PREFACE

This volume contains the proceedings of the Summer Program on Nonlinear Conservation Laws and Applications held at the Institute for Mathematics and its Applications on July 13–31, 2009. The program brought together several of the world's leading experts in the field, discussing the most significant theoretical advances and a wide range of applications.

Hyperbolic conservation laws is a classical subject, which has experienced vigorous growth in recent years. For one-dimensional systems with small data, the global existence and uniqueness of entropy weak solutions is well known. In addition, the method of local decomposition of solutions along traveling wave profiles has recently provided an understanding of the convergence of various types of approximations: vanishing viscosity, relaxations, and semi-discrete schemes. On the other hand, the global existence or the finite time blow-up of solution with large data is still a major open problem.

In several space dimensions, the theoretical analysis of hyperbolic conservation laws remains a grand challenge. During the past few years, new techniques have been introduced, resulting in specific advances. Refined measure-theoretical tools have been developed for the study of scalar conservation laws, and for transport equations with rough coefficients. Intriguing counterexamples have been constructed by means of a newly developed Baire category technique. Moreover, major breakthroughs have been achieved in the understanding of shock reflection-diffraction by a wedge in the equation of gas dynamics, and in the existence theory for global weak solutions with large data for the compressible Navier-Stokes equations, in both the isentropic and non-isentropic cases.

Progress in theoretical understanding has been paralleled by an expansion in the applications of hyperbolic conservation laws. Traditional areas of applications in mathematical physics, such as fluid dynamics, magneto-hydrodynamics, nonlinear elasticity, combustion models, oil recovery, etc., have experienced sustained growth. In addition, new directions are emerging: continuum models based on conservation laws are increasingly used in the analysis of blood flow and of cell motion, and in the modeling of traffic flow and of large scale supply-chains in economic and industrial applications. A novel aspect in some of these models is that the flow is not only studied on a single road, or pipeline, but on an entire network.

The papers in the present volume provide a comprehensive account of these recent developments, and an outlook on open problems. The initial sections contain contributions from the main lecturers, who gave introductory courses during the first week of the Summer Program. The topics covered include: open questions in the theory of one-dimensional hyperbolic systems (A. Bressan), multidimensional conservation laws in several space variables (G.-Q. Chen), mathematical analysis of fluid motion (E. Feireisl), topics in the approximation of solutions to nonlinear conservation laws (E. Tadmor), and stability and dynamics of viscous shock waves (K. Zumbrun).

The remainder of the volume contains refereed research papers by the invited speakers. Contributions of more theoretical nature cover the following topics: singular limits for viscous systems of conservation laws, basic principles in the modeling of turbulent mixing, hyperbolic problems in two space dimensions related to gas dynamics, transonic flows past an obstacle and a fluid dynamic approach for isometric embedding in geometry, models of nonlinear elasticity, the Monge problem, and transport equations with rough coefficients. In addition, there are a number of papers devoted to applications. These include: models of blood flow, self-gravitating compressible fluids, granular flow, charge transport in fluids, and the modeling and control of traffic flow on networks.

We believe that this volume will provide a timely survey of the state of the art in the exciting field of conservation laws, and a stimulus for its further progress.

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