

# Preface

Turbulence is a part of fluid mechanics. Therefore, in this book, it is assumed that the reader is already familiar with the fundamentals of fluid mechanics. There are many books that the uninformed reader can consult. A first introduction is provided by the book of White (2011), which also can be recommended for its practical approach, or the books by Acheson (1990), Faber (1995), or Kundu and Cohen (2004), which can be recommended to the reader interested in the physical aspects of fluid mechanics. Standard text books on fluid mechanics are those by Landau and Lifshitz (1959), and especially by Batchelor (1967), which contains a solid mathematical treatise of fluid mechanics.

We are only able to dwell briefly on the results of linear stability theory and the solution to Burgers equation. For further details on stability analysis the reader is referred to the book of Drazin and Reid (1981), while for the Burgers equation the reader is referred to the book of Whitham (1974), where a comprehensive treatise on the Burgers equation is given. An introduction to nonlinear dynamical systems and chaos theory is given in the books by Schuster (1984) and Bergé et al. (1984).

On the topic of turbulence, several text books can be recommended to be used simultaneously with this book; it is often very clarifying when the same material is considered from different viewpoints. Foremost, we suggest the book of Tennekes and Lumley (1972), which has been among the most cited books on turbulence for decades and which has been the inspiration for certain parts of the present book. Traditional descriptions of turbulence that originate from statistical mechanics can be found in the books by Monin and Yaglom (1973) and Landahl and Mollo-Christensen (1986). Also, there are a number of standard works in the field of turbulence, which can be consulted for various topics. Classic text books on turbulence are those by Townsend (1976) and Hinze (1975), while more recent books are those by Pope (2000) and Davidson (2004), which all can be used by those who wish to continue on the topics introduced in this book. There are also several books on specialized topics in turbulence, such as the book by Batchelor (1953) on the theory of homogeneous turbulence, while developments in the field of spectral models can be found in the book by Lesieur (2008) and in the field of

renormalization methods in the book by McComb (1990). Also, much attention in physics has been devoted recently to scaling of the microstructure, following the theory of Kolmogorov. An overview of this modern theory can be found in the book by Frisch (1995).

This book was originally written by Frans T.M. Nieuwstadt to support his lectures on turbulence at the level of master students at the Delft University of Technology. It was based on his lecture notes for a course taught at the University of Utrecht before he was appointed at the Delft University of Technology. His objective had been to write a concise introduction on the physical aspects of turbulence (partly inspired by the work of Tennekes and Lumley), but substantially extended to include insights from nonlinear dynamical systems and chaos theory, stability analysis, modern numerical methods, and an overview of current turbulence *closure models* used in *computational fluid dynamics* (CFD) codes. Besides, he wanted to have a book that was also affordable to students.

The original work was written in Dutch, and it was used also at other Dutch universities. However, since around the year 2000, courses had to be taught in English, and we resorted to English language textbooks. Although various excellent books have been available, we could not find the mix of topics that we were used to in the original book by Frans T.M. Nieuwstadt. Since long we had planned to translate, update, and extend the book. Also, we received requests from colleagues to make available a translation of the book. The present book is the result of this effort.

We are indebted to many colleagues who contributed to the completion of this book; in particular we would like to thank Gijs Ooms for proofreading this book and Herman Clercx of the *Vortex Dynamics and Turbulence Group* at the Eindhoven University of Technology for writing a special topic on *rotating turbulence* (Sect. B.4).

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