INTERNATIONAL CENTRE FOR MECHANICAL SCIENCES

COURSES AND LECTURES - No. 329

ROTATING FLUIDS IN GEOPHYSICAL AND INDUSTRIAL APPLICATIONS

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Springer-Verlag

Wien GmbH

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Originally published by CISM, Udine in 1992.

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ISBN 978-3-211-82393-4 ISBN 978-3-7091-2602-8 (eBook)
DOI 10.1007/978-3-7091-2602-8

PREFACE

Most of the research on rotating fluids has been motivated by geophysical applications because in these situations rotation effects are of primary importance.

Understanding atmospheric and oceanic motions is of vital interest for climate prediction and we are also increasingly concerned with the dispersion of pollution by biochemical and chemical substances released in the atmosphere and the oceans. The release of CO₂ for instance is of great concern in the general question of global warming.

Rotation is also plays a key role in rotating machines where, for example, it effects the boundary layers structure on the runner blades of turbines and can give rise to intense vortex formation. Vortex flows or swirling flows are widely encountered and are made use of in engineering problems related with cyclone separators, the aerodynamics of combustion chambers and vortex valves. There is renewed interest in the fundamental understanding of these complex engineering flows. Although the scales of motions in rotating industrial devices are very different from those encountered on planets, the fundamental concepts of rotating fluids presented in this volume have general value; much can, therefore, be gained by interdisciplinary research.

The main effects of rotation are the tendency toward two-dimensionality of fluid motions, the rapid spin-up or spin-down of fluid columns due to Ekman pumping and the possibility of sustained wave motions. A number of flow instabilities are a result of rotation or the combined effect of rotation and stratification. Some of these are well known while others are at the forefront of research. Considerable progress has also been made recently on turbulence and shear flows in rotating fluids. The mechanisms of

energy and anstrophy transfers in turbulence with rotation is better understood, and exciting new phenomena like the transition to a rotationally dominated turbulence state and the possibility of vorticity concentration have recently been demonstrated. This raises new questions concerning vortex waves, vortex breakdown and vortex stability in general (in two and three dimensions).

The topics covered in this volume include general concepts and the fundamentals of rotating fluids, a comprehensive treatment of Ekman layer and Stewartson layer theories, aspects of instabilities (including baroclinic instability and vortex instabilities), different types of wave motions, vortex flows, interactions of geostrophic vortices, geostrophic and rotationally dominated turbulence and shear flows with rotation.

Emphasis is placed on both, theory and experiments, either physical or numerical. The book is intended for graduate students and research workers interested in geophysical fluid dynamics or those concerned with engineering problems of rotating fluids.

The volume comprises the lecture notes of the course on rotating fluids given in Udine in July 1991. All the lectures were ready to revise and amend their notes for publication in the form of this book and I owe them special thanks. The willingness to make this additional effort is partly due to the warm welcome by the staff of the International Centre for Mechanical Sciences in Udine and to the stimulating atmosphere of the center which were greatly appreciated by the lecturers and the students. I think the lecturers will join me in expressing our gratitude for the support received from the CISM and in particular to Professor G. Bianchi, S. Kaliszky and the administrative staff of the center for their constant readiness to help.

E.J. Hopfinger

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