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Deterministic Aspects of Turbulent Shear Flows

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I came to the Wissenschaftskolleg for the purpose of outlining, writing and editing a book on the deterministic aspects of turbulence. The idea stems from the fact that twenty-five years have already passed since flow visualization exposed the existence of large orderly structures in turbulent shear flows. During these years, the direction of turbulence research had slowly changed from experimental compilation of statistical data to be used in models relying on the Reynolds-averaged equations of motion, to a search for the coherent aspects of turbulence. From accepting the inevitable existence of "universal" shear flows determined by the time-averaged equations and by the geometry, to an active manipulation and alteration of this "universality" without a concomitant change in the geometry. The "new" ideas in turbulence research became wide-spread and gained a fair amount of respectability among researchers belonging to a variety of disciplines. Yet, despite the ever increasing number of scientific meetings, workshops, and symposia devoted to the subject, the knowledge accumulated is transferred mostly by scattered proceedings and by word of mouth. There are small groups of researchers who frequent specific types of symposia and exchange among themselves new information and associated jargon. There is no reference book which reflects the new outlook on turbulent shear flows and guides a newcomer. We believe that time has come to gen-

erate some consensus on the subject and present a consistent view on the subject matter which might guide future graduate students and engineers and provide targets for criticism by other researchers.

The objective of this monograph is to describe and to quantify some deterministic aspects of turbulent shear flows. It is an attempt to chart the large coherent structures concentrating on the dynamics leading to their generation, their mutual interactions and their effect on the quasi steady mean flow. In short, this should encompass the processes that create and maintain turbulent flows. The dissipation of turbulence will probably rely, as it did in the past, on statistical methods.

The manuscript will represent selective points of view rather than a comprehensive review of the available literature. We may naturally refer to the material with which we are most familiar; we neither ignore nor fail to appreciate other data or other venues of research. We preferred to sacrifice completeness in favor of consistency and timely publication. A large fraction of the manuscript is therefore concerned with the simplest forms of turbulent shear flows in which the fluid is continuous and of constant density. Nevertheless, the implications for transport in inhomogenous flows are not ignored. Mixing of species, heat release and chemical reaction are considered for the simpler flow configurations. We shall also include a chapter devoted to the control and manipulation of large coherent structures, which should provide a practicing engineer with new design tools enabling him to increase the operational efficiency of some turbulent flow systems. Consequently, the book will not only address graduate students for the purpose of serving as an educational tool emphasizing the fundamental physical and mathematical principles. We shall therefore provide a guided path through the book for the following categories of readers: graduate students in aeronautical, mechanical, chemical or nuclear engineering, engineers interested in mixing, chemical reaction, drag reduction and the control of the turbulent boundary layer.

This monograph will represent the combined effort of twelve coauthors who elected to write different sections in accordance with their prime interests. Although each chapter will be written by a different subgroup of authors, the material presented will circulate and will be thoroughly discussed among all the contributors. It may therefore be regarded as a collective effort with a somewhat limited responsibility of everyone involved. The idea of such a cooperation is not new. Members of the Fluid Motion Panel of the Aeronautical Research Committee in England undertook a project of similar magnitude in the early thirties which resulted in a most successful monograph on fluid dynamics (edited by Sydney Goldstein). The chapter on turbulence in that book (written by G.I. Taylor) is still one of the most illuminating treatises on the subject. Our book has

been provisionally called *Turbulence From "B" to "W"*, not only because the name of the first author (in alphabetical order) starts with B and that of the last author starts with W, but also because it does not pretend to be all inclusive.

We outlined the contents of the main nine chapters of the book and allocated individual co-authors their responsibilities. I also used my time to write a large section of two of these chapters. Generating consensus among individual collaborators was not an easy task, but we are making progress.

During my stay in Berlin I collaborated closely with Professor Fiedler of the Technical University not only on the book project but also on other research projects of current interest. I helped in supervising a Ph. D. candidate and two Dipl. Ing. candidates at the Technical University as well as one at the University of Stuttgart. I had numerous discussions with Professors Berger and Fernholz from the Technical University; Dr. Michel from the *Deutsche Forschungsanstalt für Luft- and Raumfahrt*, Professor Rodi from Karlsruhe and Professors Eckelmann and Dinkelacker from the *Max-Planck-Institut* in Göttingen. I gave seminars at the Technical University of Berlin as well as in Karlsruhe, Göttingen, and Stuttgart. Furthermore, I wrote three articles which will appear in the proceedings of international conferences and completed two articles which were accepted for publication in the *Journal of Fluid Mechanics*, which is considered to be the top quality journal in this field.

Finally, in order to keep the collaboration with the Berlin Fluid Dynamics community, I wrote joint research proposals to be submitted to the German-Israeli Foundation for Scientific Research and to the National Science Foundation in the USA. I shall not only leave *"einen Koffer in Berlin"* but a bicycle as well, together with many experiences, memories and a few new found friends encountered at the Wissenschaftskolleg. I trust this expresses my thoughts on the year that passed. Do I need to say more?