Eur. J. Mech. B - Fluids 20 (2001) 155–162

Book reviews

S0997-7546(00)01101-8/BRV

Boundary Layer Theory (8th (English) revised and enlarged edition) by H. Schlichting, K. Gersten (Springer-Verlag Berlin, Heidelberg, New York, 2000, 799 pp.) DM 179.00 – US $ 98.00; ISBN 3 540 66270 7.

K. Gersten has taken on the formidable task of revising, enlarging and editing Schlichting's 'Boundary Layer Theory', first as a new German edition (published in l997) and now as a follow up in English, translated by Katherine Mayes. E. Krause has written an additional chapter on numerical methods in boundary-layer theory and H. Oertel has revised the section on the onset of turbulence.

The revised version has largely retained the framework of the 8th edition and is divided into five parts: (I) Fundamentals of viscous flows. (139 pages), (II) Laminar boundary layers (263 pages), (III) Laminar-turbulent transition (75 pages), (IV) Turbulent boundary layers (180 pages), (V) Numerical methods in boundary-layer theory (24 pages) and References (78 pages).

This book derives from the lecture notes of H. Schlichting's boundary-layer course in Braunschweig and has developed over the years into a handbook of boundary layer theory which retains strong links to its roots in Göttingen. Research on boundary layers has long spread all over the world and this is best illustrated by the fact that about 800 papers on the subject appear every year. Although boundary layers represent a microcosm within the wide field of fluid mechanics it appears no longer feasible that a single person can review the full range of the theoretical and experimental aspects of boundary layers. Once this opinion has been expressed, one can admire Gersten's courage and at the same time feel allowed to make a few critical remarks about this revised version of the original 'Grenzschichttheorie' which the reviewer grew up with, as did so many others in the fluid mechanics community. The German version of Schlichting's book was translated elegantly into English by J. Kestin who was at home in fluid mechanics and with boundary-layer terminology. The present translator is not entirely secure in this, and also in the application of prepositions. Since several parts of the seventh and eighth English editions are based on the same German text (e.g. Introduction and Some Features of Viscous Flows) comparisons of the translations can be made easily by any reader. Interestingly chapter 23 seems much more secure.

The revision of the book has required the literature of about 15 additional years to be considered. To keep the size under control it has unfortunately proved necessary to reduce the number of diagrams and flow photographs which were a characteristic of the earlier versions, and further compress the new information. (The quality of the printing has also, regrettably, declined.) This brings us to the update reflected in the references, more than 2000 citations consolidated on 78 pages but with only 7% from 1990 onwards. It is often found that an author quotes papers in larger proportions from his own realm of activity but here the literature survey of the handbook sections needs to be 'internationalised' (this is also true of the chapter on transition). The personal touch in the revised edition is apparent in the emphasis laid, wherever possible, on aspects of asymptotic theory for high Reynolds numbers, a speciality of the second author. Students should be warned that low Reynolds number flows still exist and the book is full of examples of this. The combination of phenomenological descriptions and results derived from the equations of motion and energy is a characteristic of Schlichting's book, and this pattern has been kept. The fundamentals of boundary-layer theory are followed by the field equations for flows of Newtonian fluids and exact solutions of the Navier–Stokes equations. The boundary-layer equations in the section 'Plane flow; plate boundary layer' are derived from page 145 onwards, meaning the equations for 2-dimensional laminar boundary-layers along a wall without curvature. Here we find a repetition of the introduction of displacement thickness and friction drag (chapters 2.2 and 6.3) where the former is defined again in chapter 6.5. The important similar solutions of the boundary-layer equations are presented in chapter 7 with the exception of the Blasius solution (see chapter 6.5), followed by solutions for free shear layers and the laminar wall-jet. The chapter is concluded by a first series of coordinate transformations without any comment on the importance of the Crocco transformation (1941 and 1946) for compressible boundary layers. A further set of transformations can be found in sections (10.4.3) (10.5.2) and (12.1.2).

The Hartree-profiles which are the result of the Falkner–Skan equation are contained in the section on integral methods which are denoted "as being nowadays mainly of practical importance for turbulent boundary layers" and here they indeed appear (chapter 18.4). Integral methods in the form developed by A. Walz appear repeatedly in sections (9.5), (10.4.5), (12.1.3) and (13.1.6). The chapters dealing with free and mixed convection are new (10.5 to 10.7). For the remarks on binary boundary layers (11.3) one would at least wish to see a reference to a more general survey. The section on laminar boundary layers is concluded by unsteady motion (both compressible and incompressible) (chapter 13) and by higher order boundary-layer theory (chapter 14) with the emphasis on viscous – inviscid interaction and wall curvature effects, including an introduction to triple-deck theory.

Part III deals with laminar-turbulent transition. The number of pages has been reduced from 90 to 80 which led to cuts in the field of Couette flows and axisymmetric flows. There are new or extended topics, such as absolute and convective instability investigated first by using the method of Briggs (here we miss the description given by Huerre & Monkewitz (p. 431). The latter authors are mentioned only with other important researchers in passing at the end of section 15.4. Important review papers published in Annual Reviews in the nineties were simply not quoted, the phenomena of by-pass transition and receptivity are non-existent and so are papers by the Stuttgart, Novosibirsk and Zürich 'stability groups', to name but a few. Klingmann et al. have solved the differences between experiment and theory as far as the neutral stability curve is concerned and Lingwood found the absolute instability in the flow over a rotating disk in 1996. A handbook should certainly contain this.

Turbulent boundary layers are covered by Part IV (181 pages). The phenomenological introduction contains a historical photograph (1929) of turbulent flow in a water channel and the remark that a purely numerical computation of turbulent flow has only been possible in a few special cases. We have better photographs of turbulent boundary layers (see van Dyke's Album of Fluid Motion) and direct numerical simulations of turbulent boundary layers by, for example, P. Spalart which are not even mentioned in the list of references. Why?

The derivation of the Reynolds equations of motion and energy is performed separately for flows with constant (16.3) and variable (19.1) physical properties and the same pattern is followed for the boundary layer equations. Schlichting's book has not been renowned for his chapter on two-dimensional incompressible turbulent boundary layers. So the opportunity of a revision for this purpose presented itself. Unfortunately this has not been taken and after a rather sketchy description of turbulent fluctuations (Klebanoff's Reynolds stress plots were omitted), Couette flow (constant shear stress!) was chosen as an example of a turbulent flow of universal importance. Although several important aspects of wall bounded shear flows were addressed and some boundary layer results included, this is a dangerous mix for any student who is looking for an introduction to turbulent boundary layers. The pattern is repeated in the following chapter where fully developed internal flow (pipe flow and slender channel theory including the entrance region) is treated.

The genuine chapter on incompressible turbulent boundary layers begins with a description of turbulence models and continues with a rather author-specific discussion of a two-layer boundary-layer structure. The reader looks in vain for a simple relationship describing the development of the skin-friction coefficient (e.g. Kàrmàn–Schoenherr) or the boundary layer thickness δ. Boundary layers with separation are exemplified by the Stratford flow which, admittedly, is a specific case. Only at the end of section (18.5.2) does one find a reference to Simpson's review paper, which in combination with other reviews might have been part of a more general introduction to the phenomenon of separation. The turbulent boundary layer "coupled to the temperature field" is dealt with in chapter 19 (15 pages) and axisymmetric and three-dimensional boundary layers in chapter 20 (12 pages). Free turbulent shear flows conclude Part IV. Section 23 finally deals with the numerical integration of the boundary-layer equations, which is a review in its own right.

In conclusion, the reviewer is convinced that this book would have gained a lot by having been revised by a team of specialists who could at least have provided a more balanced view of the field and a more modern update of many sections. Time will show whether this book will attract the same target audience as the old book. I shall keep my old 'Schlichting'.

H.-H. Fernholz
Hermann-Föttinger-Institut für Strömungsmechanik
Technische Universität Berlin
Straße des 17. Juni 135
10623 Berlin, Germany

S0997-7546(00)01113-4/BRV

Viscous Fluid Flow by T.C. Papanastasiou, G. Georgiou, A.N. Alexandrou (Springer-Verlag, Heidelberg, Germany, 2000, 418 pp.) DM 176; öS 1285; sFr 159; FF 663; £ 60.50; US$ 89.95 hardcover
ISBN 0-8493-1606-5

This is an interesting book on viscous fluid flow which has both strengths and weaknesses. One of its main strengths is the enormous amount of information it contains but, as a result, it is short on explanation and it is difficult to see who would benefit from reading it – it is too hard for a first introduction to viscous flow yet does not go far enough with the more advanced material to do more than act as a reference source. The introduction suggests it is based on a lecture course and it does seem that it would be most effective as a 'back up' reference book to a set of lectures – where the explanations and physical background missing in the book can be given in the lectures.

The stated aims of the book are to "develop and rationalize the mathematics" and "to exhibit the systematic application of these principles to flow occurring in fluid processing and other applications". These two aims do cause some unevenness in the presentation and it is particularly noticeable that the style varies from chapter to chapter and there is very little reference from one chapter to another. The second of these aims is the more interesting, since there are already many textbooks on the mathematics of viscous flow, and is mostly achieved by interesting practical examples (both worked and as problems for the reader), and a very broad set of references which are provided chapter by chapter. Some of these problems look very challenging, however, and I wish some 'hints for solution' could have been provided. The open-ended aspect of many of the exercises is intentional but it will often be frustrating for both student and teacher.

The order in which the early material is presented is unconventional and I have my doubts as to whether this will work pedagogically. However, while I am of the school of thought that believes in starting with the easiest