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ANALYSIS AND CONTROL OF MIXING WITH AN APPLICATION TO MICRO AND MACRO FLOW PROCESSES

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PREFACE

The present monograph takes inspiration from the Advanced School on "Analysis and Control of Mixing with Application to Micro and Macro Flow Processes" held in Udine, Italy, (June 1-5, 2005) at the International Center for Mechanical Sciences (CISM). The Advanced School was made possible by the financial and logistic support of CISM and by the financial support of the Marie Curie Program of the European Atelier for Engineering and Computational Sciences (EUA4X). The Advanced School was complemented by a workshop. The workshop provided a fertile environment for discussions where participants in the Advance School, as well as academic and industry experts from fluids, combustion and control disciplines, presented their most recent results. The Advanced School and the workshop attracted a wide range of scientists and practitioners: postgraduates, postdoctoral researchers, mechanical, chemical and aeronautical engineers, and applied mathematicians in universities and industries.

The study of mixing two or more fluids with or without chemical reactions is of great practical relevance to both engineering applications and natural phenomena. The analysis and control of mixing at macro and micro scales is receiving great attention because of the potential for optimizing the performance of many flow processes. In modern and futuristic industrial applications, the time allowed to find the appropriate mixing action is becoming increasingly shorter while the demands are increasingly more severe. A better understanding of mixing is crucial for improving old and designing new mixing devices that are able to reduce the residence mixing time, improve mixing homogeneity and allow the process of new materials highly sensitive to the presence of concentration and temperature gradients. In spite of much advancement, the understanding of mixing is still somewhat limited in three-dimensional flows. In particular optimization and feedback control of mixing are still in their infancy. Consequently, mixing continues to represent a rich and appealing research field for both the fundamental and the application oriented scientists.

The Advanced School provided an overview of the physics, mathematics and state-of-the-art theoretical/numerical modeling and experimental investigations of mixing in laminar and turbulent flows at macro and micro scales. This monograph follows the footsteps of

the Advanced School and contains the following contributions: Anthony Leonard presents an "Overview of Turbulent and Laminar Diffusion and Mixing", Igor Mezić discusses "Mixing and Dynamical Systems", Stefano Cerbelli presents the "Hyperbolic Behavior of Laminar Chaotic Flows", Massimiliano Giona discusses "Advection-diffusion in Chaotic Flows", Emmanuel Villermaux elaborates on "Random Mixing", Fotis Sotiropoulos presents an "Experimental Visualization of Lagrangian Coherent Structures Using Eulerian Averaging", Tatyana Krasnopolskaya discusses "Quality Measures and Transport Properties" of mixing, Tamás Tel discusses some aspects of "Reactions in Chaotic Flows", Mark A. Stremler elaborates on "Fluid Mixing, Chaotic Advection, and Microarray Analysis", Jean-Luc Thiffeault presents "The Size of Ghost Rods", Bartosz Protas discusses the utility of "Nonlinear Preconditioning in Problems of Optimal Control for Fluid Systems" and, finally, Luca Cortelezzi elaborates on the "Sensitivity of Mixing Optimization to the Geometry of the Initial Scalar Field".

We would like to thank all the contributors for their scholarly dedication in making this volume a reality. We would also like to thank all members of CISM for their help in making the Advanced School and this monograph a success. In particular, we would like to thank the Secretary General, Prof. Bernhard A. Schrefler, for encouraging and supporting our Advanced School, Dr. Sara Guttilla, for her dedicated help in all stages of our Advanced School and, finally, the Executive Editor Prof. Paolo Serafini for his precious assistance during the editing of this monograph.

Luca Cortelezzi and Igor Mezić

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