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REVIEWS

Topological Fluid Mechanics: Proceedings of the IUTAM Symposium. Edited by H. K. MOFFATT and A. TSINOBER. Cambridge University Press, 1990. 805 pp. £60.

So now, in addition to physico-chemical hydrodynamics, statistical hydrodynamics and geophysical hydrodynamics, a new example of the same semantic device has appeared. We may first of all ask ourselves whether this natural scientific tendency to form new communities and identify new complex branches of science is a help or a hindrance. A positive feature is obviously the additional opportunity for people with differing backgrounds to come together, exchange ideas and approaches which they had previously accumulated and become accustomed to, and ultimately to be able to consider their phenomena, problems and results from differing and unexpected viewpoints. Success brings the right to organize symposia, colloquia, journals, etc., which is important. The only negative feature, as far as I can see, is that there may exist a tendency to form closed subcommunities, with their own rapidly elaborating languages, and sometimes their own mathematics and concepts of rigour, which in the end become separated from the ambient scientific community. Therefore, the conditions of birth of the new subject are important and the background of the people around the cradle of the new-born branch of science is critical.

Circumstances have favoured the formation of Topological Fluid Mechanics as such a complex subject. In his introductory talk at the Symposium, H. K. Moffatt mentioned as precursors the classical results of W. Thompson and P. Tait on the invariant topological properties of knotted vortex lines (he could also have mentioned ideal, plane potential flows in multiconnected regions – see H. Lamb's *Hydrodynamics* for a discussion in a genuinely topological style). As is known, these considerations were related to Kelvin's vortex theory of atoms (which turned out to be misconceived), but the results remain in fluid mechanics independently of the author's original intentions. In some sense a similar thing happened later, in the 1950s and 1970s, when physicists from both sides of the Atlantic persuaded their governments that they were close to achieving the results necessary for the design of thermonuclear power stations, and were supplied with huge amounts of money as a result. Like the vortex theory of atoms, this goal was, so to speak, forgotten and disappeared gradually, but many talented people concentrated at that time on plasma problems, and they produced many remarkable things (some of them participated in the Symposium); it is enough to mention here the theory of collisionless shocks and the discovery of the inverse scattering method for the Korteweg–de Vries equation. The magnetic helicity-invariant integral characterizing the topology of a magnetic field, discovered by the plasma physicist Woltjer, also belongs to this category. The next developments in Topological Fluid Mechanics were made by the hydrodynamicist Moffatt and the mathematician Arnol'd. Moffatt recognized the topological nature of such invariants for magnetic fields of a rather simple nature, whilst Arnol'd demonstrated their very general nature for fields of general type. In 1969 Moffatt introduced the concepts of the helicity density and the helicity integral for vortex flows. Proper recognition of the helicity invariant for vortex flows without external magnetic fields was the natural consequence, so that now helicity, like energy and entropy, has its proper place among the invariants of ideal fluid flow. Helicity, in common with these other invariants, changes under the influence of viscous effects due to diffusion and reconnection of vortex lines, i.e. under varying topology. Thus, an important question arises immediately: if helicity, the second robust invariant of incompressible flow, does affect the cascade process in developed turbulence, how does it do so? And if not, why not?

So more than 100 people from very different backgrounds (including fluid mechanicists, plasma physicists, specialists in magnetohydrodynamics and mathematicians) gathered in Cambridge in August 1989 to consider together what could be achieved in fluid mechanics by topological (or perhaps even wider, qualitative), rather than analytical, methods. This volume contains the papers which were discussed, and refereed after the Symposium, and it represents a genuine wealth of important information concerning modern fluid mechanics.

The volume is divided into nine sections, and deals with the following subjects:

(I) Flow kinematics and Lagrangian chaos;
(II) Dynamo theory;
(III) Relaxation and formulation of discontinuities;
(IV) Two-dimensional and quasi-two-dimensional flows;
(V) Topology of three-dimensional flows;
(VI) Vortex interactions and reconnection.

The list of contributors makes a great impression. I did not participate myself, but I have read more or less carefully all the papers. This is a genuinely useful book, and the reader is forced to think about some ideas which he did not pay due attention to before. The volume is useful for general reading, especially for those who teach fluid mechanics. It ought to be in the libraries of universities and research bodies related to fluid mechanics.

I may say in conclusion that this volume is a worthy contribution to the sequence of summarizing accounts of fluid mechanics which have emanated from Cambridge. Like those, it will attract general attention and collect a lot of citations.

G. I. BARENBLATT

Flow and Heat Transfer in Rotating-Disc Systems. Volume 1. Rotor–Stator Systems. By J. M. OWEN and R. H. ROGERS. Wiley, 1989. 278 pp. £37.20.

A problem of great importance in turbomachinery engineering is the determination of the fluid flow and heat transfer produced by rotating mechanical parts adjacent to non-rotating structures. The most basic system of this type, comprising a rotating disk near a stationary one, has long been studied, not always without controversy: two different types of flow, associated with the names of Batchelor and Stewartson, were identified in the early 1950s, and only later were the circumstances found in which one type would occur and not the other. The book by Owen and Rogers gives a systematic account of the flow and heat transfer in such systems, including the effects of complications such as superposed external flow, ingress of surrounding fluid, and instability leading to vortex breakdown and jets; the simpler problem of an isolated rotating disk is also considered in detail, as a preliminary setting in which to develop the most fundamental parts of the theory. Laminar and turbulent regimes are given equal prominence, and the fluid dynamicist's three main weapons (theory, experiment and computation) are used to the full. Many comparisons of theory and data are presented.

The authors have written a successful book: it is clear and logical, contains a detailed account of the literature, and moves easily from the governing equations of fluid dynamics to the required special cases, such as the equations describing an Ekman boundary layer and the systems of ordinary differential equations of 'von Kármán type', governing similarity solutions appropriate to flow near a rotating disk. The book may be recommended.

C. J. Chapman

Foundations of Statistical Mechanics. Volume II. Nonequilibrium Phenomena.

By W. T. Grandy. Reidel, 1988. 307 pp. £62.

This book is part of a series on The Fundamental Theories of Physics: Their Clarification, Development and Application. It is an ambitious attempt to describe a statistical mechanical theory of nonequilibrium phenomena and irreversible processes. The foundation of the theory is a quantum-statistical nonequilibrium ensemble, proposed by Jaynes, which may be regarded as a generalization of the Gibbs canonical ensemble. The density operator, characterizing the ensemble, is constructed by maximization of an entropy functional, subject to constraints imposed by knowledge of results of measurements at different points in space and time. In principle the density operator, together with the time-evolution operator of the system, then allow one to make predictions of results of new observations. It is shown that for small deviations from equilibrium the postulated density operator reduces to the one employed in linear response theory. This establishes the connection with more customary formulations of nonequilibrium statistical mechanics. Apart from this connection there is no evidence that the postulated ensemble corresponds to physical reality or is useful in the interpretation of computer simulations.

A large part of the book is devoted to the mathematical analysis of correlation functions corresponding to the proposed nonequilibrium ensemble. Explicit results are derived for the ideal quantum gases. A diagrammatic perturbation theory is presented which allows for partial account of interactions between particles.

The remainder of the book deals with a description of conventional results in the theory of irreversible processes. The topics covered include hydrodynamics, transport processes, sound propagation and sound attenuation. All these subjects could have been dealt with on the basis of classical statistical mechanics. The relation to the quantum-statistical foundation is tenuous. There is a chasm, of which the author is well aware, between the elaborately constructed theoretical foundation and the description of nonequilibrium processes by standard phenomenological equations.

This book will be of interest to those who wish to appraise the present state of the art in the elaboration of Jaynes' ideas on nonequilibrium statistical mechanics. It may be questioned whether information-theoretical concepts are sufficient foundation to justify the validity of the chosen nonequilibrium ensemble. In my view the results presented in this book do not provide convincing support from physical applications.

B. U. Felderhof