

Vortex Dynamics in Plasmas and Fluids

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Abstract The existence and dynamics of vortical structures in both homogeneous and inhomogeneous systems will be discussed. In particular the dynamics of monopolar and dipolar vortices in a plasma with nonuniform density and in a rotating fluid with varying Coriolis force is described. The role of vortical structures in connection with electrostatic plasma turbulence and the associated cross-field plasma transport will also be addressed.

1. Introduction

The existence of coherent vortical structures is a characteristic feature of two-dimensional or quasi-two-dimensional flows [1], such as planetary atmospheres and oceans, laboratory experiments with rotating or stratified fluids and strongly magnetized plasmas. The structures have life times much longer than their own period of internal rotation. They are dominating the large scale dynamics and are naturally of great importance in connection with the transport of mass, heat and momentum. Since they can trap particles and convect them over distances much larger than their own scale size they provide a transport mechanism, which in its nature is essentially different from classical diffusion dominated transport. Coherent structures are likely to form after external forcing and seem to be the universal outcome of any regular as well as irregular forcing in two-dimensional systems. They are easily excited in laboratory experiments in rotating [2,3] and stratified fluids [4]. They also appear spontaneously in two-dimensional turbulence [5] due to self-organization processes characterizing two-dimensional flows. The simultaneous conservation of energy and enstrophy (mean squared vorticity) for two-dimensional flows leads to an inverse spectral cascade, by which energy is cascading to smaller and smaller wavenumbers, whereas enstrophy is cascading to larger and larger wavenumbers. This effect is clearly demonstrated in high resolution numerical simulations of two-dimensional flows [6,7,8]. Vortical structures have also been excited in magnetized plasmas [9], where the low-frequency electrostatic dynamics is well described by a two-dimensional model, and the coalescence of like signed vortices, which is mediating the inverse cascade, was directly demonstrated [10]. In this connection the structures have often been termed convective cells [11]. Vortical structures are further found to appear spontaneously in low-frequency electrostatic turbulence [12,13] and to play an important role in connection with the plasma confinement by the magnetic field.

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Dynamics Of Fluids Plasmas

Daniel F McAuley



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Dynamics of Fluids and Plasmas, 1966 Dynamics of fluids and plasmas, 1966 **Dynamics of Fluids and Plasmas**, 1966 *Dynamics of Fluids and Plasmas* Shiyi Bai, Johannes Martinus Burgers, United States. Air Force. Office of Scientific Research, University of Maryland, College Park. Institute for Fluid Dynamics and Applied Mathematics, 1966 **Topological Aspects of the Dynamics of Fluids and Plasmas** H.K. Moffatt, G.M. Zaslavsky, P. Comte, M. Tabor, 2013-03-09 This volume contains papers arising out of the program of the Institute for Theoretical Physics ITP of the University of California at Santa Barbara August-December 1991 on the subject Topological Fluid Dynamics The first group of papers cover the lectures on Knot Theory Relaxation under Topological Constraints Kinematics of Stretching and Fast Dynamo Theory presented at the initial Pedagogical Workshop of the program The remaining papers were presented at the subsequent NATO Advanced Research Workshop or were written during the course of the program We wish to acknowledge the support of the NATO Science Committee in making this workshop possible The scope of Topological Fluid Dynamics was defined by an earlier Symposium of the International Union of Theoretical and Applied Mechanics IUTAM held in Cambridge England in August 1989 the Proceedings of which were published Eds H K Moffatt and A Tsinober by Cambridge University Press in 1990 The proposal to hold an ITP program on this subject emerged from that Symposium and we are grateful to John Greene and Charlie Kennel at whose encouragement the original proposal was formulated Topological fluid dynamics covers a range of problems particularly those involving vortex tubes and or magnetic flux tubes in nearly ideal fluids for which topological structures can be identified and to some extent quantified The Physics of Fluids and Plasmas Arnab Rai Choudhuri, 1998-11-26 A good working knowledge of fluid mechanics and plasma physics is essential for the modern astrophysicist This graduate textbook provides a clear pedagogical introduction to these core subjects Assuming an undergraduate background in physics this book develops fluid mechanics and plasma physics from first principles This book is unique because it presents neutral fluids and plasmas in a unified scheme clearly indicating both their similarities and their differences Also both the macroscopic continuum and microscopic particle theories are developed establishing the connections between them Throughout key examples from astrophysics are used though no previous knowledge of astronomy is assumed Exercises are included at the end of chapters to test the reader's understanding This textbook is aimed primarily at astrophysics graduate students It will also be of interest to advanced students in physics and applied mathematics seeking a unified view of fluid mechanics and plasma physics encompassing both the microscopic and macroscopic theories

Lecture Notes on Turbulence and Coherent Structures in Fluids, Plasmas and Nonlinear Media Michael Shats, Horst Punzmann, 2006 This book is based on the lectures delivered at the 19th Canberra International Physics Summer School held at the Australian National University in Canberra Australia in January 2006 The problem of turbulence and coherent structures is of key importance in many fields of science and engineering It is an area which is vigorously

researched across a diverse range of disciplines such as theoretical physics oceanography atmospheric science magnetically confined plasma nonlinear optics etc Modern studies in turbulence and coherent structures are based on a variety of theoretical concepts numerical simulation techniques and experimental methods which cannot be reviewed effectively by a single expert The main goal of these lecture notes is to introduce state of the art turbulence research in a variety of approaches theoretical numerical simulations and experiments and applications fluids plasmas geophysics nonlinear optical media by several experts A smooth introduction is presented to readers who are not familiar with the field while reviewing the most recent advances in the area This collection of lectures will provide a useful review for both postgraduate students and researchers new to the advancements in this field as well as specialists seeking to expand their knowledge across different areas of turbulence research

Dynamics of Fluids and Plasmas Shiyi Bai, 1966

Coherent Vortex Structures in Fluids and Plasmas Anatoli Tur, Vladimir Yanovsky, 2017-04-09 This monograph introduces readers to the hydrodynamics of vortex formation and reviews the last decade of active research in the field offering a unique focus on research topics at the crossroads of traditional fluids and plasmas Vortices are responsible for the process of macroscopic transport of momentum energy and mass and are formed as the result of spontaneous self organization Playing an important role in nature and technology localized coherent vortices are regularly observed in shear flows submerged jets afterbody flows and in atmospheric boundary layers sometimes taking on the form of vortex streets In addition the book addresses a number of open issues including but not limited to which singularities are permitted in a 2D Euler equation besides point vortices Which other even more complex localized vortices could be contained in the Euler equation How do point vortices interact with potential waves

The Physics of Laser Plasmas and Applications - Volume 2 Hideaki Takabe, 2024-03-28 This open access book Volume 2 is part of the series The Physics of Laser Plasmas and Applications It serves as an introduction to the physics of compressible hydrodynamics which is used to describe the temporal evolution of plasmas generated by intense laser irradiation of solid surfaces For the benefit of students and young researchers the book presents the fundamental equations and provides a comprehensible explanation of solutions to intricate fluid phenomena It builds upon the concept of plasma generation through the heating of matter via the classical absorption of a laser as expounded in Volume 1 The high temperature plasma resulting from the laser interaction manifests in diverse hydrodynamic occurrences like shock waves and expansion waves The initial sections of this book expound the essentials of compressible hydrodynamics magnetohydrodynamics MHD and the physics of shock waves The transfer of laser energy within an expanding plasma towards regions of higher density is achieved through electron and X ray transport mechanisms In both instances conventional diffusion models prove inadequate necessitating mathematical frameworks founded on the Boltzmann equation The conveyed energy engenders ablation pressure equivalent to tens of millions of atmospheres on the solid surface This pressure initiates powerful shock waves propagating through the solid material The propagation of these shock waves is

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