Fields Institute Communications

The Fields Institute for Research in Mathematical Sciences

Topics in Kinetic Theory

Thierry Passot
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The Fields Institute for Research in Mathematical Sciences

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Preface

This volume collects lectures given at the Short Course and Workshop on Kinetic Theory organized in the framework of the Thematic Program in Partial Differential Equations at the Fields Institute of Mathematical Sciences in Toronto during the Spring 2004.

The contributions cover a variety of topics related to the kinetic theory in neutral gases and magnetized plasmas, with extensions to quantum plasmas that may have technological applications in miniaturized semiconductor devices and nanoscale objects, and to other systems such as granular flows. A comprehensive presentation of the Boltzmann and other kinetic equations for neutral gases is presented, together with the rigorous derivation of fluid models for the dynamics at scales large compared with the particle mean free path. Several papers are devoted to collisionless plasmas where electromagnetic effects are dominant, a regime characteristic of both fusion and space environments. Rigorous results concerning the well-posedness of the Vlasov-Maxwell system for the one-particle distribution function are reviewed. Special interest is devoted to asymptotic regimes where the spatial and temporal scales of variation of the electromagnetic field are clearly separated from those associated with the particle gyromotion. This includes the dynamics of the guiding center of an individual charged particle, resulting from the averaging over the gyromotion, and the statistical extension of this description at the level of the so-called drift approximation. The more general gyrokinetic theory that retains electromagnetic perturbations with transverse scales comparable to the gyroradius is introduced. In the absence of collisions, the closure of the hierarchy of the equations for the moments of the distribution function can hardly be justified, even in the presence of an intense magnetic field that contributes to bind particles together. Semi-heuristic closures, consistent with the kinetic theory in the linear approximation, were nevertheless recently introduced in order to simulate regimes involving a broad range of scales. These approaches that include Landau damping within a fluid description are reviewed. The origin of the irreversibility of the statistical description in situations where the primitive many-body dynamics is Hamiltonian, is also addressed.

We thank the Fields Institute for financial and administrative support and for the publication of these proceedings. We are grateful to the Fields Institute staff for their outstanding work and wish to express our thanks to the lecturers and to all participants who contributed to the success of the meetings.

T. Passot, C. Sulem, P.-L. Sulem

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This book covers a variety of topics related to kinetic theory in neutral gases and magnetized plasmas, with extensions to other systems such as quantum plasmas and granular flows. A comprehensive presentation is given for the Boltzmann equations and other kinetic equations for a neutral gas, together with the derivations of compressible and incompressible fluid dynamical systems, and their rigorous justification. Several contributions are devoted to collisionless magnetized plasmas. Rigorous results concerning the well-posedness of the Vlasov-Maxwell system are presented. Special interest is devoted to asymptotic regimes where the scales of variation of the electromagnetic field are clearly separated from those associated with the gyromotion of the particles. This volume collects lectures given at the Short Course and Workshop on Kinetic Theory organized at the Fields Institute of Mathematical Sciences in Toronto during the Spring of 2004.

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