MATHEMATICAL MODELING AND SIMULATION IN HYDRODYNAMIC STABILITY

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Preface

In the last several decades, there has been great progress on the subject of hydrodynamic stability mainly due to mathematical modeling and numerical simulation efforts which were based on various analytical and computational methods. The subject of hydrodynamic stability is of fundamental importance in the mechanics of fluids and its applications in various fields of engineering, geophysical, astrophysical and environmental sciences. An important problem that hydrodynamic stability is concerned is that of instabilities that can take place and their transition sequences towards turbulence regime.

The initial motivation for preparing the present volume was the interest expressed by several invited speakers at the 14th World Congress of the International Association for Mathematics and Computers in Simulation (IMACS) (Atlanta, GA, July 1994) who participated in special sessions on hydrodynamic stability one of which was organized by the present editor. As a latest research volume on the subject of hydrodynamic stability, this book has developed from manuscripts submitted by internationally recognized applied mathematicians and scientists who have made important contributions to the mathematical modeling and simulation aspects of hydrodynamic stability. This book brings together current developments in the theory and applications of hydrodynamic stability, which were due to the mathematical modeling and simulation efforts in the subject, and it is hoped that they provide sufficient stimulation and directions for future research investigations on the subject.

The chapters in this book are placed in a sequence based on the alphabetical order of the main authors' last name. The first chapter, by A. Bottaro and P. Luchini, presents development of a mathematical model for the problem of the stability of the disturbances for the Görtler vortices. Chapter two, by F.H. Busse and R.M. Clever, present a general outline of the bifurcation type approach towards an understanding of complex flows. The evolution from simple to complex flows is studied by a sequence of mathematical models and simulations through the Galerkin procedure. Chapter three, by A.L. Frenkel and K. Indreshkumar, discusses the evolution equations and the associated theories for wavy flows of viscous films on solid surfaces. Both perturbation analysis and numerical simulations are employed and some unresolved questions are posed and discussed. Chapter four, by L. Hadji, considers the influence of thermal Soret diffusion on the instabilities in a dilute binary mixture during solidification process. The issue of constitutional super cooling and the importance of the coupling between solidification and Soret-driven flow are analyzed and discussed. Chapter five, by W.R.C. Phillips, reviews rotational waves and their nonlinear interaction with shear flows. The interaction process is described through a Lagrangian formulation and a theory. Chapter six, by D.N. Riahi, reviews nonlinear stability analysis and modeling for convective flows, and the latest research results for several convective flow problems are presented. Chapter seven, by D.N. Riahi, reviews primary hydrodynamic instabilities and their mathematical modeling and simulation for several shear flow cases, and the latest research results for these shear flows are presented. Chapter eight, by A. Zebib, A. Bottaro and B.G.B. Klingmann, determines spatial development of longitudinal vortices through modeling and simulation, and various results are presented for a range of rotation numbers.

I would like to thank the authors for their effective contributions which demonstrate the power of mathematical modeling and simulation for the advancement of the research in the subject of hydrodynamic stability. I also would like to thank Ms. Kim Tan, editor at World Scientific Publishing Company, Inc., for her help in publishing this monograph.

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