

## BOOK REVIEWS

**Air-Sea Interaction. Laws and Mechanisms.** By G. T. CSANADY. Cambridge University Press, 2001. 248 pp. ISBN 0 521 79259 2. £60 or \$95 (hardback); ISBN 0 521 79680 6. £21.95 or \$34.95 (paperback).

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The interaction between the atmosphere and the sea is a fundamental piece of the climate puzzle. The ocean has the ability to store huge amounts of heat compared to the atmosphere, and the transfers of heat can have large effects on the thermodynamics of the system. Much of the motion in the oceans is driven by the wind and by heating and evaporation at the sea surface. In addition, the processes that transfer heat and momentum at the sea surface are very complicated. They involve turbulent flow, waves and both gas and liquid phases.

Csanady's book discusses the thermodynamics and physics of these irreversible processes. Chapter 1 discusses the turbulent flow in the air and the water in terms of Monin–Obukhov similarity theory, and addresses the issue of the roughness length of the sea surface. Recognizing that waves are a ubiquitous feature, chapter 2 reviews theoretical and experimental work on the generation of waves by wind. This chapter focuses on more classical theory and, unfortunately, ignores recent work that has shed new light on the generation mechanisms.

Chapter 3 moves away from the surface down into the oceanic mixed layer and up into the atmospheric surface layer. Csanady points out and exploits the similarity between the two layers, which have mirror-image symmetry in the surface in a number of important features. He shows how the physics in the two regions is often essentially the same, just that in the sea the processes occur in the liquid phase described by an appropriate equation of state, while in the atmosphere they occur in what can be well approximated as a perfect gas.

Chapters 4 and 5 concentrate on the atmosphere and oceans, respectively. In chapter 4, Csanady discusses the thermodynamics of the most vigorous convecting structures in the atmosphere, including hurricanes and tropical cumulonimbus clouds that can carry moist warm air some 15 km into the atmosphere. Chapter 5 is devoted to the region of the ocean extending from about 50°N to 40°S, which contains a pool of warm water at the surface extending down to about 1 km at the equator. This region supplies most of the water vapour to the atmosphere, and absorbs much of the solar radiation. The maintenance of this pool and its links to the main oceanic flow is discussed.

I found the description of the symmetries of the oceans and atmosphere illuminating and the book contains interesting compilations of theory and observational data. Some of these are not as up to date as they could be, but nevertheless they provide useful information. The book is written in an informal style which, while it will make the subject more accessible for some readers, glosses over some of the physics. It is hard to see the book being used as a course text, but it contains useful information and insights that will reward the reader who is prepared to dig.

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**Computational Rheology.** By R. G. OWENS & T. N. PHILLIPS. World Scientific, 2002. 415 pp. ISBN 1 86094 186 9. \$78 or £53.

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One of the difficulties that faces a student of rheology is the multi-disciplinary nature of the subject. The formulation of appropriate constitutive equations involves statistical physics for the microstructure; the analysis of these equations poses mathematical problems; the computational task of calculating complex flows is formidable; and the results must ultimately be compared with experiment.

The objective of this book is to provide researchers and students in applied mathematics and engineering with a 'flavour of some of the distinctive issues and computational challenges associated with the simulation of viscoelastic flow problems'. As such it offers only one piece of the jigsaw – the larger picture is missing. Sometimes this narrow focus makes the subject less accessible. For example, early chapters are concerned with 'fundamentals'. The approach is largely phenomenological with little microstructural underpinning. In consequence, discussion of, say, boundary conditions is largely mathematical, and in this area useful existence and uniqueness proofs are rare. In the same vein, the important discussion of the difficulties of parameter estimation for phenomenological models makes no mention of the possibilities of measurement by direct microscopic observation.

The heart of the book is concerned with descriptions of computational techniques for rheological problems: finite element, finite difference, finite volume, spectral, choice of mesh, matrix inversion, etc. The coverage aims to be encyclopaedic here (there are some 658 literature citations) and presents the reader with a clear and exhaustive account of the methods that have enjoyed some success. The methods are also compared (with each other) for a class of benchmark flows. The authors are thus ideally placed to draw general conclusions and to offer advice to students as to which methods are good and which bad, whether on grounds of accuracy or cost or ease of use. Unfortunately, such comments are rather limited.

Chapter 7 of the book is challengingly entitled 'Defeating the high Weissenberg number problem' and includes the generalization that 'There is broad agreement that numerical approximation errors are primarily to blame for the loss of convergence of iterative algorithms at limiting values of the Deborah number'. There is no doubt that elastic boundary layers arise in some non-Newtonian flows and that failure to resolve these layers can lead to numerical difficulties, but this reviewer dissents from the proposition that all such difficulties are numerical in origin (Rallison & Hinch 1988). The suggestion, implicit in some numerical papers, that a numerical method must be better if it provides answers at higher values of the Deborah number is especially dangerous.

This book performs a useful service in bringing together in a single volume a set of techniques that have been used with profit in non-Newtonian problems. It flags up some of the special difficulties of viscoelastic flow computation, and properly emphasizes the importance of mesh refinement. Many students will perhaps conclude that faced with such an array of possibilities and potential pitfalls, they should instead purchase one of the commercial codes now available. I wish that the authors could have included some advice as to when and why such codes fail to work and when the results that they produce cannot be trusted.

## REFERENCE

RALLISON, J. M. & HINCH, E. J. 1988 Do we understand the physics in the constitutive equation?  
*J. Non-Newtonian Fluid Mech.* **29**, 37–55.

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**Aeroacoustic Measurements.** By T. J. MUELLER. Springer, 2002. 313 pp. ISBN  
3 540 41767 5. £69.

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The field of experimental aeroacoustics is becoming increasingly important, particularly with respect to vehicle design in which noise pollution is of growing concern. Aeroacoustics straddles the fields of experimental fluid dynamics and acoustics and shares many of the same difficulties in obtaining high-quality data, together with some additional ones. *Aeroacoustic Measurements*, edited by Thomas Mueller, aims to provide a single reference volume for practitioners, assembled by acknowledged experts in the field.

The book has five chapters, each by a different author, forming a coherent thread that is extremely readable without being technically overwhelming. The first chapter, by Paul Sodderman of NASA Ames Research Centre and Christopher Allen of Johnson Space Center, provides a broad introduction to the measurement of noise within and outside the airstream. The approach is astutely practical, starting with discussions of major sources of background noise and microphone placement considerations, before moving on to tackle the more complex issues of shear layer refraction in open-jet facilities, high-frequency microphone corrections and scaling from wind tunnel to aircraft flyover test conditions. For each sub-section the theoretical principles are summarised in a useful step-by-step form.

Robert Dougherty, of OptiNAV and formerly of Boeing Commercial Aircraft Group, lays down the theoretical foundations for microphone array beamforming in the second chapter. This is built up in a logical manner from ray-tracing basics through to the crucial issues of sidelobe control and removal of flow noise. A hybrid spatial/spectral eigenvalue analysis technique is presented for the reader to consider as an alternative to the standard beamforming approach, along with details of array calibration techniques and issues. While Chapter 2 covers the more theoretical aspects of array processing, Chapter 3 provides extensive descriptions of phased array design and testing based on experience gained from experiments in a number of environments, including pressurised, hard-walled wind tunnel facilities. James Underbrink provides many case studies of particular aspects of array testing carried out by the Boeing Commercial Airplane Company, as well as tests performed at NASA Ames and Langley Research Centres. While the results of these experiments have been published in the open literature, it is only here that the practical details are discussed at a level which is useful to those wishing to perform similar types of measurements. There are numerous insights into array design, aimed at maximising accuracy and controlling sidelobe behaviour for a given number of sensors over the desired measurement frequency range. The familiar logarithmic spiral approach is described, along with situations in which alternative solutions must be devised, such as in the presence of wind tunnel windows and turntables for model mounting. In addition to addressing overall array configuration, Underbrink also covers construction, installation and instrumentation issues, including sensor selection, flush-mounting problems, signal conditioning and traversing systems. Phased array calibration and

data acquisition in a production wind tunnel testing environment are non-trivial tasks, and best practice guidelines are helpfully included in the system level descriptions. A concise summary of a typical data reduction procedure concludes this comprehensive chapter on phased array testing in low speed wind tunnels.

Chapter 4, by William Blake of the Naval Surface Warfare Centre and Denis Lynch III of the University of Notre Dame, introduces the reader to concepts of cross-correlation that can be used in aeroacoustic testing to deduce the relationship between sound and its source. The basic mathematical theory is reinforced with examples of how these techniques can be effectively applied in practice: to compute the direction of sound wave propagation; to provide usable data in a low signal-to-noise ratio environment such as is used for studying trailing edge noise; and to correlate surface pressures with sound pressure on a propeller fan in a turbulent airstream. The final chapter, by the editor Thomas Mueller and Denis Lynch III of the University of Notre Dame, provides a description of the design, construction and validation of the anechoic open-jet wind tunnel at the University of Notre Dame. While specific to this particular facility, the details provide good reference data for others to consider in designing and operating a similar tunnel. The second half of the chapter is a detailed case study of propeller response to non-uniform inflow distortions, and demonstrates what can be achieved in a well-designed facility by using many of the techniques described within the text.

Throughout *Aeroacoustic Measurements* there are up-to-date case studies, real experimental data and references to put the information in context and show its practical relevance. Its unique strength is the considerable amount of low-level technical detail that would otherwise remain unavailable to practitioners in the field. This well-written and concise volume will prove to be invaluable for those involved in aeroacoustic measurement work at any level.

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