

Nonlinear Waves and Chaos in Space Plasmas

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Preface

Nonlinear waves and chaos have been the subjects of intense research in a variety of branches of natural sciences in recent years. Space plasma physics has been no exception. The space plasmas, naturally embedded in an immense interplanetary space, provide a unique and ideal 'natural laboratory' for studying nonlinear physical processes. In particular, the fact that the space plasmas are almost perfectly collisionless promoted the development of a considerable number of new fields in plasma physics. Some examples are the collisionless shock waves, micro-instabilities, anomalous dissipation, and the magnetohydrodynamic turbulence. Also, the complex properties of nonlinear waves in space plasmas are one of the eminent research topics which have fascinated many space plasma physicists for decades.

From the early days of spacecraft experiments, it was already evident that space plasmas were abundant with numerous kinds of nonlinear plasma waves. Recently, theoretical understanding of these observations has rapidly begun to become clear, which could be ascribed to the following three reasons. First, the new generation spacecrafts with advanced experimental techniques started to capture plasma and field data with improved accuracy and time resolution. Nowadays such detailed information as the three-dimensional velocity space plasma distribution function is commonly available. With the use of multi-spacecrafts, it becomes possible to separate temporal and spatial variations. As the data become more sophisticated, quite naturally, theories pertinent to the observations are urged to become more elaborate. Second, remarkably rapid progress of computer power, both in speed and in storage space, made it possible to perform numerical simulations with increasingly larger number of particles and more grid cells, for a longer running time, and with higher phase space dimensions. Assisted also by the development of the state-of-the-art simulation and diagnostics techniques, it is now possible to predict complex nonlinear behavior of space plasmas using realistic parameters, although one should still bear in mind that there are limitations. Third, there has been significant development in applied mathematics on the theory of nonlinear dynamical systems with a small number of intrinsic degrees of freedom. This involves analysis on nonlinear waves, chaos, and turbulence. Actually, many of the key concepts related to these fields have emerged much ear-

lier: for example, back in 1960's a series of revolutionary ideas had already been born in nonlinear wave physics, such as the concept of solitons, the reductive perturbation method, and the procedures of exactly linearizing nonlinear evolution equations. However, it is only recently that scientists have started to apply these concepts to the discussion of nonlinear waves and chaos in space plasma physics.

It was thus quite timely that the International Workshop on Nonlinear Waves and Chaos in Space Plasmas was held, with great success, in Uji Japan, from June 13th to the 16th, 1994. The main objective of the workshop was to discuss up-to-date research results related to nonlinear space plasma waves, turbulence, and chaos, from the perspectives of spacecraft and laboratory experiments, plasma theory and computer simulation, and the theory of nonlinear dynamical systems and evolution equations. Equally stressed was that the workshop provides a unique forum for stimulating interaction between the scientists from the different fields. In order to make discussions intensive and informal, the workshop was designed to be small in scale: there were some fifty participants, mostly invited, from 11 countries. The workshop was roughly grouped into four sessions: hydro-magnetic waves in space plasmas, physics of nonlinear waves and shocks, turbulence and new methods, and chaos and stochasticity in magnetoplasmas.

The present volume is a collection of eleven distinct papers presented at the workshop. Unlike conventional conference proceedings, all the papers are refereed by (at least) two reviewers. Although they by no means cover the topics related to nonlinear waves and chaos in space plasma physics completely, they do represent some essential portions of our current understanding on the subject. We hope this volume will be beneficial to those interested in this new and exciting field of research.

Editors

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