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REVIEWS

Developments in the Theory of Turbulence. By D. C. LESLIE. Clarendon Press, 1973. 368 pp. £12.00.

The main difficulty in the theory of turbulence arises from the nonlinearity of the fluid dynamic equations, which implies that the equations for the moments of turbulent fluctuations of the orders n and $n+1$ are coupled with each other. Therefore it is impossible to obtain a strict closed system of equations for a few moments of lower orders and it is necessary to use some artificial closure by means of plausible hypotheses.

There are two quite different approaches to the closure problem of the theory of turbulence which are widely used in theoretical investigations. One of them is mostly suitable for the solution of engineering problems related to the various types of shear flows; it is based on the closure of the equations for the mean fluid dynamic fields or for these fields and some (or all) of the second moments with the aid of hypotheses, including the notions of eddy diffusivities, mixing lengths, and so on. This approach is traditionally called 'semiempirical theories of turbulence'. Another approach is mostly appropriate for the study of isotropic turbulence and is based on special assumptions about spectral characteristics of turbulent fluctuations (first of all about energy transfer across a wavenumber spectrum). The term 'analytical theories of turbulence' is often applied to different versions of this approach.

The book by Leslie is devoted to a detailed consideration of the analytical theory of turbulence developed by R. Kraichnan at the end of fifties and to some other theories closely related to this one. Kraichnan's theory is the so-called 'direct-interaction approximation' (or DIA) which is one of the first and apparently the most well-known among all the analytical theories. DIA has arisen quite naturally from the application of perturbation theory to the nonlinear Navier–Stokes equations and has many very attractive features, but it leads to a rather complicated system of integro-differential equations and moreover it gives incorrect results for small-scale turbulent fluctuations in the case of very large Reynolds numbers. This latter deficiency is closely connected with the violation by DIA equations of the Galilean transformation invariance; it prompted Kraichnan to develop an even more complicated Lagrangian-history direct-interaction approximation (LHDIA) which is Galilean invariant and gives the correct Kolmogorov form for the high wavenumber part of the spectrum of turbulence.

The first six chapters of Leslie's book contain a short introduction to the theory of isotropic turbulence and a careful discussion of the original (Eulerian) form of DIA. The seventh chapter is one of the most interesting in the book. It contains a very clear formulation of Edwards' method of closing the equations of turbulence based on the Fokker–Planck equation for the probability distribution and an analysis of the relation of this method to DIA; a few other related closing methods are considered briefly at the end of the chapter. Chapter

8 is devoted to the application of DIA equations to the problem of turbulent diffusion of a passive scalar in a turbulent flow. (It seems a little strange that the author suggests in this chapter the title "the Batchelor constant" and the notation *Ba* for the universal coefficient in the Obukhov–Corrsin $(-\frac{5}{3})$-law for the spectrum of a passive scalar; moreover the coefficient in Batchelor's (-1)-law for that spectrum at $Pr \ll 1$ is denoted simply as A_1.) The next three chapters contain the presentation of the LHDIA for both the velocity field and the passive scalar field. Finally the last three chapters are devoted to the attempts (quite preliminary and not very useful from the engineering point of view) to apply DIA to the real shear flows met in practice.

Summing up, we must say that Leslie's book gives a full and quite clear representation of DIA and LHDIA methods of obtaining the approximate closed system of dynamic equations for a turbulent flow. It makes the study of these methods much simpler; the book would be quite intelligible to post-graduate students or engineers familiar with the basic principles of the turbulence theory whereas the original papers of Kraichnan are suitable only for highbrow specialists. The book also simplifies considerably the study of Edwards' important contributions to the theory of turbulence and of some related methods of closure. However, the content of the book is narrow when compared to all the modern developments of turbulence theory, and this makes the book interesting only to the limited circle of people having a special interest in Kraichnan's methods. There are many other closure approximations which have been analysed recently, but they are not discussed by Leslie, possibly because they appeared too close to completion of the book. As examples of modern analytical theories of turbulence which seem to me to deserve comparison with DIA and LHDIA I may mention Nakano's perturbation approach (*Ann. Phys.* vol. 73, 1972, pp. 326–371), Lundgren's methods for a closure of the equations for turbulent probability distribution functions (*Lecture Notes in Physics*, vol. 12, 1972, pp. 70–100) and the methods of Wiener–Hermite expansion (one of the latest papers on this method is by J. C. T. Wang and S. S. Shu, *Phys. Fluids*, vol. 17, 1974, pp. 1130–1134). Leslie's book also does not mention quite different approaches to the theory of isotropic turbulence put forward recently by P. Martin, M. Nelkin and some other theoretical physicists; moreover it exploits quite insufficiently the use of numerical simulation of turbulence for the verification of the theoretical predictions. Therefore the appearance of Leslie's book leaves unsolved the urgent problem of preparation of a book considering different theories of isotropic (and locally isotropic) turbulence in all its various aspects and interrelations but maybe in less detail. However now it is easier to write such a book since it is possible to use systematically DIA and LHDIA as exemplary theories and to refer to Leslie for a detailed derivation and analysis of these basic examples. Let us hope that such a sequel to Leslie's book will appear soon.

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Computers and Fluids. Editor: M. H. BROWN. Pergamon. One volume of 4 parts per year; began in 1973. $75 per volume.

International Journal of Multiphase Flow. Editors: G. HETSRONI and H. C. SIMPSON. Pergamon and Elsevier. One volume of 6 parts per year; began in 1974. $60 per volume.

Letters in Heat and Mass Transfer. Many editors. Pergamon. One volume of 6 parts per year; began in 1974. $45 per volume.

Mechanics Research Communications. Editors-in-Chief: B. A. BOLEY and H. LIPPMANN. Pergamon. One volume of 6 parts per year; began in 1974. $35 per volume.

Previews of Heat and Mass Transfer. Editors: J. P. HARTNETT, T. F. IRVINE, Z. ZARIC and A. A. ZUKAUSKAS. Rumford Publ. Co. One volume of 4 parts per year; began late in 1974. $40 per volume.

Journal of Industrial Aerodynamics. Editor: R. I. HARRIS. Elsevier. One volume of 4 parts per year; began in 1975. $54.95 per volume.

Journal of Non-Newtonian Fluid Mechanics. Executive Editor: K. WALTERS. Elsevier. One volume of 4 parts per year; to begin in 1976. $50.95 per volume

Since the end of World War II there has been a continual and rapid increase in the number of scientific journals. New journal titles seem always to be appearing, and in large numbers, with no compensating disappearances. The present number of scientific journals is about 30000, and the present rate of growth corresponds to doubling in about 25 years. This staggering rate of increase of publications is too familiar to startle, but the motives for establishing more and more journals are not as well recognised. The common view is that new journals are simply a consequence of increased pressure on the existing journals from a rising tide of submitted papers. But there is more to it than that. In most cases a new journal results from a coincidence of the desires of a group of scientists (or perhaps only one) and a publisher. On the scientists' side there is a natural urge to obtain recognition of the importance of some field of specialization, and to put publication of papers in that field into the hands of the right specialists. And on the publishers' side, journals are a very attractive commerical proposition since they provide a regular base-load of printing work and a more-or-less guaranteed income from libraries.

One might question whether it is right to allow these motives to operate without check and to produce journals with titles invented by a small group of scientists. The existence of a journal with a certain scope undoubtedly has an influence on the further development of that field, possibly but not certainly favourable. Continued sub-division of fields by the establishment of new journals may indeed hinder the process of scientific interaction and integration of different specialist fields. How can the collective voice of restraint and – where appropriate – opposition be put to the enthusiasts who want to start a journal as a means of putting their field on the scientific map? No way exists at the moment.

But even though journals have proliferated during the years since the war, and even though most of us have had no experience of a different state of affairs and regard continual increase as the norm, there cannot be any doubt that it will be different henceforth, at any rate in most of the western world. In most countries the total money available for scientific research in universities is no longer increasing; the science-based industries are not expanding; money for higher education is in short supply; enrolments for Ph.D. courses are mostly diminishing; and library budgets are hitting their ceiling. For the next few years we may expect little or no further increase in the number of scientific papers seeking publication and there is certain to be considerable resistance on the part of librarians to new subscriptions. And the substantial current increases in the prices of existing journals due to inflation, combined with the shortage of money in universities, may even lead to some cut-backs in present subscription lists. If that happens the newer journals will feel a cold wind blowing about them. And the editors of all journals, old and new, will have an increased obligation to weed out the good from the bad, to persuade authors to think not twice, but three times, before seeking publication, and to suppress papers which are misleading, incomplete or without significance.

What can one say about these seven newcomers to the journal scene? Which of them are needed scientifically, which fill a gap, which will help to bring order to a subject and not fragmentation, which are likely to have high standards – and which will survive? The questions are important, but, aside from the last one, there is not much point in asking them at this stage. The journals exist, and the resulting good or harm can be observed but not avoided. But even though comment may have no effect, the convention of expressing a polite welcome to newcomers to the list of journals needs to be challenged. The influence of a journal on the scientific development of a subject may be profound, in ways not yet fully appreciated among scientists (and even less among publishers), and the establishment of a new title calls for hard-nosed appraisal. The pages of *J.F.M.* are not the right place for an objective assessment of other journals concerned with fluid mechanics, but it is hoped that the critical tone of this notice will draw attention to the need.

Most of the facts about these new journals are provided in the heading to this review. Six of them come from two commercial publishing firms. *Letters in Heat and Mass Transfer* and *Mechanics Research Communications* are journals "for the rapid communication of contributions in..." and expect to publish short notes by photographic reproduction of type-scripts within a couple of months. Is it useful to be able to publish abbreviated papers more rapidly at the expense of time spent on reviewing and improvement? And shall we see these same papers in enlarged form in other journals in due course? *Previews of Heat and Mass Transfer*, also reproduced photographically from type-script, is rather a mixture. In the first issue a little over half the space is devoted to the reproduction of title, author, journal reference and abstract of papers on heat and mass transfer being published in other journals, this being intended as an 'alert service'. In the remaining space we have news for the heat and mass transfer community and a large number of summaries of 'technical reports'

sent in to the editors. The remaining four are journals of the conventional kind. *Computers and Fluids* is one of a family of "Computers and ..." journals (and if you think the combination of computers and fluids in a journal title is arbitrary, how about *Computers and Human Concern*?) and seems unlikely to contribute anything except confusion to the journal scene. The *Journal of Industrial Aerodynamics* is intended to provide a publishing medium for an active new field of technology, wind effects on buildings and structures. It might have a role as a kind of house journal for those working in this field, but from a scientific point of view the subject matter seems rather specialized. The dangers of separateness and fragmentation also come to mind when contemplating the *Journal of Non-Newtonian Fluid Mechanics*, the first issue of which will appear early in 1976. There are journals of rheology and journals of fluid mechanics and their area of overlap is exactly the area that the new journal will claim for its own. Is it a distinct subject which can and should be developed separately? The *International Journal of Multiphase Flow*, now in its third year, is going strong in its collaborative form, after an awkward first year when there were two journals with this name launched by different publishers. There is a strong technological base, associated with techniques of cooling with liquids near their boiling point, for a journal of multiphase flow, but the list of associate editors and the contents of the first two volumes suggest that the journal will also embrace flow problems involving two phases in a superficial sense only – e.g. particles moving through fluid – which does not make sense scientifically. The existence of heat or mass transfer between phases in motion might be a suitable unifying theme for a journal, and perhaps *Intern. J. Multiphase Flow* will settle down with this in time.

It will be interesting to see, 10 years from now, what becomes of all these vehicles for the hopes and aspirations of many editors and authors. Meanwhile there will be a good deal of overlap of the fields of different journals.

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