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REVIEWS

Solar and Stellar Granulation. Edited by R. J. RUTTEN and G. SEVERINO. Kluwer, 1989. 661 pp. $173 or £97.

The Sun is a typical cool main-sequence star – and the only one whose surface can be observed in any detail. So the study of solar and stellar convection, unlike some other branches of astrophysical fluid dynamics, is heavily constrained by observations. Viewed in white light, the solar photosphere reveals bright granular features with a characteristic diameter of about 1000 km. With improved resolution it has become clear that these granules are turbulent convection cells, with hot rising plumes enclosed by a network of cold sinking gas. There are also large-scale cells (the supergranulation) with typical diameters of 30000 km, as well as the newly discovered mesogranulation, with a scale around 6000 km. Similar structures must exist on other stars with deep convective envelopes but they can only be probed by studying their effects on spectral lines.

This volume contains the proceedings of a NATO Advanced Research Workshop held on Capri in 1988. The meeting was carefully structured, with a wide selection of expert reviews. Since it coincided with important breakthroughs both in observations and in theoretical models the proceedings are timely and provide a valuable record. New observations have been obtained both from space and from observatories on the ground. More important, techniques have been developed for filtering the data so as to eliminate acoustic modes and to produce image sequences of unprecedented clarity. There has also been rapid progress in numerical modelling of nonlinear compressible convection, including interactions with magnetic fields. Here there are two approaches: one is to simulate a star in as much detail as possible, including realistic properties such as ionization and radiative transfer; the other relies on idealized numerical experiments designed to isolate particular effects. There is already a close correspondence between results obtained with modern supercomputers and photospheric observations but the real challenge is to model convection below the surface, where we cannot see it.

N. O. WEISS

Physicochemical Hydrodynamics. An Introduction. By R. F. PROBSTEIN. Butterworths, 1989. 353 pp. £50.

In 1962 the translated version of V. G. Levich's book *Physicochemical Hydrodynamics* appeared in the West. (The first edition of the Russian version was published ten years earlier.) This book contained several results that at the time were unknown to western scientists and has since been widely cited. For example, many of Levich's own pioneering investigations of the important role of fluid motion in various electrochemical phenomena were breakthroughs of a fundamental nature. Physicochemical hydrodynamics was defined by Levich as 'the aggregate of problems dealing with the effect of fluid flow on chemical or physicochemical transformations as well as the effect of physicochemical factors on fluid flow'. The field of research is thus very large and several of its sub-areas are only loosely connected with each other. In some of these sub-areas there has been an impressive development since 1962, and there is definitely a need for an introduction to this expanded body of knowledge. This gap is partly filled by the present book by Probstein. As everybody having an interest, to a greater or lesser extent, in physicochemical hydrodynamics is likely to be familiar with the book by Levich, some comparative comments may be in order.

The book by Probstein, which is intended for graduate students, takes up some of the basic material given in that by Levich but also a significant number of recent developments. Personally, this reviewer found the text in the present book somewhat easier to read than that in Levich's book. One reason for this is that a translation, even if very skilfully done, hardly ever does full justice to the text in the original language. Another reason is that Levich's style of presentation is more compact than Probstein's. Also, the mathematics used in Probstein's book is simpler than that in the book by Levich. It should also be pointed out that the latter book takes up several aspects of the subject that are not dealt with by Probstein. Examples of such problem areas are free convection and physicochemical phenomena in turbulent flows.

The author of an introductory text on a large and reasonably well-developed subject faces a serious but unavoidable problem. In order to circumvent the practically impossible task of writing a complete encyclopedia, a choice between depth and width has to be made. In his well-known textbook for graduate students *An Introduction to Fluid Dynamics*, G. K. Batchelor chose the former approach and deliberately excluded, for example, turbulence and compressible flows. Probstein, on the other hand, chooses to span a comparatively large variety of phenomena in a less extensive text. Although this by necessity means that several specialized areas of the subject can only be treated in a sketchy manner, the impression of this reviewer is that the author on the whole has been successful.

Probstein puts emphasis on mathematical modelling in the spirit of continuum mechanics, but considerable space is also devoted to simplified physical arguments. No experimental techniques are taken up, but physical implications of experimental results are frequently discussed. The titles of the chapters are: (1) Introduction, (2) Transport in fluids, (3) Equations of change, (4) Solutions of uncharged molecules, (5) Solutions of uncharged macromolecules and particles, (6) Solutions of electrolytes, (7) Solutions of charged macromolecules and particles, (8) Suspension stability and particle capture, (9) Surface tension.

Apart from the first three chapters, in which a brief review of appropriate parts of fundamental fluid mechanics is given, a distinct class of phenomena is discussed in each chapter. In most of these latter chapters, the text starts with a general survey in physical terms of the type of phenomenon to be dealt with and thereafter an outline of its mathematical modelling is given. After such an introductory discussion, some illustrative examples are worked out in detail. In some cases, technical applications related to the presented material are discussed. This scheme of presentation has been executed in a way that makes for interesting and stimulating reading. Probstein's way of presenting, arguing and discussing is generally clear and pleasant to follow. As always, there are some exceptions. For example, this reviewer suspects that the foundations of the kinematic wave theory for settling of particle suspensions as presented in chapter 5 may be found a bit difficult by some graduate students. However, such parts of the text are not common and are balanced by other parts that are indeed very good. One example is the short but clear description of the diffuse electric double layer in chapter 6.

At the end of each chapter a number of problems are given. The problems chosen are no doubt illustrative but unfortunately, as is disturbingly often the case for books for graduate studies, no answers and hints are given. A graduate student reading the book will probably have some opinion about this.

Quite a lot of work has been put into making the book attractive. The disposition and layout are very good and so is the quality of the graphs. This reviewer found only a few misprints.

To sum up, *Physicochemical Hydrodynamics. An Introduction* is a good book. It will be appreciated not only by graduate students specializing in chemical engineering but also by engineers and scientists in chemistry who feel a need to improve their knowledge of the important role that is played by fluid motion in many phenomena. Also researchers in fluid mechanics who find it interesting to include new phenomena in their studies, may find inspiration from the book.

FRITZ H. BARK

An Introduction to Rheology. By H. A. BARNES. J. F. HUTTON and K. WALTERS. Elsevier, 1989. 199 pp. $92 (hardback) or $60.50 (paperback).

The term 'rheology' was coined by Bingham more than 70 years ago to denote the science of deformation and flow of matter. The reader may ask, well – what is the difference or the border between rheology and continuum mechanics? I think it lies mainly in the difference between the corresponding communities. In Bingham's times the study of complicated non-Newtonian fluids, which was the main object of rheology, was out of fashion for the high-brow hydrodynamics community. Meanwhile the existing practical demands were favourable for the formation of an ecological niche sufficient to support a rather closed and self-reproducing community with its own standards for research, teaching, mathematical tools and traditions. The rheological community proved to be very active and produced national societies throughout the whole world, the Bingham medal, national and international congresses, wide activities in particular in organizing research, consulting in industry, and teaching.

Hydrodynamicists and rheologists coexisted without essential exchange till post-World War II times, when many problems appeared having both practical importance and fundamental interest from a general viewpoint. They attracted the attention of hydrodynamicists of the more classical kind, especially of a younger generation. Gradually problems of non-Newtonian fluids of various kinds entered the fields of interest of some people with a high reputation in hydrodynamics and in general continuum mechanics. Nevertheless some separation between the two communities remained – perhaps a more engineering approach and orientation is characteristic for the people who call themselves rheologists.

I think that the present book will undoubtedly be of interest for both rheologists and hydrodynamicists. Beginners in traditional rheology and their teachers will find there a good systematic course to begin with, and also some introductory text at the end of the book demonstrating the more sophisticated approach of continuum mechanics. Hydrodynamicists and specialists in continuum mechanics will find in the book interesting and non-traditional problems, experimental results, semi-quantitative estimates and the traditional approach of rheologists.

The book consists of eight chapters. The first chapter, 'Introduction', provides historical information and definitions, in particular definition of the subject itself. The second chapter, called 'Viscosity', contains a large amount of data concerning the viscosity of non-Newtonian fluids together with discussion of 'models', that is, various equations for the dependence of the viscosity on shear rate for various types of materials. The presentation is interesting and useful, although one point could be discussed more extensively, namely the universality of proposed models and equations. In other words, are the constants entering the equations material properties or do they depend also on the measuring device?

The third chapter, which concerns linear viscoelasticity, is – as it should be – more traditional. Various combinations of elementary modes are presented and the technique of dealing with them is explained clearly and concisely. The fourth chapter on 'Normal Stresses' and the fifth on 'Extensional Viscosity' are doubtless the highlight of the book, explaining characteristic fundamental problems for elastic fluids. Perhaps the photographs illustrating the Weissenberg effect could be better (marvellous photographs by D. D. Joseph, G. S. Beavers and R. L. Fosdick could be recommended), as well as those illustrating the open syphon effect.

The next two chapters, devoted to 'Rheology of Polymeric Liquids' and 'Rheology of Suspensions', outline these very important and difficult subjects. The last chapter contains an introduction to continuum mechanics (theoretical rheology).

The book is short, comprehensive and useful: it can be recommended to libraries of fluid mechanics. For the next edition the presentation of the important phenomenon of elastic turbulence with several photographs by J. J. Benbow can be recommended, as well as some minor corrections. For instance, symmetry of the shear stresses does not follow from the angular momentum equation alone: the absence of internal couples is needed.

G. I. Barenblatt

Introduction to Polymer Dynamics. By P. G. de Gennes. Cambridge University Press, 1990. 57 pp. £20 (hardback) or £6.95 (paperback).

This little book is based on four topics from lectures by de Gennes to an Italian faculty and graduate class in 1986. The chapters of the book are concerned with distinct topics in polymer science, although the underlying theme is concerned with polymer reptation. Chapter 1 gives a very useful and simply presented account of scaling and reptation concepts for polymer dynamics. It also contains a short section on the effect polymer dynamics might be expected to have on the influence of chemical kinetics. Chapter 2 deals with a topic concerning the allowed configuration of polymer chains that may have specific receptor sites along the chain. Chapter 3 addresses the problem of liquid interfacial spreading and the kinetics of wetting, which is an issue of course not exclusive to polymers. Finally, the longest of the chapters is concerned with polymeric turbulent drag reduction, and here de Gennes puts forward his novel arguments to explain this subtle effect.

The book is mainly concerned with concepts and ideas. It is deceptively simple in presentation and certainly represents an enjoyable read for polymer physicists with interests in reptation, biophysics, interfaces and hydrodynamics. De Gennes' already formidable reputation will ensure the book is read by many.

M. R. Mackley