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Book Review

Whither Turbulence? Turbulence at the Crossroads

J. L. Lumley (ed.), Vol. 357, Lecture Notes in Physics, Springer-Verlag, New York, 1990, 535 pp., $60.00.

This book is essentially an outgrowth and the proceedings of a workshop organized by the editor, held at Cornell University during March 22-24, 1989. The conference had as one of its aims, if not the primary aim, the joining of managers of grants and contracts from research funding agencies and most of the turbulence research community in an attempt to answer the question "whither turbulence?", thereby bringing about the possible answer to "whither the funding of turbulence research?"

One of the basic issues raised by Professor Lumley was whether proponents of one turbulence research area ought to subjugate areas of research not of particular interest to them but that, nevertheless, capture the attention of a sizable community. This is a universal issue, or "culture," that is found in other research areas as well. Specifically, Lumley has in mind the subject area of higher order closures. Regardless of whether the aims set forth are achieved or not, or are even achievable in such a workshop, Lumley must be commended for bringing some of the basic issues, more scientific than political, into the open with all the agenda in full view.

Professor Hans Liepmann's absence renders the workshop rather incomplete in that his unique point of view admits no substitute. However, Professor R. Narashima had much to contribute, more reflective of his own point of view, bringing to the workshop cited literature from his distinguished research team and including work originating from (but not entirely beyond) the West Coast of the United States.

Although there is not much attempt at cross-referencing, the individual contributors, reporters, and commentors made considerable and effective efforts in bringing their subject areas and points of view up to date. This in itself renders the book invaluable to those educated and judicious readers without prior prejudices who may want to attempt to find some of the answers to the turbulence question. For instance, Professor W. C. Reynolds estimated that, to numerically simulate all the relevant scales in a three-dimensional coherent structure experiment of an otherwise simple plane mixing layer, some 10^9 grid points are needed. This is quite beyond the capabilities of computing power in the near future.

On the other hand, this reviewer frequently takes to invoking an idea—a forerunner to that of coherent structures—due to Hugh Dryden. (Dryden, H. L., "Recent Advances in the Mechanics of Boundary Layer Flow," *Advances in Applied Mechanics*, edited by R. von Mises and Th. von Kármán, Vol. 1, Academic Press, New York, 1948, pp. 1-40.) That is, if periodicities existed in a turbulent shear flow they ought to be sorted out from the random oscillations in its description. From the enlightened articles on coherent structures contributed at this workshop, there is increasing recognition on the part of turbulent shear flow researchers that coherent structures are identifiable with the ubiquity of hydrodynamic instabilities (with identifiable frequencies and wave numbers in the presence of shear flows).

Elsewhere, work on hydrodynamic instabilities has shown increasing awareness of the obvious role of fine-grained turbulence. This reviewer sees that one important message this workshop and the resulting proceedings could convey, subject to judicious interpretation, is that progress in the description of high Reynolds number turbulent shear flows might be brought about by the explicit calculation of no more than a few of the relevant larger scale coherent hydrodynamical, rather than Fourier, modes coupled to a dynamical closure of the finer scales of motion. Conceivably, the latter is more universal and amenable to closure.

The coherent structures are definitely not universal in the context of hydrodynamic instability mechanisms; this reason alone may well account for the necessity of exercising the "science of variable constants" in prevailing closures whose constants are dependent upon geometrical/physical situations. Both Liepmann and Lumley have contributed, though from less overlapping points of view, to the incipient and sustaining research on coherent structures. It is seen that their work and the work discussed (as well as not discussed) at this workshop point toward the development of higher order closures using a dynamical model for the fine-grained turbulence coupled to an explicit description of large-scale hydrodynamical coherent structures.

The present lack of computing power for high Reynolds number flows, the lack of success of existing turbulence models, particularly in situations of unsteadiness and separated flows, and the need for reliable *predictive*, rather than curve-fitting, models such as in aircraft design and in internal flows crucial to propulsive devices, point to the imperative cooperation, rather than competition, between coherent structure research and the work on higher order closures. It is precisely the opportunity afforded the reader to extract an informed answer to the question "whither turbulence?" that renders this book an invaluable reference, even though the nonscientific questions posed earlier, which have drastic impact on the possibilities for the execution of research, are not simply answerable.

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