Plasma Kinetics In Atmospheric Gases

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Plasma Processes and Plasma Kinetics Logos Verlag Berlin GmbH
Infrared laser absorption spectroscopy (IRLAS) employing both tuneable diode and quantum cascade lasers (TDLs, QCLs) has been applied with both high sensitivity and high time resolution to plasma diagnostics and trace gas measurements. TDLAS combined with a conventional White type multiple pass cell was used to detect up to 13 constituent molecular species in low pressure Ar/H2/N2/O2 and Ar/CH4/N2/O2 microwave discharges, among them the main products such as H2O, NH3, NO and CO, HCN respectively. The hydroxyl radical has been measured in the mid infrared (MIR) spectral range in-situ in both plasmas yielding number densities of between 1011 ... 1012 cm-3. Strong indications of surface dominated formation of either NH3 or N2O and NO were found in the H2-N2-O2 system. In methane containing plasmas a transition between deposition and etching conditions and generally an incomplete oxidation of the precursor were observed. The application of QCLs for IRLAS under low pressure conditions employing the most common tuning approaches has been investigated in detail. A new method of analysing absorption features quantitatively when the rapid passage effect is present is proposed. If power saturation is negligible, integrating the undisturbed half of the line profile yields accurate number densities without calibrating the system. By means of a time resolved analysis of individual chirped QCL pulses the main reasons for increased effective laser line widths could be identified. Apart from the well-known frequency down chirp non-linear absorption phenomena and bandwidth limitations of the detection system may significantly degrade the performance and accuracy of inter pulse spectrometers. The minimum analogue bandwidth of the entire system should normally not fall below 250 MHz. QCLAS using pulsed lasers has been used for highly time resolved measurements in reactive plasmas for the first time enabling a time resolution down to about 100 ns to be achieved. A temperature increase of typically less than 50 K has been established for pulsed DC discharges containing Ar/N2 and traces of NO. The main NO production and depletion reactions have been identified from a comparison of model calculations and time resolved measurements in plasma pulses of up to 100 ms. Considerable NO struction is observed after 5 ... 10 ms due to the impact of N atoms. Finally, thermoelectrically cooled pulsed and continuous wave (cw) QCLs have been employed for high finesse cavity absorption spectroscopy in the MIR. Cavity ring down spectroscopy (CRDS) has been performed with pulsed QCLs and was found to be limited by the intrinsic frequency chirp of the laser suppressing an efficient intensity build-up inside the cavity. Consequently the accuracy and advantage of an absolute internal absorption calibration is not achievable. A room temperature cw QCL was used in a complementary cavity enhanced absorption spectroscopy (CEAS) configuration which was equipped with different cavities of up to 1.3 m length. This spectrometer yielded path lengths of up to 4 km and a noise equivalent absorption down to 4 x 10-8 cm-1Hz-1/2. The corresponding molecular concentration detection limit (e.g. for CH4, N2O and C2H2 at 1303 cm-1/7.66 Aem) was generally below 1 x 1010 cm-3 for 1 s integration times and one order of magnitude less for 30 s integration times. The main limiting factor for achieving even higher sensitivity is the residual mode noise of the cavity. Employing a 0.5 m long cavity the achieved sensitivity was good enough for the selective measurement of trace

atmospheric constituents at 2.2 mbar.
Plasma Kinetics in Atmospheric Gases Wiley-VCH
Describing non-equilibrium "cold" plasmas through a chemical physics approach, this book uses the state-to-state plasma kinetics, which considers each internal 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.
Plasma Physics and Engineering Springer
Providing a fundamental introduction to all aspects of modern plasma chemistry, this book describes mechanisms and kinetics of chemical processes in plasma, plasma statistics, thermodynamics, fluid mechanics and electrodynamics, as well as all major electric discharges applied in plasma chemistry. Fridman considers most of the major applications of plasma chemistry, from electronics to thermal coatings, from treatment of polymers to fuel conversion and hydrogen production and from plasma metallurgy to plasma medicine. It is helpful to engineers, scientists and students interested in plasma physics, plasma chemistry, plasma engineering and combustion, as well as chemical physics, lasers, energy systems and environmental control. The book contains an extensive database on plasma kinetics and thermodynamics and numerical formulas for practical calculations related to specific plasma-chemical processes and applications. Problems and concept questions are provided, helpful in courses related to plasma, lasers, combustion, chemical kinetics, statistics and thermodynamics, and high-temperature and high-energy fluid mechanics.
Reactions Under Plasma Conditions Springer
Lists citations with abstracts for aerospace related reports obtained from world wide sources and announces documents that have recently been entered into the NASA Scientific and Technical Information Database.
Physical and Chemical Processes in Gas Dynamicsphysical and Chemical Kinet Ics and Thermodynamics Springer Science & Business Media
The International Conference on Computational Science (ICCS 2004) held in Krak´ ow, Poland, June 6–9, 2004, was a follow-up to the highly successful ICCS 2003 held at two locations, in Melbourne, Australia and St. Petersburg, Russia; ICCS 2002 in Amsterdam, The Netherlands; and ICCS 2001 in San Francisco, USA. As computational science is still evolving in its quest for subjects of inves- gation and e?cient methods, ICCS 2004 was devised as a forum for scientists from mathematics and computer science, as the basic computing disciplines and application areas, interested in advanced computational methods for physics, chemistry, life sciences, engineering, arts and humanities, as well as computer system vendors and software developers. The main objective of this conference was to discuss problems and solutions in all areas, to identify new issues, to shape future directions of research, and to help users apply various advanced computational techniques. The event harvested recent developments in com- tationalgridsandnextgenerationcomputingsystems,tools,advancednumerical methods, data-driven systems, and novel application ?elds, such as complex - stems, ?nance, econo-physics and population evolution.
Plasma Kinetics Studies of Rare-gas and Rare-gas/metal-vapour Discharges Used as Visible/UV/UVU Light Sources Springer
Each scientist works with certain information and collects it in the course of prof- sional activity. In the same manner, the author collected data for atomic physics and atomic processes. This information was checked in the course of the author's p- fessional activity and was published in the form of appendices to the corresponding books on atomic and plasma physics. Now it has been decided to publish these data separately. This book contains atomic data and useful information about atomic particles and atomic systems including molecules, nanoclusters, metals and condensed s- tems of elements. It also gives information about atomic processes and transport processes in gases and plasmas. In addition, the book deals with general concepts and simple models for these objects and processes. We give units and conversion factors for them as well as conversion factors for spread formulas of general physics and the physics of atoms, clusters and ionized gases since such formulas are used in professional practice by each scientist of this area.
Plasma Chemistry Springer Science & Business Media
This is a comprehensive textbook designed for graduate and advanced undergraduate students. Both authors rely on more than 20 years of teaching experience in renowned Physics Engineering courses to write this book addressing the students' needs. Kinetics and Spectroscopy of Low Temperature Plasmas derives in a full self-consistent way the electron kinetic theory used to describe low temperature plasmas created in the laboratory with an electrical discharge, and presents the main optical spectroscopic diagnostics used to characterize such plasmas. The chapters with the theoretical contents make use of a deductive approach in which the electron kinetic theory applied to plasmas with basis on the electron Boltzmann equation is derived from the basic concepts of Statistical and Plasma Physics. On the other hand, the main optical spectroscopy diagnostics used to characterize experimentally such plasmas are presented and justified from the point of view of the Atomic and Molecular Physics. Low temperature plasmas (LTP) are partially ionized gases with a broad use in many technological applications such as microelectronics, light sources, lasers, biology and medicine. LTPs lead to the production of atomic and molecular excited states, chemically reactive radicals, and activated surface sites, which are in the origin, among others, of the deposition of thin films, advanced nanotechnology products, solar cells, highly efficient combustion motors, and treatment of cancer cells.
New Enhanced Sensitivity Infrared Laser Spectroscopy Techniques Applied to Reactive Plasmas and Trace Gas Detection Cambridge University Press
The NATO . Advanced Research Insti tute 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.
Physics of Non-equilibrium Plasmas Springer
This book describes selected problems in contemporary spectroscopy in the context of quantum mechanics and statistical physics. It focuses on elementary radiative processes involving atomic particles (atoms, molecules, ions), which include radiative transitions between discrete atomic states, the photoionization of atoms, photorecombination of electrons and ions, bremsstrahlung, photodissociation of molecules, and photoattachment of electrons to atoms. In addition to these processes, the transport of resonant radiation in atomic gases and propagation of infrared radiation in molecular gases are also considered. The book subsequently addresses applied problems such as optical pumping, cooling of gases via laser resonance radiation, light-induced drift of gas atoms, photoresonant plasma, reflection of radio waves from the ionosphere, and detection of submillimeter radiation using Rydberg atoms. Lastly, topical examples in atmospheric and climate change science are presented, such as lightning channel glowing, emission of the solar photosphere, and the greenhouse phenomenon in the atmospheres of the Earth and Venus. Along with researchers, both graduate and undergraduate students in atomic, molecular and atmospheric physics will find this book a useful and timely guide.
28th International Symposium on Shock Waves AIAA
This book presents the theory of gas discharge plasmas in a didactical way. It explains the processes in gas discharge plasmas. A gas discharge plasma is an ionized gas which is supported by an external electric field. Therefore its parameters are determined by processes in it. The properties of a gas discharge plasma depend on its gas component, types of external fields, their geometry and regimes of gas discharge. Fundamentals of a gas discharge plasma include elementary, radiative and transport processes which are included in its kinetics influence. They are represented in this book together with the analysis of simple gas discharges. These general principles are applied to stationary gas discharge plasmas of helium and argon. The analysis of such plasmas under certain conditions is theoretically determined by numerical plasma parameters for given regimes and conditions.
Plasma Kinetic Theory Nova Science Publishers
Emphasis is placed on the analysis of translational, rotational, vibrational and electronically excited state kinetics, coupled to the electron Boltzmann equation.
An Introduction to Plasma Physics CRC Press
Plasma Physics and Engineering presents basic and applied knowledge on modern plasma physics, plasma chemistry, and plasma engineering for senior undergraduate and graduate students as well as for scientists and engineers working in academia; research labs; and industry with plasmas, laser and, combustion systems. This is a unique book providing a clear fundamental introduction to all aspects of modern plasma science, describing all electric discharges applied today from vacuum to atmospheric pressure and higher, from thermal plasma sources to essentially cold non-equilibrium discharges. A solutions manual is available for adopting professors, which is helpful in relevant university courses. Provides a lucid introduction to virtually all aspects of modern plasma science and technology Contains an extensive database on plasma kinetics and thermodynamics Includes many helpful numerical formulas for practical calculations, as well as numerous problems and concepts This revised edition includes new material on atmospheric pressure discharges, micro discharges, and different types of discharges in liquids Prof. Alexander Fridman is Nyheim Chair Professor of Drexel University and Director of C. & J. Nyheim Plasma Institute. His research focuses on plasma approaches to biology and medicine, to material treatment, fuel conversion, and environmental control. Prof. Fridman has almost 50 years of plasma research in national laboratories and universities of Russia, France, and the United States. He has published 8 books, and received numerous honors for his work, including Stanley Kaplan Distinguished Professorship in Chemical Kinetics and Energy Systems, George Soros Distinguished Professorship in Physics, the State Prize of the USSR, Plasma Medicine Award, Kurchatov Prize, Reactive Plasma Award, and Plasma Chemistry Award. Prof. Lawrence A. Kennedy is Dean of Engineering Emeritus and Professor of Mechanical Engineering Emeritus at the University of Illinois at Chicago and Professor of Mechanical Engineering Emeritus at the Ohio State University. His research focuses on chemically reacting flows and plasma processes. He is the author of more than 300 archival publications and 2 books, the editor of three monographs and served as Editor–in-Chief of the International Journal of Experimental Methods in Thermal and Fluid Science. Professor Kennedy was the Ralph W. Kurtz Distinguished Professor of Mechanical Engineering at OSU and the Stanley Kaplan University Scholar in Plasma Physics at UIC. Prof. Kennedy is also the recipient of numerous awards such as the American Society of Mechanical Engineers Heat Transfer Memorial Award (2008), and the Ralph Coats Roe Award from ASEE (1993). He is a Fellow of the American Society of Mechanical Engineers, the American Physical Society, the American Institute of Aeronautics and Astronautics and the American Association for the Advancement of Science.
Kinetic Processes in Gases and Plasmas Springer Science & Business Media
Proposed by A.A. Vlasov in 1938, the kinetic equation with a self-consistent electromagnetic field led to a fundamentally new perspective in plasma physics. This equation represents the most profound approach to the description of plasma because it operates directly with plasma particles using the distribution function. Plasma is found everywhere in space; that is why this equation has an extensive application. A large number of works where the study of plasma properties based on the solution of the Vlasov equation have appeared. However, the results based on the solution of the Vlasov equation should be assumed with caution. As noted in the manuscript, the Vlasov equation has a set of formal solutions. The researcher must have the ability to select the correct solutions, correct in the sense of their adequacy to the processes under investigation. Some aspects of the polarization of a magnetoactive plasma are investigated. It is shown that neglecting the electric field in problems of such sharply inhomogeneous structures as a boundary or current layers leads to an inadequate model. Thus, the successive solution of the kinetic equation taking

into account the electric polarization field indicates that the equations describing the equilibrium of these sharply inhomogeneous structures become nonlinear and exhibit the property of structural instability. Natural science over time included the expansion of the field of numbers from natural to real. Now, physics is in the stage of semi-recognition of complex numbers. On the one hand, when solving the differential equation, the physicist finds the value of the roots of the characteristic equation in a complex field. However, at the final stage, all imaginary parts are discarded, and only real values of physical quantities are passed in response. In this case, the complex field has a fundamental feature that distinguishes it: it is algebraically closed. The restriction of physical quantities only to the field of real numbers seems logically unsatisfactory since often mathematical operations derive them from the field of the original definition. In this manuscript, some problems of the complexification of physics are investigated

Fundamental Aspects of Plasma Chemical Physics Springer Science & Business Media

Plasma plays an important role in a wide variety of industrial processes, including material processing, environmental control, electronic chip manufacturing, light sources, and green energy, not to mention fuel conversion and hydrogen production, biomedicine, flow control, catalysis, and space propulsion. Following the general outline of the bests

Kinetics of Nonequilibrium Low-Temperature Plasmas Springer

This problems supplement to plasma physics textbooks covers plasma theory for both science and technology. Written by a renowned plasma scientist, experienced book author and skilled teacher, it treats all aspects of plasma theory in no fewer than 520 very detailed worked-out problems. With this systematic collection the reader will gain a sound understanding of plasma physics in all fields, from fusion and astrophysics to surface treatment. The book also includes the transport of particles as well as radiation in plasmas, and while designed for graduate students and young researchers, it can equally serve as a reference.

Plasma Chemistry and Catalysis in Gases and Liquids Springer

This book presents results of experimental and theoretical studies of "gas-solid particles" turbulent two-phase flows. It analyzes the characteristics of heterogeneous flows in channels (pipes), as well as those in the vicinity of the critical points of bodies subjected to flow and in the boundary layer developing on their surface. Coverage also treats in detail problems of physical simulation of turbulent gas flows which carry solid particles.

Turbulent Particle-Laden Gas Flows CRC Press

Electric glow discharges (glows) can be found almost everywhere, from atmospheric electricity to modern plasma technologies, and have long been the object of research. The main purpose of this book is to provide simple illustrations of the basic physical mechanisms and principles that determine the properties of electric glow discharges. It should enable readers to successfully participate in scientific and technical progress.

Plasma Physics and Engineering Springer

A comprehensive and readily accessible work for studying the physics of ionized gases, based on "Physics of Ionized Gases". The focus remains on fundamentals rather than on the details required for interesting but difficult applications, such as magnetic confinement fusion, or the phenomena that occur with extremely high-intensity short-pulse lasers. However, this new work benefits from much rearranging of the subject matter within each topic, resulting in a more coherent structure. There are also some significant additions, many of which relate to clusters, while other enlarged sections include plasmas in the atmosphere and their applications. In each case, the emphasis is on a clear and unified understanding of the basic physics that underlies all plasma phenomena. Thus, there are chapters on plasma behavior from the viewpoint of atomic and molecular physics, as well as on the macroscopic phenomena involved in physical kinetics of plasmas and the transport of radiation and of charged particles within plasmas. With this grounding in the fundamental physics of plasmas, the notoriously difficult subjects of nonlinear phenomena and of instabilities in plasmas can then be treated with comprehensive clarity. The work is rounded off with appendices containing information and data of great importance and relevance that are not easily found in other books. Valuable reading for graduate and PhD physics students, and a reference for researchers in low-temperature ionized gases-plasma processing, edge region fusion plasma physics, and atmospheric plasmas.

Non-Equilibrium Air Plasmas at Atmospheric Pressure John Wiley & Sons

This book deals with the physics of low temperature plasmas of atomic and molecular gases. Several diagnostic methods for nonequilibrium plasma are described. The relevant elementary processes governing the kinetics and transport of atomic and chemically active molecular plasmas are discussed and numerical models of plasmas aimed at systematically solving MHD-equations are also presented. Intended for use by scientists and engineers active in various fields of low-temperature plasma physics, this book is also suitable for teachers and students at pre- and postgraduate level. In chapter 1 general problems of the elementary physics of plasma are considered and the principal ideas relating to plasma properties are given. In chapter 2 the principles which form the basis of atomic and molecular spectra radiated by a plasma are briefly described. Chapter 3 reviews experimental material associated with the peculiarities of molecular excitation processes in nonequilibrium low-temperature plasma. In chapter 4 a number of problems related to the technique and methods of spectroscopy are considered. Chapter 5 presents experimental material gained from studying the peculiarities of molecular excitation spectra from low-pressure gas discharges and describes diagnostics for nonequilibrium chemically active plasma. In chapter 6 the problems of mathematical modeling of equilibrium plasma in arcs, microwave and optical discharges are analyzed. In chapter 7, a theoretical description of nonequilibrium plasma in electrical arcs, microwave and radio-frequency discharges based on two-temperature approximation of the plasma parameters is offered. Chapter 8 presents a detailed case-study on the transport and excitation of a magnetized plasma of intermediate electron density. Several diagnostic techniques and models introduced in earlier chapters are used to obtain information on plasma properties.

Kinetics and Spectroscopy of Low Temperature Plasmas BoD – Books on Demand

An Introduction to Plasma Physics, Second Edition focuses on the processes, reactions, properties, and approaches involved in plasma physics, including kinetic theory, radiation, particle motions, and oscillations. The publication first offers information on the introduction to plasma physics and basic properties of the equilibrium plasma. Discussions focus on the occurrence of plasma in nature, technological aspects of plasma physics, quasi-neutrality and plasma oscillations, transmission of electromagnetic radiation through plasma, production of plasma by shock waves, and degree of ionization in a thermal plasma. The text then ponders on arc plasma, magnetohydrodynamics, and magnetohydrodynamic stability. The manuscript takes a look at plasma dynamics and particle motions and kinetic theory of the plasma. Topics include dielectric behavior of a magnetized plasma, approximate treatment of particle orbits, formal derivation of the drifts, macroscopic effects of particle motion, consequences of the magnetic moment, and transport equations and hydrodynamics. Low-frequency oscillations of a uniform magnetized plasma, stability and perturbation theories, and approximate procedure for solving the transport equations are also discussed. The publication is a highly recommended source material for readers interested in plasma physics.