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Diagnostics for Experimental Thermonuclear Fusion Reactors 2 Springer **This book of proceedings collects the papers presented at the workshop on "Diagnostics for Experimental Fusion Reactors" held at Villa Monastero, Varenna (Italy) September 4-12, 1997. This workshop was the seventh organized by the International School of Plasma Physics "Piero Caldirola" on the topic of plasma diagnostics and the second devoted to the diagnostic studies for the International Thermonuclear Experimental Reactor (ITER). The proceedings of the first workshop on ITER diagnostics were published by Plenum Press in 1996 with the title "Diagnostics for Experimental Thermonuclear Fusion Reactors". While many of the ideas and studies reported in the first workshop remain valid, there has been sub stantial progress in the design and specification of many diagnostics for ITER. This moti vated a second workshop on this topic and the publication of a new book of proceedings. ITER is a joint venture between Europe, Japan, Russia and USA in the field of con trolled thermonuclear fusion research. The present aim of ITER is to design an experimental fusion reactor that can demonstrate ignition and sustained burn in a magnetically confined plasma. To achieve this goal, a wide range of plasma parameters will have to be measured reliably. It is also anticipated that diagnostics will be used much more extensively as input to control systems on ITER than on present fusion devices and this will require increased relia bility and long-term stability. Diagnostics for Experimental Thermonuclear Fusion Reactors 2** Springer Science & Business Media **This book of proceedings collects the papers presented at the workshop on "Diagnostics for Experimental Fusion Reactors" held at Villa Monastero, Varenna (Italy) September 4-12, 1997. This workshop was the seventh organized by the International School of Plasma Physics "Piero Caldirola" on the topic of plasma diagnostics and the second devoted to the diagnostic studies for the International Thermonuclear Experimental Reactor (ITER). The proceedings of the first workshop on ITER diagnostics were published by Plenum Press in 1996 with the title "Diagnostics for Experimental Thermonuclear Fusion Reactors". While many of the ideas and studies reported in the first workshop remain valid, there has been sub stantial progress in the design and specification of many diagnostics for ITER. This moti vated a second workshop on this topic and the publication of a new book of proceedings. ITER is a joint venture between Europe, Japan, Russia and USA in the field of con trolled thermonuclear fusion research. The present aim of ITER is to design an experimental fusion reactor that can demonstrate ignition and sustained burn in a magnetically confined plasma. To achieve this goal, a wide range of plasma parameters will have to be measured reliably. It is also anticipated that diagnostics will be used much more extensively as input to control systems on ITER than on present fusion devices and this will require increased relia bility and long-term stability. Diagnostics for Experimental Thermonuclear Fusion Reactors** Springer Science & Business Media **This book of proceedings collects the papers presented at the Workshop on Diagnostics for ITER, held at Villa Monastero, Varenna (Italy), from August 28 to September 1, 1995. The Workshop was organised by the International School of Plasma Physics "Piero Caldirola. " Established in 1971, the ISPP has organised over fifty advanced courses and workshops on topics mainly related to plasma physics. In particular, courses and workshops on plasma diagnostics (previously held in 1975, 1978, 1982, 1986, and 1991) can be considered milestones in the history of this institution. Looking back at the proceedings of the previous meetings in Varenna, one can appreciate the rapid progress in the field of plasma diagnostics over the past 20 years. The 1995 workshop was co-organised by the Istituto di Fisica del Plasma of the National Research Council (CNR). In contrast to previous Varenna meetings on diagnostics, which have covered diagnostics in present-day tokamaks and which have had a substantial tutorial component, the 1995 workshop concentrated specifically on the problems and challenges of ITER diagnostics. ITER (the International Thennonuclear Experimental Reactor, a joint venture of Europe, Japan, Russia, and the United States, presently under design) will need to measure a wide range of plasma parameters in order to reach and sustain high levels of fusion power. A list of the measurement requirements together with the parameter ranges, target measurement resolutions, and accuracies provides the starting point for selecting a list of candidate diagnostic systems. Development of Laser Based Plasma Diagnostics for Fusion Research on NSTX-U Worldwide demand for power, and in particular electricity, is growing. Increasing population, expanding dependence on electrical devices, as well as the development of emerging nations, has created significant challenges for the power production. Compounding the issue are concerns over pollution, natural resource supplies, and political obstacles in troubled parts of the world. Many believe that investment in renewable energy will solve the expected energy crisis; however, renewable energy has many shortfalls. Consequently, additional sources of energy should be explored to provide the best options for the future. Electricity from fusion power offers many advantages over competing technologies. It can potentially produce large amounts of clean energy, without the serious concerns of fission power plant safety and nuclear waste. Fuel supplies for fusion are plentiful. Fusion power plants can be operated as needed, without dependence on location, or local conditions. However, there are significant challenges before fusion can be realized. Many factors currently limit the effectiveness of fusion power, which prevents a commercial power plant from being feasible. Scientists in many countries have built, and operate, experimental fusion plants to study the fusion process. The leading examples are magnetic confinement reactors known as tokamaks. At present, reactor gain is near unity, where the fusion power output is nearly the same as the power required to operate the reactor. A tenfold increase in gain is what reactors such as ITER hope to achieve, where ~50 MW will be used for plasma heating, magnetic fields, and so forth, with a power output of ~500 MW. Before this can happen, further research is required. Loss of particle and energy confinement is a principal cause of low performance; therefore, increasing confinement time is key. There are many causes of thermal and particle transport that are being researched, and the prime tools for conducting this research are plasma diagnostics. Plasma diagnostics collect data from fusion reactors in a number of different ways. Among these are far infrared (FIR) laser based systems. By probing a fusion plasma with FIR lasers, many properties can be measured, such as density and density fluctuations. This dissertation discusses the theory and design of two laser based diagnostic instruments: 1) the Far Infrared Tangential Interferometer and Polarimeter (FIReTIP) systems, and 2) the High-k[subscript theta] Scattering System. Both of these systems have been designed and fabricated at UC Davis for use on the National Spherical Torus Experiment - Upgrade (NSTX-U), located at Princeton Plasma Physics Laboratory (PPPL). These systems will aid PPPL scientists in fusion research. The FIReTIP system uses 119 [mu]m methanol lasers to pass through the plasma core to measure a chord averaged plasma density through interferometry. It can also measure the toroidal magnetic field strength by the way of polarimetery. The High-k[subscript theta] Scattering System uses a 693 GHz formic acid laser to measure electron scale turbulence. Through collective Thomson scattering, as the probe beam passes through the plasma, collective electron motion will scatter power to a receiver with the angle determined by the turbulence wavenumber. This diagnostic will measure k[subscript theta] from 7 to 40 cm-1 with a 4-channel receiver array. The High-k[subscript theta] Scattering system was designed to facilitate research on electron temperature gradient (ETG) modes, which are believed to be a major contributor to anomalous transport on NSTX-U. The design and testing of these plasma diagnostics are described in detail. There are a broad range of components detailed including: optically pumped gas FIR lasers, overmoded low loss waveguide, launching and receiving optical designs, quasi-optical mixers, electronics, and monitoring and control systems. Additionally, details are provided for laser maintenance, alignment techniques, and the fundamentals of nano-CNC-machining. New Developments in Nuclear Fusion Research** Nova Publishers **Nuclear fusion is a process in which two nuclei join, forming a larger nucleus and releasing or absorbing energy. With some exceptions, nuclei lighter than iron release energy when they fuse, while heavier nuclei absorb energy; this is because iron has the largest binding energy. Nuclear fusion of light elements is the energy source which causes stars to shine and hydrogen bombs to explode. Nuclear fusion of heavy elements is part of the process that triggers supernovae. Nuclear fusion as an energy source has several advantages: It is vast, new source of energy; Fuels are plentiful; Inherently safe since any malfunction results in a rapid shutdown; No atmospheric pollution leading to acid rain or "greenhouse" effect; Radioactivity of the reactor structure, caused by the neutrons, decays rapidly and can be minimised by careful selection of low-activation materials. Provision for geological time-span disposal is not needed. This book brings together leading research in this field which will play a major role in the 21st century. Prospects for Tokamak Fusion Reactors This paper first reviews briefly the status and plans for research in magnetic fusion energy and discusses the prospects for the tokamak magnetic configuration to be the basis for a fusion power plant. Good progress has been made in achieving fusion reactor-level, deuterium-tritium (D-T) plasmas with the production of significant fusion power in the Joint European Torus (up to 2 MW) and the Tokamak Fusion Test Reactor (up to 10 MW) tokamaks. Advances on the technologies of heating, fueling, diagnostics, and materials supported these achievements. The successes have led to the initiation of the design phases of two tokamaks, the International Thermonuclear Experimental Reactor (ITER) and the US Toroidal Physics Experiment (TPX). ITER will demonstrate the controlled ignition and extended bum of D-T plasmas with steady state as an ultimate goal. ITER will further demonstrate technologies essential to a power plant in an integrated system and perform integrated testing of the high heat flux and nuclear components required to use fusion energy for practical purposes. TPX will complement ITER by testing advanced modes of steady-state plasma operation that, coupled with the developments in ITER, will lead to an optimized demonstration power plant. Advances in Plasma Physics Research** Nova Publishers **Advances in Plasma Physics Research Materials for Advanced Energy Systems and Fission & Fusion Engineering Proceedings of the Seventh China-Japan Symposium** World Scientific **In this proceedings volume, the following topics are discussed: systems and design; blanket and first wall technology of fission and fusion reactors; fission and fusion materials; radiation damage analysis; calculation codes; databases. Nuclear Fusion Fusion Nucléaire. ÎÀdernyĭ Sintez. Fusión Nuclear Fusion Energy Update Fusion The Energy of the Universe** Academic Press **Fusion: The Energy of the Universe, 2e is an essential reference providing basic principles of fusion energy from its history to the issues and realities progressing from the present day energy crisis. The book provides detailed developments and applications for researchers entering the field of fusion energy research. This second edition includes the latest results from the National Ignition Facility at the Lawrence Radiation Laboratory at Livermore, CA, and the progress on the International Thermonuclear Experimental Reactor (ITER) tokamak programme at Caderache, France. Comprehensive coverage- basic principles, detailed developments and practical applications Wide accessibility, but with sufficient detail to keep the technical reader engaged Details the initial discovery of nuclear fusion, current attempts to create nuclear fusion here on earth and today's concern over future energy supply Color illustrations and examples Includes technical notes for aspiring physicists Diagnostics for Experimental Thermonuclear Fusion Reactors 2** Springer Science & Business Media **This book of proceedings collects the papers presented at the workshop on "Diagnostics for Experimental Fusion Reactors" held at Villa Monastero, Varenna (Italy) September 4-12, 1997. This workshop was the seventh organized by the International School of Plasma Physics "Piero Caldirola" on the topic of plasma diagnostics and the second devoted to the diagnostic studies for the International Thermonuclear Experimental Reactor (ITER). The proceedings of the first workshop on ITER diagnostics were published by Plenum Press in 1996 with the title "Diagnostics for Experimental Thermonuclear Fusion Reactors". While many of the ideas and studies reported in the first workshop remain valid, there has been sub stantial progress in the design and specification of many diagnostics for ITER. This moti vated a second workshop on this topic and the publication of a new book of proceedings. ITER is a joint venture between Europe, Japan, Russia and USA in the field of con trolled thermonuclear fusion research. The**

present aim of ITER is to design an experimental fusion reactor that can demonstrate ignition and sustained burn in a magnetically confined plasma. To achieve this goal, a wide range of plasma parameters will have to be measured reliably. It is also anticipated that diagnostics will be used much more extensively as input to control systems on ITER than on present fusion devices and this will require increased relia bility and long-term stability. European Fusion Research Area Background Information on All Participating Organisations Recoge: 1. Fusion energy research in the 6th framework programme euratom - 2. European fusion development agreement - 3. The iter experimental fusion reactor - 4. Association Euratom. Advanced Diagnostics for Magnetic and Inertial Fusion Springer Science & Business Media **Proceedings of the International Conference on Advanced Diagnostics for Magnetic and Inertial Fusion, held September 3-7, 2001 at Villa Monastero, Varenna, Italy. This volume focuses on future diagnostic requirements for fusion energy research emphasizing advanced diagnostics, new techniques and areas where further progress is required. ERDA Energy Research Abstracts Sixth Carolus Magnus Euro-Summer School on Plasma and Fusion Energy Physics September 1-12, 2003, Brussels, Belgium Principles of Plasma Diagnostics** Cambridge University Press **This book provides a systematic introduction to the physics of plasma diagnostics measurements. It develops from first principles the concepts needed to plan, execute and interpret plasma measurements, making it a suitable book for graduate students and professionals with little plasma physics background. The book will also be a valuable reference for seasoned plasma physicists, both experimental and theoretical, as well as those with an interest in space and astrophysical applications. This second edition is thoroughly revised and updated, with new sections and chapters covering recent developments in the field. Burning Plasma Diagnostics An International Conference** American Institute of Physics **Varenna, Italy, 24-28 September 2007 Design of a Rail Gun System for Mitigating Disruptions in Fusion Reactors Magnetic fusion devices, such as the tokamak, that carry a large amount of current to generate the plasma confining magnetic fields have the potential to lose magnetic stability control. This can lead to a major plasma disruption, which can cause most of the stored plasma energy to be lost to localized regions on the walls, causing severe damage. This is the most important issue for the $20B ITER device (International Thermonuclear Experimental Reactor) that is under construction in France. By injecting radiative materials deep into the plasma, the plasma energy could be dispersed more evenly on the vessel surface thus mitigating the harmful consequences of a disruption. Methods currently planned for ITER rely on the slow expansion of gases to propel the radiative payloads, and they also need to be located far away from the reactor vessel, which further slows down the response time of the system. Rail guns are being developed for aerospace applications, such as for mass transfer from the surface of the moon and asteroids to low earth orbit. A miniatured version of this aerospace technology seems to be particularly well suited to meet the fast time response needs of an ITER disruption mitigation system. Mounting this device close to the reactor vessel is also possible, which substantially increases its performance because the stray magnetic fields near the vessel walls could be used to augment the rail gun generated magnetic fields. In this thesis, the potential viability on Rail Gun based DMS is studied to investigate its projected fast time response capability by design, fabrication, and experiment of an NSTX-U sized rail gun system. Material and geometry based tests are used to find the most suitable armature design for this system for which the desirable attributes are high specific stiffness and high electrical conductivity. With the best material in these studies being aluminum 7075, the experimental Electromagnetic Particle Injector (EPI) system has propelled an aluminum armature (weighing ~3g) to a velocity more than 150 m/s within two milliseconds post trigger, consistent with the predicted projection for a system with those parameters. Fixed magnetic field probes and high-speed images capture the velocity profile. To propel the armatures, a 20 mF capacitor bank charged to 2 kV and augmented with external field coils powers the rails. These studies indicate that an EPI based system can indeed operate with a fast response time of less than three milliseconds after an impending disruption is detected, and thus warrants further studies to more fully develop the concept as a back-up option for an ITER DMS. RADECS ... Fusion Technology A Journal of the American Nuclear Society and the European Nuclear Society Proceedings of the Fifth Carolus Magnus Euro-Summer School on Plasma and Fusion Energy Physics Physikzentrum Bad Honnef, Germany, September 10-21, 2001 Plasma Physics An Introduction to Laboratory, Space, and Fusion Plasmas** Springer **The enlarged new edition of this textbook provides a comprehensive introduction to the basic processes in plasmas and demonstrates that the same fundamental concepts describe cold gas-discharge plasmas, space plasmas, and hot fusion plasmas. Starting from particle drifts in magnetic fields, the principles of magnetic confinement fusion are explained and compared with laser fusion. Collective processes are discussed in terms of plasma waves and instabilities. The concepts of plasma description by magnetohydrodynamics, kinetic theory, and particle simulation are stepwise introduced. Space charge effects in sheath regions, double layers and plasma diodes are given the necessary attention. The novel fundamental mechanisms of dusty plasmas are explored and integrated into the framework of conventional plasmas. The book concludes with a concise description of modern plasma discharges. Written by an internationally renowned researcher in experimental plasma physics, the text keeps the mathematical apparatus simple and emphasizes the underlying concepts. The guidelines of plasma physics are illustrated by a host of practical examples, preferentially from plasma diagnostics. There, Langmuir probe methods, laser interferometry, ionospheric sounding, Faraday rotation, and diagnostics of dusty plasmas are discussed. Though primarily addressing students in plasma physics, the book is easily accessible for researchers in neighboring disciplines, such as space science, astrophysics, material science, applied physics, and electrical engineering. This second edition has been thoroughly revised and contains substantially enlarged chapters on plasma diagnostics, dusty plasmas and plasma discharges. Probe techniques have been rearranged into basic theory and a host of practical examples for probe techniques in dc, rf, and space plasmas. New topics in dusty plasmas, such as plasma crystals, Yukawa balls, phase transitions and attractive forces have been adopted. The chapter on plasma discharges now contains a new section on conventional and high-power impulse magnetron sputtering. The recently discovered electrical asymmetry effect in capacitive rf-discharges is described. The text is based on an introductory course to plasma physics and advanced courses in plasma diagnostics, dusty plasmas, and plasma waves, which the author has taught at Kiel University for three decades. The pedagogical approach combines detailed explanations, a large number of illustrative figures, short summaries of the basics at the end of each chapter, and a selection of problems with detailed solutions. Physics Briefs Physikalische Berichte Design and Implementation of an Electron Cyclotron Emission Imaging Diagnostic for the TEXTOR Tokamak The advancement of magnetic confinement nuclear fusion toward a viable source of energy on the scale of today's conventional power plants requires the development of a broad range of instruments for use in present day experimental fusion reactors. A class of plasma diagnostic systems that make use of electromagnetic emission from free electrons includes Electron Cyclotron Emission Imaging (ECEI), conceived at the University of California at Davis as an extension of ECE radiometry. A new ECEI system with unique capabilities is designed and realized for use on the Tokamak Experiment for Technology Oriented Research (TEXTOR), a toroidal plasma confinement device located at Forschungszentrum Jülich, Germany. The TEXTOR ECEI system is capable of 128 channel (16 vertical by 8 radial) 2-D imaging of electron temperature fluctuations below 1% in the poloidal plane on [mu]s time scales. Advancements in a variety of millimeter wave technologies are discussed, including the development of dual-dipole antennas and miniature elliptical substrate lenses, planar quasi-optical notch filters, dichroic plate high-pass filters, dielectric film beamsplitters, RF electronics for double down-conversion heterodyne frequency mixing and signal detection, and optical coupling of electron cyclotron emission signals and local oscillator power. Particular emphasis is given to the development of a new heuristic for the design of optical coupling systems for millimeter wave imaging arrays which has resulted in the realization of the feature of independent vertical zoom, new to ECEI, by which the vertical extent of the plasma image may be continuously varied from 20 to 35 cm. The new TEXTOR ECEI system is compared in laboratory characterization to the legacy ECEI system, which it replaced in 2008, to reveal dramatic improvements in image quality, optical performance, and system noise temperature. Finally, the installation of this diagnostic is discussed and data obtained during commissioning are presented. A look forward to continuing projects in the field of ECEI reveals an exciting future for the technology with growing international collaboration and invaluable contributions to the effort to develop energy resources that may some day eliminate mankind's dependence on fossil fuels. Plasma Physics Index Energetic Particles in Tokamak Plasmas** CRC Press **The study of energetic particles in magnetic fusion plasmas is key to the development of next-generation "burning" plasma fusion experiments, such as the International Thermonuclear Experimental Reactor (ITER) and the Demonstration Power Station (DEMO). This book provides a comprehensive introduction and analysis of the experimental data on how fast ions behave in fusion-grade plasmas, featuring the latest ground-breaking results from world-leading machines such as the Joint European Torus (JET) and the Mega Ampere Spherical Tokamak (MAST). It also details Alfvenic instabilities, driven by energetic ions, which can cause enhanced transport of energetic ions. MHD spectroscopy of plasma via observed Alfvenic waves called "Alfvén spectroscopy" is introduced and several applications are presented. This book will be of interest to graduate students, researchers, and academics studying fusion plasma physics. Features: Provides a comprehensive overview of the field in one cohesive text, with the main physics phenomena explained qualitatively first. Authored by an authority in the field, who draws on his extensive experience of working with energetic particles in tokamak plasmas. Is suitable for extrapolating energetic particle phenomena in fusion to other plasma types, such as solar and space plasmas. Technical Publications by JAERI Staff in ... Plasma Physics Reports Fusion Science and Technology An International Journal of the American Nuclear Society Plasma Physics and Fusion Energy** Cambridge University Press **There has been an increase in interest worldwide in fusion research over the last decade and a half due to the recognition that a large number of new, environmentally attractive, sustainable energy sources will be needed to meet ever increasing demand for electrical energy. Based on a series of course notes from graduate courses in plasma physics and fusion energy at MIT, the text begins with an overview of world energy needs, current methods of energy generation, and the potential role that fusion may play in the future. It covers energy issues such as the production of fusion power, power balance, the design of a simple fusion reactor and the basic plasma physics issues faced by the developers of fusion power. This book is suitable for graduate students and researchers working in applied physics and nuclear engineering. A large number of problems accumulated over two decades of teaching are included to aid understanding. Plasma Science Enabling Technology, Sustainability, Security, and Exploration Plasma Science and Engineering transforms fundamental scientific research into powerful societal applications, from materials processing and healthcare to forecasting space weather. Plasma Science: Enabling Technology, Sustainability, Security and Exploration discusses the importance of plasma research, identifies important grand challenges for the next decade, and makes recommendations on funding and workforce. This publication will help federal agencies, policymakers, and academic leadership understand the importance of plasma research and make informed decisions about plasma science funding, workforce, and research directions. Ultrashort Pulse Reflectometry (USPR) Fundamentals of Magnetic Thermonuclear Reactor Design** Woodhead Publishing **Fundamentals of Magnetic Thermonuclear Reactor Design is a comprehensive resource on fusion technology and energy systems written by renowned scientists and engineers from the Russian nuclear industry. It brings together a wealth of invaluable experience and knowledge on controlled thermonuclear fusion (CTF) facilities with magnetic plasma confinement – from the first semi-commercial tokamak T-3, to the multi-billion international experimental thermonuclear reactor ITER, now in construction in France. As the INTOR and ITER projects have made an immense contribution in the past few decades, this book focuses on its practical engineering aspects and the basics of technical physics and electrical engineering. Users will gain an understanding of the key ratios between plasma and technical parameters, design streamlining algorithms and engineering solutions. Written by a team of qualified experts who have been involved in the design of thermonuclear reactors for over 50 years Outlines the most important features of the ITER project in France which is building the largest tokamak, including the design, material selection, safety and economic considerations Includes data on how to design magnetic fusion reactors using CAD tools, along with relevant regulatory documents Optimization of a CO[sub 2] Laser Thomson Scattering Alpha Particle Diagnostic The optimization of a CO[sub 2] laser Thomson scattering system for measurement of the velocity distribution of fusion product alpha particles is studied. It is found that for the International Thermonuclear Experimental Reactor (ITER) plasma, the optimal system conditions are a 20-MW source laser and a receiver bandwidth of 15 GHz. Oxidation and Volatilization of a Niobium Alloy This report presents the findings from a preliminary investigation into oxidation and volatilization characteristics of a niobium alloy. Niobium is a candidate alloy for use in plasma facing components (PFCS) in experimental fusion reactors like the Intemational Thermonuclear Experimental Reactor (ITER). An experimental alloy was tailored to simulate small changes in chemistry which could result from transmutations from irradiation. The alloy was exposed in air and steam between 800[degree]C and 1200[degree]C. Volatilized products and hydrogen were collected and measured. Post-test examinations were also performed on the samples to determine the amount of material loss during the exposures. The obtained measurements of volatilization flux (g/m[sup 2]-s), hydrogen generation rates (liters/m[sup 2]-s), and recession rates (mm/s) are data which**

can be used for safety analyses and material performance to predict consequences which may result from an accident involving the ingress of air or steam into the plasma chamber of fusion reactor. In our volatility tests, only molybdenum and niobium were found at release levels above the detection limit. Although molybdenum is present at only 0.12 wt%, the quantities of this element volatilized in air are nearly comparable to the quantities of niobium released. The niobium release in steam is only three to four times higher than that of molybdenum in steam. The hydrogen production of the niobium alloy is compared with other PFC materials that we have tested, specifically, beryllium, graphite, and a tunesten alloy. At high temperatures, the hydrogen production rate of the niobium alloy is among the lowest of these materials, significantly lower than beryllium. To understand what this means in an accident situation, modeling is necessary to predict temperatures, and therefore total hydrogen production. The INEL is currently doing this modeling. Euro Abstracts The Abstracting Journal of Scientific and Technical Publications of the Commission of the European Communities The Cumulative Book Index Journal of the Physical Society of Japan Nuclear News