics contains the text of nine of the contributions to the conference. Like other books in the series it is a reproduction of camera-ready typed copy and, although not pleasing to the eye, is adequate for conference proceedings. (It would be more convenient to use if each page heading included some reference to the paper of which that page is a part, so that a reader would know how to find the beginning and end of the paper.) Most of the papers are about different kinds of instability of interfaces, as affected by surface-tension variations, chemical reactions, and the rheological properties of the interface. Two others are concerned with the formation and rupture of thin liquid films. Taken as a whole the book shows the diversity of interfacial processes and the scope for scientific enquiry in this interesting area of overlap of fluid mechanics and surface physical chemistry.

A Course in Thermodynamics. Volumes I and II. By J. KESTIN. McGraw-Hill, 1979. Volume I, 725 pp. Volume II, 617 pp. $21.50 per volume.

This is a revised printing of a work which first appeared in 1966 and 1968. It is a straightforward reprint of the original version with printing errors corrected. Volume I was reviewed by J. H. Horlock in *J. Fluid Mech.* vol. 29, 1962, p. 622, and Volume II by W. E. Ibele in *J. Fluid Mech.* vol. 55, 1972, p. 177.

Contemporary Developments in Continuum Mechanics and Partial Differential Equations. Edited by G. M. de La Penha and L. A. J. Medeiros. Mathematics Studies, Volume 30. North-Holland, 1978. 612 pp. $53.25.

The contributions that make up this conference proceedings include two 'short courses' and a 'critical appraisal' in addition to 25 research papers. The conference was held in Rio de Janeiro in August 1977. The short courses are on nonlinear elasticity (M. E. Gurtin) and boundary-value problems in mathematical physics (J. L. Lions) and the critical appraisal is of continuum thermomechanics (C. Truesdell). Only a few of the papers refer particularly to fluid mechanics, their authors being T. B. Benjamin (bifurcation theory), R. Glowinski & O. Pironneau (least-square solution of nonlinear problems), D. D. Joseph (constitutive equations and free surfaces), J. L. Lions (various topics) and R. Temam (qualitative analysis). As the title of the book suggests, all the contributions are written in the language of modern mathematical analysis.

Dynamical Critical Phenomena and Related Topics. Edited by C. P. Enz. Lecture Notes in Physics, Volume 104. Springer, 1979. 390 pp. $21.50.

This conference, held in Geneva in April 1979, devoted one session to the topic of hydrodynamic stability and three papers from that session are published in this volume. Papers by P. Berge and M. G. Velarde describe the Landau approach to the study of hydrodynamic stability in which equations from the theory of critical phenomena (for example ferromagnetism) are heuristically adapted to the problem. Applications to Rayleigh–Bénard convection and Taylor instability are given. A paper by P. L. Sulem, J. D. Fournier & A. Pouguet discusses applications of the theory of renormalization groups to turbulent flow. In addition, a paper by K. Kawasaki & A. Onuki studies a critical fluid perturbed by shear.

Topics on Contamination in Hydraulic Systems. Edited by W. Rolland. Society of Automotive Engineers Inc., 1979. 60 pp. £9.00.

This short publication contains the eight papers presented at one of the sessions of the 1979 Society of Automotive Engineers Off-Highway Vehicle Meeting and Exposition. The papers discuss attempts to quantify, to assess the effects of, and to establish, cost-effective control methods in the area of hydraulic system contamination.

Two-Phase Momentum, Heat and Mass Transfer. Volumes 1 and 2. Edited by F. Durst, G. V. Tsiklauri and N. H. Afgan. Hemisphere Publishing Corporation, 1979. Volume 1, 502 pp. Volume 2, 474 pp. $92.00 (for both volumes).

The papers contained in these two volumes represent the proceedings of a seminar sponsored by UNESCO, organized by the International Centre for Heat and Mass Transfer, and held on 4–9 September 1978 at Dubrovnik, Yugoslavia. Volume 1 contains 37 papers on fundamental physical processes and numerical studies, while Volume 2 is devoted to 38 papers on heat transfer and pressure drop, reactor safety, and chemical systems. An unusual and valuable feature is a subject index covering

0022-1120/80/0404-1240 $00.35

all the papers. This feature, together with the welcome publication of a large number of useful papers on two-phase flow in one place, will come as a relief to research workers used to scanning a disparate range of journals for work in the general area. Perhaps inevitably, the papers have less to offer to designers and operators of two-phase flow equipment.