



Nonequilibrium Processes in Partially Ionized Gases

Edited by
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J. Norman Bardsley

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Nonequilibrium Processes In Partially Ionized Gases

Ekaterina Nagnibeda, Elena Kustova



Nonequilibrium Processes In Partially Ionized Gases:

Nonequilibrium Processes in Partially Ionized Gases M. Capitelli, J. Norman Bardsley, 2012-10-17 The NATO Advanced Research Institute on Nonequilibrium Processes in Partially Ionized Gases was held at Acquafredda di Maratea during 4-17 June 1989. The Institute considered the interconnections between scattering and transport theories and modeling of nonequilibrium systems generated by electrical discharges, emphasizing the importance of microscopic processes in affecting the bulk properties of plasmas. The book tries to reproduce these lines. In particular, several contributions describe scattering cross sections involving electrons interacting with atoms and molecules in both ground and excited states from theoretical and experimental point of view of energy transfer processes as well as reactive ones involving excited molecules colliding with atoms and molecules as well as with metallic surfaces. Other contributions deal with the basis of transport theories, Boltzmann and Monte Carlo methods for describing the bulk properties of non-equilibrium plasmas as well as with the modeling of complicated systems, emphasizing in particular the strong coupling between the Boltzmann equation and excited state kinetics. Finally, the book contains several contributions describing applications in different fields such as Excimer Lasers, Negative Ion Production, RF Discharges, Plasma Chemistry, Atmospheric Processes, and Physics of Lamps. The Organizing Committee gratefully acknowledges the generous financial support provided by the NATO Science Committee as well as by Azienda Autonoma di Soggiorno e Turismo of Maratea, by University of Bari, by C.N.R. Centro di Studio per la Chimica dei Plasmi, and Comitato per la Chimica, by ENEA, by Lawrence Livermore Laboratory, and by US Army Research Office.

Nonequilibrium Processes in Partially Ionized Gases M. Capitelli, J. Norman Bardsley, 2012-12-06 The NATO Advanced Research Institute on Nonequilibrium Processes in Partially Ionized Gases was held at Acquafredda di Maratea during 4-17 June 1989. The Institute considered the interconnections between scattering and transport theories and modeling of nonequilibrium systems generated by electrical discharges, emphasizing the importance of microscopic processes in affecting the bulk properties of plasmas. The book tries to reproduce these lines. In particular, several contributions describe scattering cross sections involving electrons interacting with atoms and molecules in both ground and excited states from theoretical and experimental point of view of energy transfer processes as well as reactive ones involving excited molecules colliding with atoms and molecules as well as with metallic surfaces. Other contributions deal with the basis of transport theories, Boltzmann and Monte Carlo methods for describing the bulk properties of non-equilibrium plasmas as well as with the modeling of complicated systems, emphasizing in particular the strong coupling between the Boltzmann equation and excited state kinetics. Finally, the book contains several contributions describing applications in different fields such as Excimer Lasers, Negative Ion Production, RF Discharges, Plasma Chemistry, Atmospheric Processes, and Physics of Lamps. The Organizing Committee gratefully acknowledges the generous financial support provided by the NATO Science Committee as well as by Azienda Autonoma di Soggiorno e Turismo of Maratea, by University of Bari, by C.N.R. Centro di Studio per la

Chimica dei Plasmi and Comitato per la Chimica by ENEA by Lawrence Livermore Laboratory and by US Army Research Office

Nonequilibrium Effects in Ion and Electron Transport Jean W. Gallagher, 2012-12-06 This volume presents the contributions of the participants in the Sixth International Swarm Seminar held August 2-5 1989 at the Webb Institute in Glen Cove New York The Swarm Seminars are traditionally held as relatively small satellite conferences of the International Conference on the Physics of Electronic and Atomic Collisions ICPEAC which occurs every two years The 1989 ICPEAC took place in New York City prior to the Swarm Seminar The focus of the Swarm Seminars has been on basic research relevant to understanding the transport of charged particles mainly electrons and ions in weakly ionized gases This is a field that tends to bridge the gap between studies of fundamental binary atomic and molecular collision processes and studies of electrical breakdown or discharge phenomena in gases Topics included in the 1989 seminar ranged the gamut from direct determinations of charged particle collision cross sections to use of cross sections and swarm parameters to model the behavior of electrical gas discharges Although the range of subjects covered was in many respects similar to that of previous seminars there was an emphasis on certain selected themes that tended to give this seminar a distinctly different flavor There was for example considerable discussion on the meaning of equilibrium and the conditions under which nonequilibrium effects become important in the transport of electrons through a gas

Atomic and Molecular Processes in Fusion Edge Plasmas R.K. Janev, 2013-06-29 This well illustrated resource provides vital cross section information for the atomic and molecular collision processes taking place in the boundary region of magnetically confined fusion plasmas and in other laboratory and astrophysical low temperature plasmas The expertly assessed information in this noteworthy volume includes the most recent experimental and theoretical results presented in a convenient format Coverage includes the processes of electron impact excitation and ionization of plasma edge atoms electron ion recombination dissociative collision processes involving electrons and much more

Non-Equilibrium Air Plasmas at Atmospheric Pressure K.H. Becker, U. Kogelschatz, K.H. Schoenbach, R.J. Barker, 2004-11-29 Atmospheric pressure plasmas continue to attract considerable research interest due to their diverse applications including high power lasers opening switches novel plasma processing applications and sputtering EM absorbers and reflectors remediation of gaseous pollutants excimer lamps and other noncoherent light sources Non Equilibrium Air Plasmas at Atmospheric Pressure reviews recent advances and applications in the generation and maintenance of atmospheric pressure plasmas With contributions from leading international researchers the coverage includes advances in atmospheric pressure plasma source development diagnostics and characterization air plasma chemistry modeling and computational techniques and an assessment of the status and prospects of atmospheric pressure air plasma applications The extensive applications sections make this book attractive for practitioners in many fields where technologies based on atmospheric pressure air plasmas are emerging

Plasma Technology M. Capitelli, C. Gorse, 2012-12-06 The present book contains the proceedings of the workshop Plasma Technology and Applications which

was held at 11 Ciocco Lucca Italy during 5-6 July 1991. The workshop was organized just before ICPIG XX to emphasize the role of plasma physics and plasma chemistry in different fields of technology. Topics cover different applications such as lamps, plasma treatment of materials, etching, deposition, nitriding, plasma sources, microwave excitation, negative ion sources, and plasma destruction of pollutants. Several chapters deal with basic concepts in plasma physics: non-equilibrium plasma modeling and plasma diagnostics, as well as with laser interaction with solid targets. The authors gratefully acknowledge the financial support provided by the University of Bari, Italy, and by CNR Centro di Studio per la Chimica dei Plasmi, Istituto di Fisica Atomica e Molecolare IFAM and Progetto Finalizzato Materiali Speciali per Tecnologie Avanzate, as well as the sponsorship of ENEA. M. Capitelli, C. Gorse, and S. Longo.

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state as a new species with its own cross sections Extended atomic and molecular master equations are coupled with Boltzmann and Monte Carlo methods to solve the electron energy distribution function Selected examples in different applied fields such as microelectronics fusion and aerospace are presented and discussed including the self consistent kinetics in RF parallel plate reactors the optimization of negative ion sources and the expansion of high enthalpy flows through nozzles of different geometries The book will cover the main aspects of the state to state kinetic approach for the description of nonequilibrium cold plasmas illustrating the more recent achievements in the development of kinetic models including the self consistent coupling of master equations and Boltzmann equation for electron dynamics To give a complete portrayal the book will assess fundamental concepts and theoretical formulations based on a unified methodological approach and explore the insight in related scientific problems still opened for the research community

Molecular Physics and Hypersonic Flows M. Capitelli, 2012-12-06 Molecular Physics and Hypersonic Flows bridges the gap between the fluid dynamics and molecular physics communities emphasizing the role played by elementary processes in hypersonic flows In particular the work is primarily dedicated to filling the gap between microscopic and macroscopic treatments of the source terms to be inserted in the fluid dynamics codes The first part of the book describes the molecular dynamics of elementary processes both in the gas phase and in the interaction with surfaces by using quantum mechanical and phenomenological approaches A second group of contributions describes thermodynamics and transport properties of air components with special attention to the transport of internal energy A series of papers is devoted to the experimental and theoretical study of the flow of partially ionized gases Subsequent contributions treat modern computational techniques for 3 D hypersonic flow Non equilibrium vibrational kinetics are then described together with the coupling of vibration dissociation processes as they affect hypersonic flows Special emphasis is given to the interfacing of non equilibrium models with computational fluid dynamics methods Finally the last part of the book deals with the application of direct Monte Carlo methods in describing rarefied flows

Physics and Applications of Pseudosparks Martin A. Gundersen, Gerhard Schaefer, 2012-12-06 The purpose of the 1989 NATO ARW was to develop applications and an improved understanding of the physics for high current emission and conduction observed in hollow cathode hollow anode switches including the pseudo spark and BLT New applications include highly emissive cathodes for microwave devices accelerators and free electron lasers high power tubes electron and ion beams microlithography accelerators and other plasma devices Recent research has produced a new generation of gas phase plasma switches that are characterized by very high current emission and conduction while operating in a glow mode These switches include the pseudospark and the BLT both of which have hollow electrodes switch over 10 to 100 kA peak current and have cathodes with emission 2×10^8 Ncm over 1 cm area The cathode properties are especially remarkable about 2 orders of magnitude larger emission than existing thermionic cathodes Part of the meeting was devoted to understanding these properties and exploiting applications of this cathode The remarkable properties of these switches are

very surprising in the light of considerable previous work in this area and these results deserve study in order to understand the underlying physical mechanisms and to develop ideas and insight into future applications and foster coherent research in this area The operating cycle of pseudo spark and BL T switches and related devices can be divided into four phases hold off triggering conduction and recovery There was very little discussion of the hold off and recovery phases

Non-Equilibrium Reacting Gas Flows Ekaterina Nagnibeda, Elena Kustova, 2009-07-09 In the present monograph we develop the kinetic theory of transport phenomena and relaxation processes in the flows of reacting gas mixtures and discuss its applications to strongly non equilibrium conditions The main attention is focused on the influence of non equilibrium kinetics on gas dynamics and transport properties Closed systems of fluid dynamic equations are derived from the kinetic equations in different approaches We consider the most accurate approach taking into account the state to state kinetics in a flow as well as simplified multi temperature and one temperature models based on quasi stationary distributions Within these approaches we propose the algorithms for the calculation of the transport coefficients and rate coefficients of chemical reactions and energy exchanges in non equilibrium flows the developed techniques are based on the fundamental kinetic theory principles The theory is applied to the modeling of non equilibrium flows behind strong shock waves in the boundary layer and in nozzles The comparison of the results obtained within the frame of different approaches is presented the advantages of the new state to state kinetic model are discussed and the limits of validity for simplified models are established The book can be interesting for scientists and graduate students working on physical gas dynamics aerothermodynamics heat and mass transfer non equilibrium physical chemical kinetics and kinetic theory of gases

Computational Science and Its Applications - ICCSA 2004 Antonio Laganà, Marina L. Gavrilova, Vipin Kumar, Youngsong Mun, C.J. Kenneth Tan, Osvaldo Gervasi, 2004-05-21 The natural mission of Computational Science is to tackle all sorts of human problems and to work out intelligent automata aimed at alleviating the burden of working out suitable tools for solving complex problems For this reason Computational Science though originating from the need to solve the most challenging problems in science and engineering computational science is the key player in the fight to gain fundamental advances in astronomy biology chemistry environmental science physics and several other scientific and engineering disciplines is increasingly turning its attention to all fields of human activity In all activities in fact intensive computation information handling knowledge synthesis the use of ad hoc devices etc increasingly need to be exploited and coordinated regardless of the location of both the users and the various and heterogeneous computing platforms As a result the key to understanding the explosive growth of this discipline lies in two adjectives that more and more appropriately refer to Computational Science and its applications interoperable and ubiquitous Numerous examples of ubiquitous and interoperable tools and applications are given in the present four LNCS volumes containing the contributions delivered at the 2004 International Conference on Computational Science and its Applications ICCSA 2004 held in Assisi Italy May 14-17 2004

Non-equilibrium

Processing of Materials C. Suryanarayana, 1999-07-22 The rapid technological developments during the later half of the 20th century have demanded materials that are stronger capable of use at much higher temperatures more corrosion resistant and much less expensive than those currently used These demands become even more significant on the threshold of the new century and the millennium Significant improvements in properties can only be achieved by processing the materials under far from equilibrium or non equilibrium conditions Several new processing technologies have been developed during the past few decades including rapid solidification spray forming mechanical alloying ion mixing vapor deposition laser processing and plasma processing Remarkable advances have been made in recent years in the science and technology of these processes used to synthesize characterize and apply these materials processed under non equilibrium conditions Some of these techniques have evolved from laboratory curiosity to commercial scale manufacturing in just a few years In other cases industrial necessity prompted development of the technology and the science followed later The chapters in this book have been written by people who are world recognized experts in their respective fields Each chapter describes the principles processing techniques special features of the materials produced and their applications An extensive list of references is provided at the end of each chapter that will facilitate location of additional information on specific aspects of any technique

Physical and Chemical Mechanisms in Molecular Radiation Biology William A. Glass, Matesh N. Varma, 2012-12-06 The fundamental understanding of the production of biological effects by ionizing radiation may well be one of the most important scientific objectives of mankind such understanding could lead to the effective and safe utilization of the nuclear energy option In addition this knowledge will be of immense value in such diverse fields as radiation therapy and diagnosis and in the space program To achieve the above stated objective the U S Department of Energy DOE and its predecessors embarked upon a fundamental interdisciplinary research program some 35 years ago A critical component of this program is the Radiological and Chemical Physics Program RCPP When the RCPP was established there was very little basic knowledge in the fields of physics chemistry and biology that could be directly applied to understanding the effects of radiation on biological systems Progress of the RCPP program in its first 15 years was documented in the proceedings of a conference held at Airlie Virginia in 1972 At this conference it was clear that considerable progress had been made in research on the physical and chemical processes in well characterized systems that could be used to understand biological effects During this period of time most physical knowledge was obtained for the gas phase because the technology and instrumentation had not progressed to the point that measurements could be made in liquids more characteristic of biological materials

Proceedings of the Symposium On Process Control, Diagnostics, and Modeling in Semiconductor Manufacturing M. Meyyappan, Demetre John Economou, Stephanie Watts Butler, 1995

Database Needs for Modeling and Simulation of Plasma Processing National Research Council, Division on Engineering and Physical Sciences, Commission on Physical Sciences, Mathematics, and Applications, Panel on Database

Needs in Plasma Processing, 1996-10-21 In spite of its high cost and technical importance plasma equipment is still largely designed empirically with little help from computer simulation Plasma process control is rudimentary Optimization of plasma reactor operation including adjustments to deal with increasingly stringent controls on plant emissions is performed predominantly by trial and error There is now a strong and growing economic incentive to improve on the traditional methods of plasma reactor and process design optimization and control An obvious strategy for both chip manufacturers and plasma equipment suppliers is to employ large scale modeling and simulation The major roadblock to further development of this promising strategy is the lack of a database for the many physical and chemical processes that occur in the plasma The data that are currently available are often scattered throughout the scientific literature and assessments of their reliability are usually unavailable Database Needs for Modeling and Simulation of Plasma Processing identifies strategies to add data to the existing database to improve access to the database and to assess the reliability of the available data In addition to identifying the most important needs this report assesses the experimental and theoretical computational techniques that can be used or must be developed in order to begin to satisfy these needs *Plasma Processing of Semiconductors* P.F. Williams, 2013-11-11 Plasma Processing of Semiconductors contains 28 contributions from 18 experts and covers plasma etching plasma deposition plasma surface interactions numerical modelling plasma diagnostics less conventional processing applications of plasmas and industrial applications Audience Coverage ranges from introductory to state of the art thus the book is suitable for graduate level students seeking an introduction to the field as well as established workers wishing to broaden or update their knowledge *Glow Discharge Optical Emission Spectroscopy* Thomas Nelis, R. Payling, 2003 Glow discharge optical emission spectroscopy GDOES is an essential technique for the direct analysis of bulk solids for elemental surface analysis and for the depth profiling of thin films and industrial coatings The technique has shown rapid growth in numbers of instruments in breadth of applications in improved quantification in recent years and is now a recognised technique within the ISO with two international standards Glow Discharge Optical Emission Spectroscopy A Practical Guide takes the reader on a journey through instrument operation sample preparation analysis and reporting results It follows two sets of samples through the whole process of analysis brass samples for bulk analysis and zinc coated steel for depth profiling Procedures are consistent with recent ISO standards and each step is loaded with hands on tips and theoretical insight The book also includes unique data tables on spectral interferences molecular bands self absorption and relative sputtering rates This book is designed for those using or managing GDOES instruments and for students interested in learning the technique from a hands on perspective It is also an invaluable aid to those considering the purchase of a GDOES instrument or those using GDOES results to understand in detail how the technique works and what is involved in maintaining the instrument and achieving high quality results

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