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Preface

According to the *The Feynman Lectures on Physics*: "The next great era of awakening of human intellect may well produce a method of understanding the qualitative content of equations. Today we cannot. Today we cannot see that the water flow equations contain such things as the barber pole structure of turbulence that one sees between rotating cylinders". Maybe Feynman was right, maybe he was not. Today we see, with increasing evidence, that in the absence of a secure method of understanding the qualitative content of the Navier-Stokes equations, numerical methods combined with the scarce theoretical understanding provide us with astonishing evidence about the structure of turbulent flows.

Numerical methods for turbulent flows are a topic which has seen much development and activity in the last decades. The reasons for this are divers.: First, there are important, if incomplete theories, trying to elucidate the properties of turbulent flows; second, there is more computing power available to approach realistic physical problems involving turbulence; and third, there are many classical and some new technical applications which require accurate simulations. In this introduction, we will briefly list some of these reasons more explicitly and then discuss how they are addressed in the various articles contained in this special issue.

As for the first reason given above, we have come to a much better understanding of the Navier-Stokes equations, its solvability and approximations of its solutions. The existing simulation schemes have been scrutinized for consistency and convergence, and been refined and simplified.

Thanks to the continuous increasing computational power, chemical reactions have been implemented, making the application to combustion, to name one important area, possible. Thus important industrial processes can and have been explored. At the interface between laminar and turbulent fluid dynamics, totally new connections and avenues towards old problems have been found in the form of turbulence models.

Subsequently, the most extraordinary development took place when it was noted that it is much better not to model large vortices, which may be simulated directly, and model only the vortices which cannot be resolved numerically. This is the method of Large Eddy Simulation (LES) which appears as the most promising tool for future developments, from both the viewpoint of increasing the accuracy and widening the range of Reynolds numbers. Direct Numerical Simulation (DNS) is an important tool to investigate theoretical questions but remains far from practical uses.

These remarks give a natural link to the third reason mentioned earlier. Turbulence arises in many technical applications, from the simulations of the flow past aircraft to the behavior of combustion chambers. Thus, the same simulation methods can in a short time pass from the area of scientific investigation to practical applications.

We are very pleased with the cross-section of the current activity in the methods to understand and describe turbulent flows offered by the 11 papers published in this volume. The papers span studies on fundamental problems to how Large Eddy Simulations can be made more efficient by suitable modifications of the subgrid model, to concrete investigations regarding the structure of very specific flows.

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We hope that this issue will become and remain a standard reference for all of the mentioned research directions in the fluid dynamics of turbulent flows.

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