Centro de Fusão
Nuclear

INSTITUTO SUPERIOR TÉCNICO

Centro de Física
dos Plasmas

2003 ANNUAL REPORT

OF THE ASSOCIATE LABORATORY ON

PLASMA PHYSICS AND ENGINEERING

Centro de Fusão Nuclear

Centro de Física dos Plasmas

IST, May 2004

1. INTRODUCTION

This document summarizes the activities carried out in 2003 by the Associate Laboratory in Plasma Physics and Engineering.

This Laboratory has two Action Lines:

- Controlled Thermonuclear Fusion;
- Plasma Technologies and High Power Lasers,

where the activities referred to in sections 2 and 3 were performed by staff of respectively "Centro de Fusao Nuclear" (CFN) and "Centro de Física de Plasmas" (CFP). Fusion related activities of both Research Units have been carried out in the frame of the Contract of Association between "Instituto Superior Técnico" and the European Atomic Energy Community (EURATOM). Sections 4 and 5 contain information about the publications, post-graduation degrees, organization of scientific meetings and participation in the management of the EURATOM Fusion Programme.

2. ACTIVITIES CARRIED OUT IN 2003 BY "CENTRO DE FUSÃO NUCLEAR"

2.1. Introduction

"Centro de Fusão Nuclear" had in 2003 nine main Projects:

- Tokamak ISTTOK;
- Participation in the collective use of the JET facilities by the EFDA Associates;
- Participation in the ASDEX-UPGRADE Programme;
- Participation in the TJ-II Programme;
- Participation in the MAST Programme;
- Participation in the TCV Programme;
- Participation in the ITER Project;
- Other activities on theory and modeling;
- Other activities on control, data acquisition and signal processing.

2.2. Tokamak ISTTOK

This Project had this year four main research lines: tokamak operation, testing of the liquid metal limiter concept, diagnostic developments and plasma physics studies.

2.2.1. Tokamak operation

ISTTOK was in operation in 2003 during 33 weeks. The remaining time was used for the maintenance of the discharge systems, the implementation of some diagnostic improvements and for the annual holidays.

2.2.2. Testing of the liquid metal limiter concept

IST/CFN has proceeded with the collaboration with the Association EURATOM/University of Latvia on the testing of the liquid metal limiter concept. The design of the liquid metal system (LMS) and the definition of the technical characteristics of the LMS components have been finalized. A digital system to control the LMS operation has been developed. An experimental stand to test the influence of a pulsed magnetic field on the behavior of the liquid metal jet has been designed and commissioned. The electrical circuit required to generate a 0.15 T B-field during 100 ms has been implemented and tested. IST/CFN staff has participated in Riga in two experimental campaigns concerning the testing of the MHD stability of the liquid gallium jet as well as the optimization of the injector. IST/CFN organized in 2003 an international workshop on the use of liquid metals in fusion research.

2.2.3. Diagnostic developments

The development of a new spectrometer devoted to the analysis of Gallium spectral lines[1] has proceeded. A new arrangement of three emissive probes and one cold probe has been implemented for the study of Reynolds stress and the radial fluctuation-induced flux in the ISTTOK edge region[2]. Improvements have been made on the operation software of the diagnostic real-time for plasma control and on the numerical codes for the analysis of the plasma equilibrium. A new time-of-flight energy analyzer (TOFEA) prototype with cylindrical electrostatic plates, together with switched power supplies for driving the TOFEA electrostatic plates, has been developed, tested and implemented. Plasma signals have been obtained on the "start" and "stop" detectors in modulation mode of HIBD operation with frequencies up to 100 kHz. A new diagnostic for the monitoring of the C^{III} spectral line has been brought to operation. Concerning the Thomson scattering diagnostic, the laser has been repaired, a new cooling system has been designed, a new beam delivery system has been designed taking into account the new constrains imposed by the implementation on ISTTOK of the liquid metal limiter system and new hardware as well as software have been developed for the link of the dedicated data acquisition system of this diagnostic to the central ISTTOK system. The conceptual design of a multi-fiber Thomson scattering diagnostic has started[3]. A Gunderstrup probe provided by IPP-Prague and an emissive electrode for biasing experiments have been implemented on ISTTOK.

2.2.4. Plasma physics studies

Studies on the investigation of the plasma column macroscopic oscillations, analysis of emissive electrode and limiter biasing experiments[4] as well as measurements of fluctuation and Reynolds stress with emissive probes[2] were carried out in 2003.

---

[1] Work in collaboration with the Association EURATOM/ University of Latvia.

[2] Work in collaboration with the University of Innsbruck of the Association EURATOM/OAW.

[3] Work in collaboration with the "Laboratório Associado de Plasmas do Instituto Nacional de Pesquisas Espaciais ", of S. José dos Campos, Brasil.

[4] Work in collaboration with the "Laboratório de Plasmas, do Instituto de Física, da Universidade de S. Paulo", Brasil.

2.3. Participation in the collective use of the JET facilities by the EFDA Associates

IST/CFN has proceeded with its participation in the collective use of the JET Facilities by the EFDA[5] Associates, with activities in the areas of operation, scientific exploitation, enhanced performance project and management.

2.3.1. Operation

Three members of the IST/CFN staff have been involved in the JET operation: Dr. Sebastien Hacquin has participated in the JET Operation Team, through a Secondment Agreement with the Association EURATOM/UKAEA, working in the Reflectometry and LIDAR Diagnostics Group; Mr. Luis Meneses and Mr. Nuno Cruz have provided technical support to the operation and maintenance of the kG8 correlation reflectometer.

2.3.2. Scientific exploitation

The participation in the JET 2003 Work Programme had contributions from fifteen scientists to the experimental campaigns C8-C12 at the JET site. The work was focused on code developments, leading to the following plasma physics studies related mainly with Task Forces M, D and E: (i) use of ICRH in JET discharges for the prevention of core impurity accumulation; (ii) sawtooth experiments with counter NBI; (iii) statistical study of neo-classical tearing modes onset; (iv) impurity penetration through the edge transport barrier; (v) sawtooth stabilization by ICRH driven fast ions as function of global parameters; (vi) sawtooth stabilization during ICRH at low plasma densities in JET; (vii) confinement effects of large islands; (viii) effect on the fast particle population of externally induced error fields; (ix) studies on density limit disruptions; (x) investigation of the runaway electrons at disruptions in JET; (xi) investigation of slowly rotating islands in JET discharges; (xii) application of the Choi-Williams distribution to the time–frequency analysis of phenomena in fusion plasmas: precursors of edge localized modes and washboard modes; (xiii) combined mass-energy analyzer for the investigations of SOL plasmas; (xiv) probability density function of the radial structure of turbulence in fusion plasmas; (xv) determination of the particle and energy fluxes in the far SOL during ELMs using the reciprocating probe diagnostic; (xvi) effect of toroidal field reversal on the SOL properties; (xvii) ELMs studies with microwave reflectometry; (xviii) plasma physics studies from MSE measurements.

2.3.3. Enhanced Performance Project

IST/CFN was in 2003 responsible for six tasks of the JET Enhanced Performance Project: Mw Access-Project Management and Implementation, Real-Time Diagnostic, FDA Project Design and

[5] EFDA means “European Fusion Development Agreement”.

Procurement Activities, MPR-Project Design and Procurement Activities[6], TOF-Project Design and Procurement Activities[6] and RTP-Development Real-time Test Facility.

The task *Mw Access – Project Management and Implementation* had in 2003 the participation of CFN-IST, IPP, FOM, CNR and CIEMAT. Dr. Luis Cupido has been the Project Leader. The design of all parts of the system has been completed and the specifications and contracts for manufacturing have been elaborated.

The task *Real-Time Diagnostic* aims at making the motional Stark effect diagnostic (KS9RT) fully automatic in its operation. The time evolution of the front-end frequency response on data acquisition has been checked. The Faraday correction on the calculated light polarization angle has been improved by reading the toroidal magnetic field in real-time on the ATM real time measurement and control network. The comparison of results provided by the real-time and off-line MSE systems has been performed for various pulses.

Concerning the *FDA-Project Design and Procurement Activities,* the final testing of the operation in the JET CODAS of the fast ADC upgrade system for the heterodyne radiometer (kk3) diagnostic was carried out in 2003. A remote boot system has been implemented and tested. The software to support the insertion of a seventh transient recorder module has been developed and configured.

Regarding the *RTP -Development Real-time Test Facility*, the conceptual design of the system has been made. A proposal regarding the use of this system on the JET Real-time upgrade Phase 2 has been elaborated and discussed with the EFDA Culham Close Support Unit. The development of the PCI DAC modules has begun.

Concerning the *MPR-Project Design and Procurement Activities* and the *TOF-Project Design and Procurement Activitie*s, IST/CFN staff discussed in 2003 new data acquisition requirements of the diagnostic with the Project Leader. The schematic, printed circuit board, programmable logic and control DSP firmware of both the PCI time digitizer and the PCI transient recorder modules have been designed. A prototype of each module have been assembled and tested.

2.3.4. Management

The Association EURATOM/IST has collaborated on the management of the use of the JET facilities by the EFDA Associates in the following manner: (i) Dr. Bruno Gonçalves as a member of the staff of the Close Support Unit to the EFDA Associate Leader for JET; (ii) Dr. Duarte Borba as deputy Task Force Leader for TFM; (iii) Prof. Horácio Fernandes and Dr. Paulo Varela as members of the Remote Participation Users Group.

2.4. Participation in the ASDEX-UPGRADE Programme

The Portuguese participation in the ASDEX-Upgrade[7] (AUG) Programme has been mainly focussed on the areas of microwave reflectometry (microwave systems and electronics, control and data

[6] Work in collaboration with the Association EURATOM/SKN.

acquisition, data processing, modeling and plasma physics studies), MHD and turbulence studies and management.

2.4.1. Microwave reflectometry

Concerning the *microwave systems and electronics*, the heterodyne Q-band fixed frequency channel using synthesizer sources has been implemented and tested. A new routing of the in-vessel waveguides has been developed to avoid future PSL induced damage to the waveguides. The in-vessel access of W band oversized waveguides as well as new routing of the oversized W band waveguides outside the vessel (to accommodate the shift to the C port access, imposed by the installation of the new ECRH antennas) have been changed. Some parts of transmission line that have been damaged in the last AUG campaign, namely the high-field side Ka band (waveguide and directional coupler) and Q band for X mode operation (waveguides) have been repaired/replaced.

Regarding *control and data acquisition,* the control clients have been adapted to allow secure remote operation. Due to security/management restrictions, the implementation of a SSL/TLS secure encrypted communication layer on the client and daemon server has been replaced by a different approach. A simple socket tunneling procedure using SSH has been implemented, which provides secure access to in-site workstations, allowing remote use of the operation/monitoring clients. The daemon to control the Fluctuation Monitor System and the respective C/X windows client has been implemented. The control software of the Fluctuation Monitor System uses a client/server approach, like in the broadband system. This software has been completed and is expected to be in advanced test/debug phase in the beginning of 2004 experimental campaign. A Java version dedicated to the Broadband System client has been implemented and tested. Another Java version dedicated to the Fluctuation Monitor System client has been developed.

Concerning *data processing*, the following main activities were carried out in 2003 aiming to improve the accuracy of automatic density profiles, in particular in the presence of high plasma turbulence as well as transient phenomena, such as ELMs: automation of the O-mode density profiles initialization using X-mode data; automatic removal of ELM effects from burst-mode (level-2) profiles; preliminary work concerning the automatic selection of the optimized window length for the spectrogram analysis of reflectometry data.

In the area of *diagnostic developments*, a software tool to simulate O/X mode reflectometry experiments has been developed aiming to improve the accuracy of profile initialization from O mode and to investigate the possibility of measuring $B_t(r)$ with combined O and X mode probing. The reliability and accuracy of plasma position measurements from reflectometry in typical plasma scenarios using a specially developed workbench of numerical tools has been assessed.

[7] ASDEX-Upgrade is a tokamak of the Association EURATOM/IPP, in operation in Garching.

Regarding *modeling*, the signature that q=2 type islands produce on the reflectometry signals has been studied aiming at investigating the possibility of localizing rational surfaces as a contribution of reflectometry to the estimation of the q-profile. The burst-mode analysis used for density profile evaluation with a 2D FDTD full-wave code has been validated.

Finally, the study of the impact of type I and type III ELMs on the plasma edge density profiles as well as MHD and turbulence studies were performed in 2003.

2.4.2. MHD and turbulence

Turbulence in the scrape-off layer (SOL) region of a tokamak plasma using fluxtube codes, such as DALF or GEM has been computed. Alfvén instabilities have been studied aiming to contribute to the optimisation of the design and future operation of a fusion tokamak reactor.

2.4.3. Management

Two members of the IST/CFN staff have participated in the management of the AUG project: Prof. Maria Emilia Manso is a member of the AUG Programme Committee and Dr. Duarte Borba is the Task Force Leader for TF V (MHD).

2.5. Participation in the TJ-II Programme

The CFN participation in the TJ-II[8] Programme has been mainly focussed on the areas of microwave reflectometry, heavy ion beam diagnostic and edge plasma physics.

2.5.1. Microwave reflectometry

The microwave reflectometry activities were focused in 2003 on the development of an advanced reflectometer for plasma fluctuation studies with increasing measuring capability, utilizing only one single frequency that can be hopped during the discharge. The development and testing of the system at CFN have been finalized. This reflectometer has been implemented and tested on the TJ-II stellarator.

2.5.2. Heavy ion beam diagnostic

This diagnostic has been designed to operate with two detectors for the secondary ions: (i) a 30^{o} Proca-Green electrostatic energy analyzer; and (ii) a multiple cell array detector (MCAD). The tests of the MCAD implemented in 2002, based on deep Faraday cup type cells, have been completed. The operation of the multiple cell array detector was performed during the TJ-II experimental campaigns. Several improvements on the signal conditioning and data acquisition system have been implemented.

[8] TJ-II is a stellarator of the Association EURATOM/CIEMAT, in operation in Madrid.

2.5.3. Edge plasma physics studies

Turbulent transport studies concerning the dynamic coupling between transport and parallel velocity as well as the analysis of the effect of the shear layer on the radial correlation of transport have proceeded in 2003. IST/CFN has constructed a graphite electrode or edge biasing experiments on TJ-II to be performed in 2004.

2.6. Participation in the MAST Programme

This Project aims at the development and scientific exploitation of a microwave reflectometer for MAST[9]. During 2003 the hardware was inspected and the testing of the system was performed. The transmission line has been improved as well as the procedure to implement the system in the machine. The data of the 2003 experimental campaign has been assessed.

2.7. Participation in the TCV Programme

The main objectives of this Project are the development and scientific exploitation of three X-ray diagnostics (a horizontal Pulse Height Amplitude (PHA) spectrometer, a vertical PHA spectrometer and a rotating crystal spectrometer) and the development of an advanced plasma control system for TCV[10].

2.7.1. Horizontal PHA diagnostic

The horizontal PHA diagnostic was in operation during the 2003 TCV experimental campaigns, allowing the measurement of the electron temperature and analysis of the line radiation in the soft X-ray range from 1 to 10 keV. The Raymond-Smith code has been adapted to the TCV conditions. The results obtained with this code, which simulates the SXR emissions for certain plasma parameters and impurity content, have been compared with those obtained with the improved Maxwellian mathematical model. The Matlab programs used for data analysis have been refurbished. The old data has been studied using the refurbished Matlab programs, the algorithm developed for the VME module and the Raymond-Smith code. Two new mathematical models (an improved Maxwellian and a Neoclassical model that accounts for diffusion phenomena inside the plasma bulk) have been developed and tested aiming at finding the factors which induced the abnormal SXR distribution and account for the irregular behaviour of the bremsstrahlung tail, many times observed, both in old and more recent spectra.

[9] MAST is a Mega Ampere Spherical Tokamak of the Association EURATOM/UKAEA, in operation in Culham.

[10] TCV is a “Tokamak de Configuration Variable” of the Association EURATOM/Confederation Suisse, in operation in Lausanne.

2.7.2. Vertical PHA diagnostic

This project has been put forward to meet the need for high throughput, fast data acquisition and real-time data analysis capabilities. The original classic spectrometer is being transformed in a real-time diagnostic by using a commercial CAMAC unit and a multi-DSP-based VME (RTPROV) system, specially developed by CFN for data acquisition, real-time parallel processing and feedback control. IST/CFN staff has supervised the project to make sure that all requirements were met. The diagnostic has been provisionally assembled on TCV in order to allow the tests of two dedicated acquisition system, based on a commercial CAMAC unit and on the RTPROV board. The RTPROV hardware and software have been adapted to the requirements of the PHA diagnostics. The software at the VME host and DSP levels for the VPHAD, including the algorithm for the calculation of the electron temperature, has been developed and tested. The software to integrate the PHAD data acquisition system into the TCV control and data acquisition system has been also developed.

2.7.3. Rotating crystal X-ray diagnostic

This diagnostic, based on a twenty-years old apparatus loaned by the Plasma Physics Princeton Laboratory, has been envisaged to record the soft-X-ray line radiation from highly charged ions of low to medium Z elements from the hot core of the TCV plasma, along a horizontal line of observation. It would provide information on the central ion temperature, electron temperature and ion-charge state distribution from which the ionization equilibrium and ion transport might be deduced. In 2003 IST/CFN staff has performed the testing of the multi-channel plates (MCP) and vacuum conditions of the diagnostic. Intensive procurement of firms that could provide new crystals and MCPs with the required specifications at a reasonable price has been made. CFN and CRPP have performed a joint assessment of the best way to conduct the process of refurbishment of the rotating crystal spectrometer. A report has been submitted in December 2003 to the CFN and CRPP management.

2.7.4. Advanced plasma control system

The research line on *advanced plasma control system* aims the development of a new real-time plasma control system, based on the CFN real-time parallel processing multi-DSP-based VME (RTPROV) board. The conceptual design of the real-time plasma control system, performed in collaboration with the TCV Control Group, has been finalized. Some improvements of the RTPROV board have been made to meet the TCV requirements. The commissioning and testing of fourteen RTPROV boards has started. The DSP operative system has been updated. The development and testing of the DSP application software for the TCV plasma control has started. Linux drivers have been developed to access the board by the VME master. Two new boards were developed in 2003: (i) a digital input/output board (XIO) that brings digital inputs and outputs from the P2 connector of each RTPROV v1.1 to the front panel; and (ii) a bus board (DMBUS to be inserted behind the VME bus in the P2 connectors, enabling the broadcast data transfer from one board to all other boards in the VME

bus that are configured to use the DMBUS protocol. The development of the software interface for MDSPLUS graphics user interface as well as of the software needed to integrate this system in the main TCV control system has been initiated.

2.8. Participation in the ITER Project

The Portuguese participation in the ITER Project included in 2003 activities related with diagnostics design and integration, microwave reflectometry and ITER Negotiations.

2.8.1. Diagnostics design and integration

Prof. Artur Malaquias belonged during 2003 to the ITER International Team, working at Garching. He has been involved in diagnostic systems design and co-ordination of design effort, integration and distribution of diagnostic systems as well as co-organization of scientific meetings. Prof. Malaquias participated in 2003 in: (i) the relocation of some systems to more suitable ports; (ii) upgrade of the microwave diagnostics implemented in eport#11 to include the Doppler reflectometry system and the integration of individual motion decoupling devices for the waveguides; (iii) elimination of the graphite reflectors X-ray array and its replacement by a new system at eport#9; (iv) redesign in eport#9 of the X-ray survey and the VUV survey in respect to their function covering now the spectral range by means of 6 sub-bands and to their vacuum chambers plus refurbishment procedures; (v) development of a new arrangement for the port plug shielding blocks and inter-space shielding; (vi) replacement of the previous X-ray system by a completely new design based on imaging crystals and relocated to eport#9; (vii) definition of a new positioning of the ECE system in order to optimise the plasma coverage; (viii) integration at the upper port level of two newly designed diagnostics: the VUV-imaging and the upper imaging X-ray; and (viii) design of the optical periscopes for the CXRS and MSE diagnostics.

2.8.2. Microwave reflectometry

IST/CFN proceeded in 2003 with studies for plasma position/shape measurements as required for ITER. The microwave and millimeter wave technologies that, besides reflectometry, will also be used by ECE and ECA diagnostics on ITER, have been assessed. The conceptual design of an advanced FM-CW reflectometer (beyond the state of art) capable of performing profile measurements at very high densities/long distances has been finalized. The selection of microwave components for a prototype system has been initiated. The FM-CW reflectometers developed by CFN for the ASDEX Upgrade tokamak have explored the control of plasma position and shape from reflectometry, as required for ITER long pulse operation.

2.8.3. ITER negotiations

Prof. Carlos Varandas has attended two meetings in 2003 of the ITER negotiations, as member of the delegation of the European Union.

2.9. Other activities on theory and modeling

Besides the work on theory and modelling previously presented, this section reports on three topics: (i) role of magnetic reconnection (ideal and resistive) processes in the dynamics and confinement of thermonuclear plasmas; (ii) non-inductive current drive; and (iii) reconstruction of tokamak MHD equilibrium.

2.9.1. Role of magnetic reconnection (ideal and resistive) processes in the dynamics and confinement of thermonuclear plasmas[11]

Studies of the destabilization of metastable modes by resonant magnetic fields and of the effects of the poloidal $\vec{E} \times \vec{B}$ velocity (V_{θ}^{ExB}) proceeded in 2003.

2.9.2. Non-inductive current drive

The wave field across a caustic, in the framework of geometrical optics, has been computed. The spectral-gap problem for Lower Hybrid (LH) current drive has been studied. IST/CFN staff has participated in the design of the ITER-like lower hybrid launcher[12].

2.9.3. Reconstruction of tokamak MHD equilibrium

A new perturbative method to avoid the drawbacks of iterative approaches has been developed. This method has been illustrated with ASDEX-Upgrade data.

2.10. Other activities on control, data acquisition and signal processing

This Project aims the development of: (i) a galvanic isolated PCI transient recorder module; (ii) an event-driven reconfigurable real-time processing system for the next generation fusion experiments; (iii) a low-cost fully integrated event-driven real-time control and data acquisition system for fusion experiments and a water-cooled; (iv) high compaction ratio Linux cluster.

2.10.1. Galvanic isolated PCI transient recorder module

The module architecture has been defined accordingly to the JET requirements. The schematic, printed circuit board, programmable logic and control DSP firmware of the module have been designed. A prototype has been assembled and tested. The operation of this module was successfully demonstrated at JET in August.

[11] Work carried out in collaboration of CNR-Milano, of the Association EURATOM/ENEA.
[12] Work performed in collaboration with the Association EURATOM/CEA.

2.10.2. Event-driven reconfigurable real-time processing system for the next generation fusion experiments

Adequate software and hardware platforms have been identified. A preliminary multiple FPGA/DSP based hardware design was developed. The software design workflow was performed.

2.10.3. Low-cost, fully integrated, event-driven real-time control and data acquisition system for fusion experiments

A System-On-Chip architecture suitable for the development of low-cost, modular, long operation period and network interconnected data acquisition and control instruments has been identified. The preliminary design of data acquisition and control module with a high number of channels was performed. An initial cost and performance estimation was made, which indicates that this module can be produced at very low cost per channel and can speed the data acquisition subsystem commissioning task.

2.10.4. Water cooled linux cluster

This project aims the development of a Pentium 4 linux based cluster intended for heavy numerical calculus. The conceptual design, commissioning and testing of the system were made in 2003. The operation software has been developed. The present version of this cluster is characterized by 24 Gflop per 8 CPU with a high volume compaction ratio and a low cost design. This is done by water cooling the 2.4 GHz CPUs so that 8 boards/1 GRam can be housed in a regular 21", 6U rack system. The cluster has a 1Gbit ethernet dedicated switch.

3. ACTIVITIES CARRIED OUT IN 2003 BY CENTRO DE FÍSICA DOS PLASMAS

3.1. Foreword

"Centro de Física dos Plasmas" has three Groups:

- Grupo de Lasers e Plasmas[13] (GoLP);
- Grupo de Plasmas Espaciais[14];
- Grupo de Descargas em Gases[15].

These Groups have independent research programmes, but they have recently established collaborative work in the area of Space Plasmas. The activities of these three Groups will be presented separately in this report.

[13] Group of Lasers and Plasmas.
[14] Group of Space Plasmas.
[15] Group of Gaseous Discharges.

3.2. GoLP – Group of Lasers and Plasmas

3.2.1. Introduction

GoLP activities in 2003 covered several areas of Physics, such as inertial fusion, high intensity laser development, physics of dense plasmas, radiation processes, plasma propulsion for space exploration, complex plasmas, and quantum optics, as well as more speculative problems related with gravitational waves, neutrino physics.

3.2.2. Keep-in-touch activities on inertial fusion energy

Of particular importance are the keep-in-touch activities on inertial fusion energy have been carried out by GoLP, in the frame of the Contract of Association EURATOM/IST. The research program developed in 2003 covered a wide range of topics: (i) development of high intensity laser technology, (ii) target area for high intensity laser experiments, (iii) high intensity laser-plasma experiments, (iv) XUV sources and applications, (v) theory and simulations on fast ignition and high energy density physics.

3.2.3. Development of high intensity laser technology

3.2.3.1. Laser status

The laser system is currently capable of delivering broadband (6 nm), 1 Joule pulses. Compression of these pulses result in a peak power of about 1 J, 200 fentoseconds (fs), corresponding to approximately 5 TeraWatt (TW). The maximum power on target, produced in 2003 was 6 TW, with a compressed pulse of 180 fs.

3.2.3.2. Introduction of a new Pockels cell driver

The performance of the regenerative amplifier was greatly improved thanks to a new high-voltage pulser which is able to drive a single intra-cavity Pockels cell, both for laser pulse seeding and extraction. Losses in the regenerative amplifier, and daily alignment time, are greatly reduced. This up-grade was responsible for a dramatic improvement in the quality and stability of the final laser pulse.

3.2.3.3. All-reflective grating stretcher

Early in the year, a new, all-reflective grating stretcher was installed and characterized. This became necessary after the previous year's oscillator upgrade. As a consequence, a final compressed pulse duration below 200 fs was attainable for the first time.

3.2.3.4. Vacuum pulse compressor

Operating the amplifiers at full power with such short durations will require vacuum pulse compression; for this purpose, we designed a new pulse compressor chamber, whose vertical configuration will allow its inclusion in the present set-up without time-consuming geometrical

rearrangements. Being the final stage of the laser system, the compressor is connected by vacuum to the target chamber, sharing its vacuum system. The planning and design of the compressor chamber were concluded in September, and the installation is scheduled for next December.

3.2.3.5. Nd:glass 45 mm amplifier

A new 45 mm Nd:glass amplifier was acquired, with the purpose of boosting the final energy beyond the 10 Joule level. Its impact on the laser performance, at the level of energy, pulse duration and non-linear effects were carefully modelled. The installation of the amplifier is scheduled for next January.

3.2.3.6. Optical Parametric Chirped Pulse Amplification (OPCPA) development

The Laboratory for Intense Lasers OPCPA program was started this year. Modelling tools for amplification are being developed in order to design an OPCPA chain, both for testing this new concept and for developing a new independent amplification line. This technique allows the amplification of broadband laser pulses with virtually no spectral and spatial degradation, allowing a compact, multi-terawatt laser system for laser pulses under 100 fs.

3.2.3.7. Diagnostic development

A new single-shot, third-harmonic auto-correlator was assembled. This system will allow high dynamic range characterisation of the pulse duration and contrast at any point in the laser chain, and will be tested later this year. A new SPIDER (*Spectral Phase Interferometry for Direct Electric-field Reconstruction*) diagnostic was also developed, and is currently undergoing calibration. This device allows the measurement of the pulse spectral phase, and is of fundamental importance for characterizing and optimising compressed ultra-short pulses.

3.2.3.8. Laser modelling

The laser team started using the *Miro* software package for laser modelling. This powerful modelling tool was originally developed for the Comissariat à l'Energie Atomique (França) *Megajoule* laser project, and is also capable of handling broadband, CPA laser chains. We are currently using it for modelling the next laser system upgrades as well as the OPCPA program.

3.2.4. Target area for high intensity laser experiments

3.2.4.1. Target area development

The target area development activity was focused on the installation of the new compressor vacuum chamber. This consists mainly in a pair of large (120 x 140 mm) diffraction gratings and a set of five mirrors to provide a double pass set-up. These will be installed in a high-vacuum chamber, with optical mounts having stability in the micrometer range. The compressed, high-power laser pulses should propagate to the target area though vacuum, in order to avoid non-linear pulse degradation. For this reason, a thin film polymer that prevents the contamination of the compressor vacuum will

optically connect the two vacuum chambers. The operation of these two vacuum systems as a whole system will be ensured by a custom-developed microcontroller-based system that can be connected to the internet for external access. The hardware and software for this system are being developed, and the final version is expected by the end of the year.

3.2.4.2. Electron spectrometer development

The existing electron spectrometer was fitted with a vacuum chamber that allows a dramatic increase in its accuracy, since it eliminates the need for a vacuum-air interface before the electrons reach the magnet gap. A new set of twelve ion-implanted silicon detectors was added in order to increase the measurement accuracy. These detectors can be attached to the vacuum chamber in precise locations resulting in a very user-friendly operation. The new up-graded spectrometer will be tested in an experiment to be performed in Oct-Nov 2003.

3.2.4.3. Gas jet development

The Laval nozzle development program was pursued with the development and characterization a new set of two low Mach number (1.5) gas jets. A new double wedge interferometer for laser-aided jet characterization was set up; this allows a 3D characterization of the jet density, by using an automatic profile retriever software package.

3.2.4.4 Instrumentation

A new mount for 75 mm diameter off-axis parabolic mirrors was developed for use in the target area. The target area “resident” forward optical imaging system was up-graded in order to allow simultaneously electron measurements and forward imaging of the focal spot, as well as to measure the spectra of the forward radiation.

3.2.5. High intensity laser plasma experiments

3.2.5.1. Electron acceleration by propagation of intense laser beams in gas jets

An experimental set-up for measuring the electron beam and forward radiation spectra generated by the propagation of the main laser pulse in a gas jet was developed and assembled in the target area. This experiment will allow the full testing of the electron spectrometer as well as other experimental techniques of laser-plasma interaction. It is now fully operational and is scheduled to run in October and November.

3.2.5.2. Plasma channels by laser-triggered high-voltage discharges

The second experiment on plasma waveguide generation by laser-triggered discharges is scheduled for December 2003 – February 2004. The objectives of this experiment are the testing of a new differential gas cell where the discharge takes place, allowing the vacuum focusing of the main pulse to be guided. A new electrical set-up will be tested in order to achieve a faster channel development.

3.2.6. XUV sources and applications

3.2.6.1. Introduction

The main goals pursued by the XUV sources group is the optimization of XUV short-pulse sources in terms of brilliance for applications. These include probing dense plasmas as with XUV interferometry, but also, if intensities are high enough, creating a plasma from using an XUV monochromatic source, paving the way for future experiments with VUV-Free Electron Lasers now under construction.

The efforts of this team have thus been divided in three ways: first, performing experiments at LOA for high harmonic (reaching 30 nm) generation and focusing; second, work on simulations for the interaction of XUV-lasers with solids,, and finally, preparing experiments in DESY's VUV-FEL by hosting a VUV-FEL experimental planning workshop at Instituto Superior Técnico.

3.2.6.2. High Harmonic Generation and focussing

The XUV Sources group has continued its collaboration with colleagues from LOA in Ecole Polytechnique, France, with Drs. Ph. Zeitoun and Ph. Balcou. An experiment was performed at LOA, where high harmonics below 30 nm, generated by interacting "Salle rouge" laser with a gas target, were focused using an off-axis parabola. The outstanding quality of the focal spot, with over 40% of the harmonics beam within a 2 μm focal spot allows us to hope that, with appropriate coating on the parabola, intensities on target should reach 10^{14}Wcm^{-2}, enough for ablation studies with XUV laser[16].

3.2.6.3. Simulation of XUV laser-solid interaction

With the construction of novel XUV sources, such as VUV FEL's, XUV laser-matter interaction will become available at ultra-high intensities (first experiment scheduled in May 2005). But as shown above, even tabletop facilities such as XUV lasers or High Harmonic Generation, are starting to reach intensities high enough to produce dense plasmas. XUV laser-matter interaction was studied by a 1D hydrodynamic lagrangian code with radiative transfer for a range of interesting XUV sources[17].

The main results were that heating is found to be very different for low close-Z elements having L-edges around the XUV laser wavelength. Possible absorption mechanisms were investigated in order to explain this behaviour, and interaction with cold dense matter proved to be dominant. Plasma sensitivity to XUV laser parameters such as energy, pulse duration, and wavelength was also studied, covering ranges of existing XUV lasers. We found that XUV laser-produced plasmas could be studied using tabletop lasers, paving the way for future VUV-FEL high intensity experiments.

[16] These results have been submitted to Optics Letters.

[17] In collaboration with J-C. Gauthier's group in CELIA, Bordeaux, and Ph. Zeitoun in LOA, Ecole Polytechnique.

Also, a collaboration was started with Prof. Pedro Velarde in Instituto Politecnico de Madrid, for the use of an Adaptive Mesh refinement hydro code to describe VUV laser-solid interaction, making the extension of the previous simulations to a bi-dimensional case.

3.2.6.4.. Sub-picosecond X-ray experiments development Workshop

In order to prepare future VUV-FEL experiments, a Workshop has been organized in Lisbon, grouping all future VUV-FEL users interested in XUV-laser-plasma interaction. The main goals of the workshop were the following:

(i) Community building and experimental project planning, by informing potential collaborators, and developing working teams;

(ii) Beginning the implementation of projects with main Organization members (e.g., DESY, SLAC, Ultra-Short Pulse community);

(iii) Assistance in Generation of future proposals

The three goals were fulfilled, with a set of two main experiments (cluster/bio molecules explosion and VUV-FEL-solid ablation) being defined. Material needs (spectrometers, vacuum chambers, manpower etc) were identified, and a "zero-th order" experiment, using available material, was put together. Also, as a full set of possible experiments using additional funding was planned, and three proposals for EU funding started to be written, one of which includes GoLP as an active member, and the other as a leader.

3.2.7 .Theory and simulations

3.2.7.1 Introduction

The main research theme is the physics of intense fields in plasmas, covering a broad range of topics going from laser-plasma accelerators to astrophysics. The unifying aspects of the work is established by the methodology followed when tackling the different problems, with a combination of relativistic kinetic theory, plasma physics, accelerator physics, theoretical astrophysics with state-of-the art massively parallel numerical simulations using particle-in-cell codes or hybrid/reduced codes.

The team has developed a strong expertise in plasma simulation codes, theoretical plasma physics, plasma-based accelerators, and advanced simulation techniques. We are now becoming recognized as the leading plasma simulation group in Europe, and achieving worldwide recognition. Collaboration with the leading research programs in the US in our fields of research is tight and strong, guaranteeing us access to state-of-the-art computing facilities such as the newly commissioned cluster at UCLA (to be ranked #2 or #3 in university supercomputers in the US) or the IBM SP3 at NERSC[18], Oakland, California.

Our research program has been quite successful in the past years, and the results of our work are now showing up, dealing with different aspects of laser-plasma interactions at extreme radiation

[18] NERSC is National Energy Research Scientific Computing Center, USA

intensities, ranging from laser-solid interactions to large-scale length plasma accelerators, from fast ignition of fusion targets to shocks in Coulomb explosions of cluster[19].

On the astrophysical context, we have recently demonstrated the role of the Weibel instability on the generation of magnetic fields in gamma-ray bursters through large-scale numerical simulations[20]. This work is being further explored with the goal of understanding baryon loading effects in magnetic field generation in explosive events.

During 2003, we have also revived the hybrid comet dcomet in order to study the plasma sail concept and the role of magnetic fields in the erosion of planetary atmospheres[21].

Our research has been widely recognized through several invited talks in Europe and in the United States in the general meetings of the Plasma Physics division of the European Physical Society or the American Physical Society, in all the workshops in the field of plasma-based accelerators or in high intensity laser-matter interactions. Two master thesis have been presented in the last year[22], and four high quality new PhD students are now preparing their thesis[23].

We are currently upgrading our cluster to an extra 40 CPU PowerPC G5 over Gigabit Ethernet, for an aggregate cluster size of 80 CPUs, 65 GB RAM. Funding for this cluster has been secured from different grants of the CFP and GoLP, mainly from ESA[24]. This cluster will be the fastest machine for science and technology in Portugal. The new cluster will be featured in press releases of Apple Europe.

Several of our research pictures have been used by RSINC inc., the makers of IDL[25], visualization software widely used in astrophysics, geophysics, and atmospheric sciences, in their advertisements (e.g. in Physics Today) and promotions (e.g. RSINC Christmas Card). RSINC has provided us three IDL licenses free for the next five years, and access to other RSINC specific resources not available to the general public. Our work was also featured in the French site of RSINC Europe.

Simulation support for the UK collaboration Alpha-X[26] has also been provided. This collaboration aims to produce a compact source for a 1 GeV electron beam for high brightness coherent radiation, combining plasma accelerators technology with free-electron laser techniques.

Our effort was concentrated on the following topics: (i) explosions of very large deuterium clusters, (ii) the Weibel instability in astrophysical and laboratory plasmas, (iii) relativistic mirrors for attosecond pulse compression, (iv) one GeV electrons in a 1 cm channel by laser wakefield

[19] These results led to one paper accepted in Physical Review Letters (published in 2004), two additional papers will be published in Physical Review Letters in 2004 (accepted for publication in 2004), and other two papers have been submitted to Physical Review Letters (November 2003 and March 2004).
[20] This work was published in the Astrophysical Journal Letters
[21] This code is being developed in collaboration with the Rutherford Appleton Laboratory, which is also supporting one MSc student.
[22] M. Marti (University of Bern) and S. Amorini (Politecnico di Torino)
[23] M. Marti, M. Fiore, P. T. Abreu, and L. Gargaté
[24] ESA is European Space Agency
[25] IDL is Interactive Data Language
[26] Collaboration involving 10 UK university teams and the Rutherford Appleton Laboratory

acceleration, (v) proton acceleration in solid targets, (vi) OSIRIS code development, (vii) dcomet code development (viii) fast electron transport in plasmas and solids.

3.2.7.2. Explosions of very large deuterium clusters

Our work on very large (10^6 atoms) deuterium clusters demonstrated the possibility to drive shocks in Coulomb explosions. We have also proposed a novel technique to enhance the formation of such shocks, thus capable of increasing the neutron yield in intra cluster reactions.

3.2.7.3. Weibel instability in astrophysical and laboratory plasmas

The role of the Weibel instability in gamma ray bursters explosions seems to be now clearly established through the large scale particle-in-cell simulations we have published in 2003. We are also continuing to study the role of this instability in fast ignitor scenarios, where we have performed large scale finite target simulations that clearly demonstrate the role of collisionless electron instabilities, and its coupling to ions dynamics on the overall picture of transport in fusion targets.

3.2.7.4. Relativistic mirrors for attosecond pulse compression

A novel mechanism to compress femtosecond pulses to the attosecond range has been proposed and tested numerically. In this configuration an intense laser pulse drives a strong wake, very close to wave breaking, and a second weaker pulse is partially reflected from the density spike of the nonlinear plasma waves. Reflection efficiencies as high as 10%, with reflected pulses in the hundreds of attosecond have been measured in proof-of-principle numerical experiments.

3.2.7.5. 1 GeV electrons in a 1 cm channel by laser wakefield acceleration

A major milestone for research in plasma based accelerators is the possibility to accelerate electrons up to 1 GeV. We have performed simulations and developed a theory that demonstrate that such goal is already possible for available laser technology provided the laser propagates in a preformed plasma channel. High quality beams (energy spread < 10%, with energies in the 500 MeV range) are also predicted in the three dimensional one-to-one simulations we have performed.

3.2.7.6. Proton acceleration in solid targets

Activity on this topic has been continued, paying particular emphasis to high dimensional effects, in particular the Rayleigh-Taylor like instability growing in the underdense region that can be created by the pre-pulse of an ultra intense laser interacting with a solid target.

3.2.7.7. OSIRIS code development

Several new features have been included in OSIRIS, namely, cathodes, external fields, arbitrary profiles, and significant performance improvement and benchmarking has been pursued. The strongest

effort was focused on optical field ionization with two ionization models now included in OSIRIS (Barrier suppression ionization and tunneling ionization – ADK model)[27].

3.2.7.8. dcomet code development

During 2003, we have revived the hybrid code dcomet (R. Bollens, UCLA[28] PhD thesis, 1993). This hybrid code examines the self-consistent dynamics of kinetic ions in a magneto-hydrodynamic electron background (massless electrons, but including the Hall term). The legacy code was modernized, and several new features have been included (arbitrary number of species, different charge to mass rations) getting the code ready to be parallelized.

3.2.7.9. Fast electron transport in plasmas and solids

Theoretical work on fast electron transport in plasmas and solids, relevant to laser-solid interactions and fast ignition inertial confinement fusion, has been continued.

An analytical model of field generation and Ohmic heating by fast electrons propagating in conductors was developed, which includes a resistivity with an arbitrary power law dependence on temperature. It clearly demonstrated the significant effect of target heating on the field generation, the effect being particularly pronounced for the magnetic field. Field generation is enhanced when the resistivity increases with temperature, as occurs in metals, and reduced when it decreases, as occurs in plasmas. If the resistivity falls faster than linearly with temperature then the magnetic field will eventually change sign, causing beam expansion and hollowing. The implications for laser-solid interactions and the fast ignitor were considered. It was found that the minimum fast electron density required to achieve ignition by Ohmic heating is prohibitively high[29].

The limitation of the current of a charged particle beam due to its self-generated magnetic field, first considered by Alfvén in 1938 in terms of particle trajectories, was reconsidered in terms of energy conservation. An absolute upper limit on the net current was derived by equating the kinetic energy of the particles to the magnetic field energy within the beam. It depends only on the current profile, is directly applicable to beams that are not mono-energetic, and can be expressed in a simple, general form, unlike Alfvén's approach. Calculations for various current profiles using both approaches gave similar results. Alfvén only considered a uniform current density. The limit is lowered if the current is concentrated on-axis, and increased if it is concentrated off-axis. In particular, an arbitrarily large current can propagate in a narrow, ring shaped profile. Magnetic field limitation only applies to beams that are, at least partially, charge neutralised, that is beams propagating in a conductor. In this situation the beam current is also initially neutralized, allowing forward currents much greater than the Alfvén limit to propagate. However, current neutralisation is temporary, as the

[27] Work performed within the OSIRIS consortitium, consisting of the University of California Los Angeles, GoLP/IST, and the University of Southern California.
[28] UCLA is the University of California Los Angeles
[29] This work was published in Physical Review E and featured in the Virtual Journal of Ultra Fast Science.

return current decays due to collisions and the currents separate due to their mutual repulsion. The resistive decay of the return current was calculated, and a magnetic inhibition time was defined for beams that exceed the Alfvén limit, as is the case for laser-generated fast electrons[30]. It was then applied to fast ignition, and it was found that the proposed ignition beam parameters are not viable. The possible solutions to this are increasing the mean energy, increasing the temperature to which the fuel is heated by lowering the beam radius and duration, using multiple beams, and using an annular beam. Taking into account the laser wavelength required showed that increasing the mean energy and the number of beams are the most practical solutions[31].

An alternative fast ignition scheme using a spherically converging heat wave, rather than a beam, was proposed in both this article and that on field generation, and it is intended to follow up on this, and other, ideas for fast ignition.

We also collaborated in the interpretation of proton emission measurements from solid targets obtained on the Astra laser at the Rutherford Appleton Laboratory, UK, by groups from Glasgow and Imperial College[32].

3.3. Space Plasmas Group

The activity of the Space Plasmas Group is centered on the theoretical study of space plasma physics and nonlinear dynamics, with present emphasis on wave generation via ion beams and (de)stabilizing effects of large amplitude waves.

During this period, the theoretical research work of this Group looked into three topics within space plasmas: (i) generation of electron Bernstein waves by ion beams; (ii) parametric decays; and (iii) assessment of the feasibility of the "magnetic bubble concept" as a means of space propulsion.

The studies on parametric decays and the stimulation of Bernstein waves were jointly carried out with L. Gomberoff of the Physics Department of the University of Chile (Santiago), within a space plasma research project partially funded by ICCTI and (Chilean Institute) FONDECYT. The investigations on the feasibility of the "magnetic bubble" propulsion arise from a CFP project supported by ESA.

Following the studies on the stability of perpendicular currents, we looked at the wave generation capabilities of almost monoenergetic ion (AMI) beams recently observed in several boundary regions of the geoplasma. The results of the investigation suggest that the (previously unexplained) Totem Pole Emissions detected by Geotail near the dayside magnetopause could be stimulated by nonconvective instabilities originated in AMI beams eventually created by current disruptions.

The effects of large-amplitude circularly polarized "pump waves" on beam instabilities have been investigated. The results show that left- and right-hand waves bring about distinct mechanisms of stabilization or wave growth that depend on their amplitude and frequency.

[30] This work was published as a brief communication in Physical Review E.
[31] This work has been submitted as a rapid communication to Physical Review E.
[32] This work was published in Physical Review E.

3.4. Gas Discharges and Gaseous Electronics

3.4.1. Introduction

The activity in 2003 of this Group was focused on studies of electronegative gases, modeling of a nitrogen discharge with graphite electrodes, dissociation and surface atomic recombination in nitrogen discharges, large-scale HF molecular plasma sources, modeling of a capacitively-coupled radio-frequency reactor, theoretical and experimental studies of microwave excitation structures, electron and heavy-species kinetics in a nitrogen afterglow, theoretical and experimental study of wave driven molecular discharges, low-temperature plasma sterilization, comparison between different methods of resolution of the Boltzmann equation for electrons, computational fluid model of the one atmosphere glow discharge plasma (OAUGDP^{TM}).

3.4.2. Studies on electronegative gases

A study on the electrical properties of discharges in mixtures of SF_6 with a non-electronegative gas, for applications in electrical power engineering has been carried out. The effective ionization coefficients, drift velocities and electron attachment coefficients have been determined for different mixture compositions of SF_6 with a companion gas (He, Ar, CO_2, N_2) from Boltzmann analysis.

3.4.3. Modeling of a nitrogen discharge with graphite electrodes

The modeling of a nitrogen discharge with graphite electrodes has been investigated[33]. Some additional work has to be done, developing an appropriate model for the negative glow. It is expected to gain more insight to the fundamental processes allowing the production of the material known as beta-carbon nitride, theoretically predicted to be harder than diamond.

3.4.4. Dissociation and surface atomic recombination in nitrogen discharges

The dissociation in nitrogen discharges at pressures above 1 Torr has been investigated by modelling. This study leads to the identification of new dissociation mechanisms involving excited vibrational levels of ground-state N_2 molecules and $N_2(A\ ^3\Sigma_u^+)$ metastable states, such as $2N_2(X, 10<v<25) \rightarrow N_2(X) + 2N$ and $N_2(X, 14 < v' < 20) + N_2(A) \rightarrow N_2(X) + 2N$[34].

A Dynamical Monte Carlo method to study surface recombination of atoms on silica and Pyrex

[33] In the framework of a collaboration with Dr. Boris F. Gordiets, from the Lebedev Physical Institute of the Russian Academy of Sciences.

[34] This work has been developed with the collaboration of Dr. E. Galiaskarov from the Ivanovo State University of Chemical Technology, Ivanovo, Russia.

has also been initiated. The method developed for heterogeneous atomic recombination allows to establish a direct relationship between Monte Carlo time and real time, which constitutes an exact way of treating time-dependent surface phenomena.

3.4.5. Large-scale HF molecular plasma sources

A new experimental project on Large-Scale HF Molecular Plasma Sources has been initiated. In the framework of the new project, building the new machine has been a time-consuming task due to budget restrictions. Nevertheless, the new machine is now already in conditions to start providing experimental results. It is worth referring here that the new machine includes a PC-controlled, 3-axes movement of the diagnostic tools, which will include wave field (electric and magnetic), probe (electrons and negative ions), and spectroscopic measurements (emission and absorption).

Within the scope of this scientific task, an electrodynamical analysis of large-area a slot antenna excited plasma sources have been performed. The theoretical results have been confirmed by experimental measurements of electric field components distribution.

3.4.6. Modeling of a capacitively-coupled radio-frequency reactor

We have pursuit the modelling of a capacitively-coupled radio-frequency (CCRF) reactor, based on low-pressure (p<1 Torr) pure hydrogen discharges, operating at frequencies up to 80 MHz[35,36]. The work included: (i) Systematic characterization of CCRF hydrogen discharges, by comparison between model results (obtained by solving a two-dimensional, time-dependent, fluid code for the transport of charged particles) and experimental measurements for various electrical parameters (the self-bias voltage, the plasma potential and impedance, and the power coupled to the plasma), at different rf applied voltages, frequencies and pressures; (ii) Development of a homogeneous kinetic model, for the populations of H(n=1-5) electronically excited atoms and $H_2(X^1\Sigma_g^+, v=0..14)$ vibrationally excited ground state molecules, and a comparison between model results and experimental measurements (obtained by LIF) for the density of H atoms, at different rf applied voltages, frequencies and pressures; (iii) Development of a two-dimensional, time-dependent, collisional-radiative model (based on a solution to the Navier-Stokes/Saint-Venant equations), including the reactive multi-component diffusion transport of H(n=1-5) electronically excited atoms and $H_2(X^1\Sigma_g^+, v=0..14)$ vibrationally excited ground state molecules.

[35] This research was carried out in collaboration with the *Laboratoire de Physique et Technologie des Plasmas* (LPTP), *École Polytechnique*, Palaiseau (France) and the *Laboratoire de Physique des Gaz et des Plasmas* (LPGP), *Université de Paris-Sud*, Orsay (France).

[36] This work is the mainframe of the co-tutored PhD thesis of MsD L. Marques, undertaken as collaboration between the *Universidade Técnica de Lisboa* and the *Université de Paris-Sud*, and developed in the framework of the *Programa de Cooperação Científica e Técnica Luso-Francesa* (2003 GRICES – France Embassy's agreement, Project 539-B4).

3.4.7. Theoretical and experimental studies of microwave excitation structures

We have intensified the interplay between modelling and experiment in the characterisation of microwave excitation structures, currently used in plasma reactors for thin films deposition, aiming to optimise the operating conditions of such reactor devices.

A one-dimensional fluid code for the transport of charged particles in a microwave discharge was self-consistently solved, coupled to the appropriate set of Maxwell's equations written for an m=0 surface-wave propagation mode. The analysis of model results focused on the wave-plasma energy coupling, and particularly on boundary phenomena involving the development of an electron plasma resonance and the maintenance of the space-charge sheath.

This work concerned mainly the study of two excitation structures:

(i) A cylindrical excitation structure (corresponding to the sequence plasma-dielectric-air-metal of propagation media, within a 1cm tube radius), operating at 2.45GHz frequency in argon, for intermediate pressures (~1Torr) and average electron densities around 10^{12} cm^{-3}. This excitation structure is part of a microwave reactor for hydrogen-based thin films deposition, existing at the *Laboratório de Ciencias de Materiales* of Sevilla (a Mixed Institute of the *Consejo Superior de Investigaciones Científicas* and the *Universidad de Sevilla*). We have performed several sets of probe measurements in this experimental setup, in order to determine, as a function of radial and axial positions, the electron energy distribution function, the electron density and the electron temperature. We have developed a collisional-radiative model (CRM) at 30 levels for the argon gas, proposing a new set of electron collision cross-sections and/or rate coefficients, for the direct and stepwise excitation/de-excitation of argon levels. The CRM results are to be compared with spectroscopic measurements of different line intensity transitions. We have also developed a thermal gas model to be self-consistently solved, coupled to the microwave discharge model[37].

(ii) A coaxial excitation structure (corresponding to the sequence metal-air-dielectric-plasma-metal of propagation media, within a ~1cm tube radius), operating at 2.45GHz frequency in argon, for low pressures (<100mTorr) and average electron densities bellow 10^{12} cm^{-3}. This excitation structure is part of a hybrid magnetron-microwave reactor for the deposition of thin film metallic vapours, existing at the *Laboratoire de Physique des Gaz et des Plasmas (LPGP)* of Orsay (France). We have compared model results (obtained with the microwave discharge model) with experimental probe measurements of the electron density and temperature profiles. We intend to extend this research work to a comparison between calculated and measured argon spectra, to the self-consistent radial and axial

[37]This research work is carried out in collaboration with the *Laboratório de Ciencias de Materiales* of Sevilla (Spain) and the *Facultad de Física* of the *Universidad de Sevilla* (Spain), under the framework of the *Acções Integradas Luso-Espanholas* (2003 CRUP – CSIC's agreement, Project E-51/02).

resolution of the microwave plasma column, and to the proposal of new excitation structure configurations for the deposition of *high-k* / *low-k* dielectric thin films[38,39].

3.4.8. Electron and heavy-species kinetics in a nitrogen afterglow

The study of the kinetics of electrons in post-discharges of nitrogen have been realised both experimentally and theoretically. The electron energy distribution functions (EEDF) have been measured in the framework of a cooperation including *Université des Sciences et Technologies de Lille* (France) and people from the Bulgarian Academy of Sciences, which has allowed to obtain EEDF measurements in a nitrogen flowing afterglow under collisional conditions. On the other hand, the theoretically study of the time-relaxation of the EEDF in a nitrogen afterglow has been also pursued. It has been shown that an equilibrium between the vibrational distribution of ground-stated N_2 molecules is established and that collisions of highly vibrationally excited molecules with N atoms are in the origin of a maximum in the electron density occuring downstream from the discharge.

In what concerns the kinetics of heavy-species in the post-discharge, some new aspects of nitrogen afterglows were also described. In particular, it was explained for the first time, the raise in the concentrations of several species occurring downstream from the discharge after a dark zone[40].

3.4.9. Theoretical and experimental study of wave driven molecular discharges

An experimental and theoretical study of wave driven molecular discharges (long cylindrical plasma columns extending out of the launcher) has been carried out in the Laboratory of Gas Discharges in H_2, N_2, and Ar gases, as well as in their mixtures (H_2–N_2, N_2–Ar). The employed discharges have been azimuthally symmetric (TM mode) surface waves operating at microwave frequencies $\omega/2\pi$ = 500 MHz and $\omega/2\pi$ = 2.45 GHz.

By means of optical emission spectroscopy, laser photodetachment, and radiophysics methods, the relevant active species concentrations, such as $N(^4S)$, H(1s), H^-, and $N_2(C)$, $N_2^+(B)$, $H_2(d)$, some discharge quantities, like gas temperature and electric field, have been measured. Emission spectroscopy methods have been developed and applied to determine the degree of molecular dissociation in H_2, N_2, N_2-Ar and N_2-H_2 discharges. Microwave H_2 discharges have also been investigated as sources of negative H ions. A significant amount of negative ions has been experimentally detected contrary to the widely accepted negligible presence of H^- ions in microwave

[38] This research work is the be pursued and deepen in the mainframe of the co-tutored PhD thesis of Mr. S. Letout, undertaken as collaboration between the *Universidade Técnica de Lisboa* and the *Université de Paris-Sud*, and developed in the framework of the *Acções Integradas de Cooperação Científica e Técnica Luso-Francesas* (2004 GRICES – EGIDE's agreement).

[39] This work is also part of the Physics degree Final Project of undergraduate student L. Novo.

[40] This work has been developed in close collaboration with colleagues from other Institutions, such as the Faculty of Engineering of the Oporto University (Portugal), *Université des Sciences et Technologies de Lille* (France) and *Université Joseph Fourier de Grenoble* (France).

hydrogen discharges.

The theoretical models developed couple self-consistently the discharge kinetics (electron and heavy particles kinetics), the gas thermal balance, the wave electrodynamics and important aspect of plasma-wall interactions. The models describe the spatial discharge structure and are instrumental in a sense that provide a tool for discharge optimization in respect of active species concentration. The important problems of molecular dissociation, i.e. creation and loss of ground state N(^{4}S) and H(1s) atoms and the inhomogeneous gas heating are analyzed in the terms of obtained theoretical and experimental results. A strong coupling between degree of dissociation, negative ions density and wall temperature has been experimentally and theoretically demonstrated . The contribution of fast charge transfer processes (between Ar^+ and N_2) with consequent dissociative recombination of N_2^+ in the kinetic of molecular dissociation in N_2-Ar microwave discharges has been elucidated.

3.4.10. Low-temperature plasma sterilization

Gas plasma sterilization in hospitals has appeared a very promising alternative to conventional sterilization processes, in particular for materials, essentially polymer based, that are heat sensitive. With the purpose to give an insight into the kinetics of a low pressure microwave flowing post-discharge in N_2-O_2 used for this kind of applications, a fully self-consistent modelling of electrons and heavy-neutral and charged species will be developed. The model considers the plasma sources and the afterglow chamber, where the objects to be sterilized are placed. The plasma sources includes the discharge tube and its connection to the sterilization chamber. In this latter a short-lived afterglow occurs. The sterilizer chamber will be modelled using a hydrodynamic 2D model. An analysis of the populating and depopulating mechanisms will be then carried out for the species with interest for the inactivation of microorganisms such as O atoms and UV photons from NO(A) and NO(B) molecules[41].

3.4.11. Comparison between different methods of resolution of the Boltzmann equation for electrons

A joint work[42] of comparison between different methods of resolution of the Boltzmann equation for electrons is being developed. Among the methods at comparison are: gradients density method, multi-term expansion, elliptic representation and the conventional two-term expansion of the electron energy distribution function.

3.4.12. Computational fluid model of the One Atmosphere Glow Discharge Plasma (OAUGDP^{TM})

It is developed a fluid model of the One Atmosphere Uniform Glow Discharge plasma

[41] This work will be carried out in collaboration with the Physics Department of the University of Montreal, and with the *Laboratoire de Science et Génie des Surfaces, Ecole des Mines de Nancy* (France).

[42] In cooperation with the Institut für Niedertemperatur-Plasmaphysik (Gresfwald, Germany), the Research Institute for Solid State Physic and Optics (Budapest, Germany), the Instituto Tecnológico Nuclear (Sacavém, Portugal) and Edward A. Richley, chief-scientist at Multispectral Solutions, Inc (Gaithersburg, MD-USA),

(OAUGDP^{TM}). Continuity equations for electrically charged species N_2^+, O_2^+, O_4^+, O_2^- and electrons in 2-dim are solved coupled to Poisson equation, subject to appropriate boundary conditions. It is used a known algorithm due to Patankar to solve the fluid equations. Particular attention should be addressed to the displacement current in a staggered geometry. The transport parameters and rate coefficients for electrons are obtained by solving the homogeneous Boltzmann equation for electrons under the hydrodynamic assumption. The electric current vs. time is calculated, the surface charge on the dielectric surface and as well the memory and gas voltage of the discharge. Our main interest in the simulation of this reactor remains in its potential application for plasma propulsion and as plasma actuator[43].

4. OTHER ACTIVITIES OF CENTRO DE FUSÃO NUCLEAR

4.1. Participation in the management of the Fusion Programme

- Some members of the Research Unit are delegates to Committees of the European Fusion Programme and of the European Fusion Development Agreement (Table 1).

Name	Member of
Carlos Varandas	CCE-FU[44]
	EFDA Steering Committee
	FTC[45]
	CFI[46]
Maria Emília Manso	CCE-FU
	EFDA Steering Committee
Fernando Serra	EFDA JET Sub-Committee / STAC[47]
	FPC[48] / STAC
J.P. Bizarro	FPC / STAC
Carlos Silva	AFAC[49]

Table 1 – Participation of members of Centro de Fusão Nuclear in the management of the European Fusion Programme and of the European Fusion Development Agreement

- *Prof. Carlos Varandas* is:
  - Chairman of the EFDA Steering Committee
  - Vice-Chairman of the "CCE-FU Special Working Group on Possible Joint Implementation of ITER";

[43] This work is being developed in cooperation with Prof. John Reece Roth, from the University of Tennessee Plasma Science Laboratory, in Knoxville.
[44] CCE-FU means "Consultative Committee for the EURATOM Specific Research and Training Programme in the Field of Nuclear Energy (Fusion).
[45] FTC means "Fusion Technology Committee", a sub-committee of CCE-FU.
[46] CFI means "Committee Fusion-Industry", a sub-committee of CCE-FU.
[47] STAC means "Scientific and Technical Advisory Committee", a sub-committee of CCE-FU and EFDA Steering Committee.
[48] FPC means "Fusion Physics Committee", a sub-committee of CCE-FU.
[49] AFAC means "Administrative and Financial Advisory Committee", a sub-committee of CCE-FU and EFDA.

- Member of the Steering Committees of the Bilateral Agreements of EURATOM with Russia, Japan and the US Department of Energy, in his position of Chairman of the EFDA Steering Committee.

- *Prof. Maria Emilia Manso* is Chairperson of the International Advisory Board on Reflectometry
- Prof. Fernando Serra is a EU member of the ITPA (International Tokamak Physics Activities) Topical Group on Diagnostics.

4.2. Organization of scientific meetings

- CFN is in charge with the organization of the "IAEA Fusion Energy Conference", to be held in Vilamoura, in November 2004.
- Prof. Carlos Varandas was member of the Programme Committee of the "30th EPS Conference on Controlled Fusion and Plasma Physics", to be held in July 2003, in S. Petersburg.

4.3. Collaboration in post-graduation programmes

- CFN has proceeded with the collaboration in post-graduation programmes of "Instituto Superior Técnico", "Universidade de Coimbra" and "Universidade da Beira Interior". Nineteen Research Assistants (T. Madeira, R.C. Pereira, P. Rodrigues, A. Silva, J. Santos, I. Nunes, F. Silva, T. Ribeiro, R. Gomes, B.B. Carvalho, H. Figueiredo, A. Batista, A.P. Rodrigues, A. Combo, J. Ferreira, F. Nabais, P. Belo, S.R. Cortes, B. Gonçalves) are carrying out Ph.D programmes, while one Research Assistants (D. Alves) are performing Master programmes.
- Three Ph.D Programmes were finalized in 2003[50].

4.4. Publications

4.4.1. Ph.D thesis

1 - "*Statistical properties of turbulence: a new approach to characterize transport in fusion plasmas"*
Bruno Gonçalves, Abril 2003
Universidade Técnica de Lisboa

2 - "*Controlo em Tempo Real do Tokamak ISTTOK"*
Bernardo Brotas Carvalho, Setembro 2003
Universidade Técnica de Lisboa

3 - "*Estabilização do modo kink interno m=1, n=1 por partículas rápidas aquecidas na ressonância ciclotrónica dos iões"*
Fernando Nabais, Outubro 2003
Universidade Técnica de Lisboa

[50] See section 4.4.1.

4.4.2. Articles in scientific journals

1 - *"Density peaking, anomalous pinch, and collisionality in tokamak plasmas"*
Angioni, C., A.G. Peeters, G.V. Pereverzev, F. Ryter, G. Tardini and ASDEX Upgrade team
Physical Review Letters, 90, 205003, 2003

2 - *"Evolution of the ITER project during the CTA"*
Aymar, R., W.R. Spears, ITER International Team
Fusion Engineering and Design, 66-68, 17, 2003

3 - *"Emissive probe measurements of plasma potential fluctuations in the edge plasma regions of tokamaks"*
Balan, P., R. Schrittwieser, C. Ionita, J.A. Cabral, H.F.C. Figueiredo, H. Fernandes, C. Varandas, J. Adamek, M. Hron, J. Stockel, E. Martines, M. Tichy, and G. Van Oost
Review of Scientific Instruments, 74, (3), 1583, 2003

4 - *"Real-time determination of confinement parameters in JET"*
Barana, O., E. Joffrin, A. Murari, F. Sartori, Contributors to the EFDA-JET Workprogramme
Fusion Engineering and Design, 66-68, 697, 2003

5 - *"A low cost, fully integrated, event-driven, real-time control and data acquisition system for fusion experiments"*
Batista, A.J.N., A. Combo, J. Sousa, and C.A.F. Varandas
Review of Scientific Instruments, 74, (3), 1803, 2003

6 - "Edge localized mode physics and operational aspects in tokamaks"
Bécoulet, M., G Huysmans, Y Sarazin, X Garbet, Ph Ghendrih, F Rimini, E Joffrin, X Litaudon, P Monier-Garbet, J-M Ané, P Thomas, A Grosman, V Parail, H Wilson, P Lomas, P deVries, K-D Zastrow, G F Matthews, J Lonnroth, S Gerasimov, S Sharapov, M Gryaznevich, G Counsell, A Kirk, M Valovic, R Buttery, A Loarte, G Saibene, R Sartori, A Leonard, P Snyder, L L Lao, P Gohil, T E Evans, R A Moyer, Y Kamada, A Chankin, N Oyama, T Hatae, N Asakura, O Tudisco, E Giovannozzi, F Crisanti, C P Perez, H R Koslowski, T Eich, A Sips, L Horton, A Hermann, P Lang, J Stober, W Suttrop, P Beyer, S Saarelma and Contributors to JET-EFDA Workprogramme
Plasma Physics and Controlled Fusion, 45, (12A), A93, 2003

7 - *"Onset of neoclassical tearing modes on JET"*
Buttery, R.J., T.C. Hender, D.F. Howell, R.J. La Haye, O. Sauter, D. Testa and EFDA-JET 2000 workprogramme contributors.
Nuclear Fusion, 43**,** (2), 69, 2003

8 - *"Improved 20 keV injection system for the heavy-ion-beam diagnostic of the tokamak ISTTOK"*
Cabral, J.A.C., I.S. Nedzelskiy, A.J. Malaquias, B. Gonçalves, C.A.F. Varandas, I.S. Bondarenko, S.M. Khrebtov, A.D. Komarov, A.L. Kozachok, and L.I. Krupnik
Review of Scientific Instruments, 74, (3), 1853, 2003

9 - *"Report on the 10th European Fusion Physics Workshop (Vaals, The Netherlands, 9-11 December 2002)"*
Campbell, D.J., D. Borba, J. Bucalossi, D. Moreau, O. Sauter, J. Stober and G. Vayakis
Plasma Physics and Controlled Fusion, 45**,** (6), 1051, 2003

10 - *"A low cost, real-time DSP-based diagnostic for the control of operation of a fusion experiment"*
Carvalho, B.B., H. Fernandes, and C.A.F. Varandas
Review of Scientific Instruments, 74, (3), 1799, 2003

11 - *"Transport properties in the TJ-II Flexible Heliac"*
Castejón, F., E. Ascasíbar, C. Alejaldre, J. Alonso, L. Almoguera, A. Baciero, R. Balbín, E. Blanco, M. Blaumoser, J. Botija, B. Brañas, A. Cappa, R. Carrasco, J. R. Cepero, A. A. Chmyga, J. Doncel, N. B. Dreval, S. Eguilior, L. Eliseev, T. Estrada, O. Fedyanin, A. Fernández, C. Fuentes, A. García, I. García-Cortés, B. Gonçalves, J. Guasp, J. Herranz, A. Hidalgo, C. Hidalgo, J. A. Jiménez, I. Kirpitchev, S. M. Khrebtov, A. D. Komarov, A. S. Kozachok, L. Krupnik, F. Lapayese, K. Likin, M. Liniers, D. López-Bruna, A. López-Fraguas, J. López-Rázola, A. López-Sánchez, E. de la Luna, A. Malaquias, R. Martín, M. Medrano, A. V. Melnikov, P. Méndez, K. J. McCarthy, F. Medina, B. van Milligen, I. S. Nedzelskiy, M. Ochando, L. Pacios, I. Pastor, M. A. Pedrosa, A. de la Peña, A. Petrov, A. Portas, J. Romero, L. Rodríguez-Rodrigo, A. Salas, E. Sánchez, J. Sánchez, K. Sarksian, S. Schchepetov, N. Skvortsova, F. Tabarés, D. Tafalla, V. Tribaldos, C. F. A. Varandas, J. Vega, and B. Zurro
AIP Conference Proceedings June 11, 669, 1, 162, 2003

12 - *"Ideal stability of an elliptical plasma column on the presence of external feedback currents"*
Coelho, R. and F. Porcelli
Phys. of Plasmas, 10, (4), 930, 2003

13 - *"An event-driven reconfigurable real-time processing system for the next generation fusion experiments"*
Combo, A., A.J.N. Batista, J. Sousa, and C.A.F. Varandas
Review of Scientific Instruments, 74, (3), 1815, 2003

14 - *Measurement of the plasma radial electric field by the motional Stark effect diagnostic on JET plasmas"*
Cortes, S. Reyes, N.C. Hawkes, P. Lotte, C. Fenzi, B.C. Stratton, J. Hobirk, R. De Angelis, F. Orsitto, C.A.F. Varandas, and Contributors to the EFDA-JET Work Program
Review of Scientific Instruments, 74, (3), 1596, 2003

15 - *"Role of the plasma shapping in ITB experiments on JET"*
Crisanti, F., P.L. Lomas, O. Tudisco, A. Bécoulet, M. Bécoulet, L. Bertalot, T. Bolzonella, G. Bracco, M. De Benedetti, B. Esposito, C. Giroud, N.C. Hawkes, T.C. Hender, O.N. Jarvis, E. Joffrin, D. Pacella, V. Riccardo, F. Rimini, K.D. Zastrow and contributers to the EFDA-JET Workprogramme
Plasma Physics and Controlled Fusion, 45**,** (4), 379, 2003.

16 - *"JET enhancements under EFDA"*
Damiani, C., EFDA-JET workprogramme
Fusion Engineering and Design, 66-68, 153, 2003

17 - *"Influence of the heating profile on impurity transport in ASDEX Upgrade"*
Dux, R., R. Neu, A.G. Peeters, G. Pereverzev, A. Mück, F. Ryter, J. Stober and ASDEX Upgrade Team
Plasma Physics and Controlled Fusion, 45**,** (9), 1815, 2003

18 - *"JET internal transport barriers: experiment vs theory"*
Esposito, B., F. Crisanti, V. Parail, P. Maget, Y. Baranov, A. Becoulet, C. Castaldo, C.D. Challis, R. De Angelis, X. Garbet, C. Giroud, N. Hawkes, E. Joffrin, X. Litaudon, D. Mazon, M. Riva, K.D. Zastrow and contributers to the EFDA JET Workprogramme
Plasma Physics and Controlled Fusion, 45**,** (6), 933, 2003

19 - *"On the use of the analytic signal to retrieve the phase from broadband reflectometry signals"*
Figueiredo, A.C.A., J.P. Bizarro
Review of Scientific Instruments, 74, (3), 1514, 2003

20 - *"Micro-stability and transport modeling of internal transport barriers on JET"*
Garbet, X., Y. Baranov, G. Bateman, S. Benkadda, P. Beyer, R. Budny, F. Crisanti, B. Esposito, C. Figarella, C. Fourment, P. Ghendrih, F. Imbeaux, E. Joffrin, J. Kinsey, A. Kritz, X. Litaudon, P. Maget, P. Mantica, D. Moreau, Y. Sarazin, A. Pankin, V. Parail, A. Peeters, T. Tala, G. Tardini, A. Thyagaraja, I. Voitsekhovitch, J. Weiland, R. Wolf and JET EFDA contributors
Nuclear Fusion, 43**,** (9), 975, 2003

21 - *High dispersion spectrometer for time resolved Doppler measurements of impurity lines emitted during ISTTOK tokamak discharges"*
Gomes, R.B., C.A.F. Varandas, J.A.C. Cabral, E. Sokolova, and S.R. Cortes
Review of Scientific Instruments, 74, (3), 2071, 2003

22 - *"Edge localized modes and fluctuations in the JET SOL region"*
Gonçalves, B., C. Hidalgo, M.A. Pedrosa, C. Silva, R. Balbin, K. Erents, M. Hron, A. Loarte and G. Matthews
Plasma Physics and Controlled Fusion, 45**,** (9), 1627, 2003

23 - *"Velocity fluctuations and time dependent E×B flows in the JET boundary region"*
Gonçalves, B., C. Hidalgo, M.A. Pedrosa, C. Silva, K. Erents, and G. Mathews
Review of Scientific Instruments, 74, (3), 1571, 2003

24 -*"Statistical properties of turbulence: a new approach to characterize transport in fusion plasmas"*
Gonçalves, B., C. Hidalgo, C. Silva, M.A. Pedrosa, K. Erents, M. Hron, A. Loarte, G. Matthews, R. Pitts,
Czech. J. Phys., 53 (10), 827-852, 2003

25 - *"ITER: burning plasma physics experiment"*
Green, B.J., ITER International Team and Participants Teams
Plasma Physics and Controlled Fusion, 45**,** (5), 687, 2003

26 - *"Tolerable ELMs in conventional and advanced scenarios at ASDEX Upgrade."*
Gruber, O., S. Günter, A. Herrmann, L.D. Horton, P.T. Lang, M. Maraschek, S. Saarelma, A.C.C. Sips, J. Stober, W. Suttrop, H. Zohm and ASDEX Upgrade Team
Proceedings of the 19th Fusion Energy Conference, (Ed.) M. Spak, IAEA, Vienna 2003, EX/C2-1

27 - *"Neoclassical tearing modes on ASDEX Upgrade: improved scaling laws, high confinement at high β_N and new stabilization experiments"*
Günter, S., G. Gantenbein, A. Gude, V. Igochine, M. Maraschek, A. Mück, S. Saarelma, O. Sauter, A.C.C. Sips, H. Zohm and the ASDEX Upgrade Team
Nuclear Fusion, 43**,** (3), 161, 2003

28 -*"Optimization of the FM-CM reflectometry W-band antenna for core density profile measurements on ASDEX Upgrade"*
Hacquin, S., D. Wagner, M. Manso, J. Borreicho, and L. Farinha
Review of Scientific Instruments, 74, (3), 1485, 2003

29 - *"Radial wave number spectrum of density fluctuations deduced from reflectometry phase signals"*
Heuraux, S., S. Hacquin, F. Da Silva, F. Clairet, R. Sabot, and G. Leclert
Review of Scientific Instruments, 74, (3), 1501, 2003

30 - *"Experimental investigation of dynamical coupling between turbulent transport and parallel flows in the JET plasma boundary region"*
Hidalgo, C., B. Gonçalves, C. Silva, M. A. Pedrosa, K. Erents, M. Hron, and G. F. Matthews
Physical Review Letters, 91, 6, 065001, 2003

31 - *"Experimental evidence of fluctuations and flows near marginal stability and dynamical interplay between gradients and transport in the JET plasma boundary region"*
Hidalgo, C., B. Gonçalves, M.A. Pedrosa, C. Silva, R. Balbín, M. Hron, A. Loarte, K. Erents, G. F. Matthews, R. Pitts
Journal Nucl. Mater, 316, 863, 2003

32 - *"Internal transport barrier triggering by rational magnetic flux surfaces in tokamaks"*
Joffrin, E., C.D. Challis, G.D. Conway, X. Garbet, A. Gude, S. Günter, N.C. Hawkes, T.C. Hender, D.F. Howell, G.T.A. Huysmans, E. Lazzaro, P. Maget, M. Marachek, A.G. Peeters, S.D. Pinches, S.E. Sharapov and JET-EFDA contributors
Nuclear Fusion, 43, (10) 1167, 2003

33 - *"Integrated scenario in JET using real-time profile control"*
Joffrin, E., F. Crisanti, R. Felton, X. Litaudon, D. Mazon, D. Moreau, L. Zabeo, R. Albanese, M. Ariola, D. Alves, O. Barana, V. Basiuk, A. Bécoulet, M. Bécoulet, J. Blum, T. Bolzonnella, K. Bosak, J.M. Chareau, M. de Baar, E de la Luna, P. de Vries, P. Dumortier, D. Elbeze, J. Farthing, H. Fernandes, C. Fenzi, R. Giannella, K. Guenther, J. Harling, N. Hawkes, D.F. Howell, P. Heesterman, F. Imbeaux, P. Innocente, L. Laborde, G. Lloyd, P.J. Lomas, D.C. McDonald, J. Mailloux, M. Mantsinen, A. Messiaen, A. Murari, J. Ongena, F. Orsitto, V. Pericoli-Ridolfini, M. Riva, J. Sanchez, F. Sartori, O. Sauter, A.C.C. Sips, T. Tala, A. Tuccillo, D. Van Ester, K-D. Zastrow and M. Zerbini
Plasma Physics and Controlled Fusion, 45**,** (12A), A367, 2003

34 - *"Edge transport and its interconnection with main chamber recycling in ASDEX Upgrade"*
Kallenbach, A., R. Dux, J. Gafert, G. Haas, L.D. Horton, M. Jakobi, B. Kurzan, H.W. Müller, R. Neu, J. Neuhauser, R. Pugno, T. Pütterich, V. Rohde, W. Sandmann, S.-W Yoon and the ASDEX Upgrade Team.
Nuclear Fusion, 43**,** (7), 573, 2003

35 - *"Hydrocarbon transport in the MkIIa divertor of JET"*
Kirschner, A., J.N. Brooks, V. Philipps, J.P. Coad and contributers to the EFDA-JET Workprogramme
Plasma Physics and Controlled Fusion, 45**,** (3), 309, 2003

36 - *"ELM frequency control by continuos small pellet injection in ASDEX Upgrade"*
Lang, P.T., J. Neuhauser, L.D. Horton, T. Eich, L. Fattorini, J.C. Fuchs, O. Gehre, A. Herrmann, P. Ignácz, M. Jakobi, S. Kálvin, M. Kaufmann, G. Kocsis, B. Kurzan, C. Maggi, M.E. Manso, M. Maraschek, V. Mertens, A. Mück, H.D. Murmann, R. Neu, I. Nunes, D. Reich, M. Reich, S.Saarelma, W. Sandmann, J. Strober, U. Vogl and the ASDEX Upgrade Team.
Nuclear Fusion, 43, 1110, 2003

37 - *"Progress towards steady-state operation and real-time control of internal transport barriers in JET"*
Litaudon, X., A. Bécoulet, F. Crisanti, R.C. Wolf, Yu. F. Baranov, E. Barbato, M. Bécoulet, R. Budny, C. Castaldo, R. Cesario, C.D. Challis, G.D. Conway, M.R. De Baar, P. De Vries, R. Dux, L.G. Eriksson, B. Esposito, R. Felton, C. Fourment, D. Frigione, X. Garbet, R. Giannella, C. Giroud, G. Gorini, N.C. Hawkes, T. Hellsten, T.C. Hender, P. Hennequin, G.M.D. Hogeweij, G.T.A. Huysmans, F. Imbeaux, E. Joffrin, P.J. Lomas, Ph. Lotte, P. Maget, J. Mailloux, P. Mantica, M.J. Mantsinen, D. Mazon, D. Moreau, V. Parail, V. Pericoli, E. Rachlew, M. Riva, F. Rimini, Y. Sarazin, B.C. Stratton, T.J.J. Tala, G. Tresset, O. Tudisco, L. Zabeo, K.-D. Zastrow and JET-EFDA contributers.
Nuclear Fusion, 43**,** (7), 565, 2003

38 - *"Integrated predictive modeling of the effect of neutral gas puffing in ELMy H-mode plasmas"*
Lonnroth, J-S, V.V. Parail, G. Corrigan, D. Heading, G. Huysmans, A. Loarte, S. Saarelma, G. Saibene, S. Sharapov, J. Spence, and contributers to the EFDA-JET Workprogramme
Plasma Physics and Controlled Fusion, 45**,** (9), 1689, 2003

39 - *"Impurity-seeded plasma experiments on JET"*
Maddison, G.P., M. Brix, R. Budny, M. Charlet, I. Coffey, J.G. Cordey, P. Dumortier, S.K. Erents, N.C. Hawkes, M. von Hellermann, D.L. Hillis, J. Hogan, L.D. Horton, L.C. Ingesson, S. Jachmich, G.L. Jackson, A. Kallenbach, H.R. Koslowski, K.D. Lawson, A. Loarte, G.F. Matthews, D. McDonald, G.R. McKee, A. Meigs, A.M. Messiaen, F. Milani, P. Monier-Garbet, M. Murakami, M.F.F. Nave, J. Ongena, M.E. Puiatti, E. Rachlew, J. Rapp, S. Sharapov, G.M. Staebler, M. Stamp, J.D. Strachan, W. Suttrop, G. Telesca, M.Z. Tokar, B. Unterberg, M. Valisa, K.-D. Zastrow and EFDA-JET 2000 workprogramme contributors.
Nuclear Fusion, 43**,** 49, 2003

40 - *"Improved ELM scalling with impurity seeding in JET"*
Maddison, G.P., R.V. Budny, P. Dumortier, S. Jachmich, A. Loarte, A.M. Messiaen, P. Monier-Garbet, M.F.F. Nave, J. Ongena, J. Rapp, J.D.Strachan and JET EFDA contributors
Plasma Physics and Controlled Fusion, 45**,** (9), 1657, 2003

41 - *"Real-time signal analysis on the TCV PHA diagnostic"*
Madeira, T.I., A.P. Rodrigues, C.A.F. Varandas, P. Amorim, and B.P. Duval
Review of Scientific Instruments, 74, (3), 2004, 2003

42 - *"Statistical analysis of internal transport barriers in JET"*
Maget, P., B. Esposito, E. Joffrin, N. Hawkes, D. Mazon, Y. Baranov, C. Fourment, G.T. Hoang and contributers to the JET-EFDA Workprogramme.
Plasma Physics and Controlled Fusion, 45**,** (8), 1385, 2003

43 - *"Comparative study design of a heavy ion and neutral beam diagnostic for the International Tokamak Experiment Reactor"*
Malaquias, A., I. Nedzelsky, B. Gonçalves, C.A.F. Varandas, J.A.C. Cabral, A. Melnikov, L. Eliseev, S. Perfilov, O. Yudina, and L. Krupnik
Review of Scientific Instruments, 74, (3), 1857, 2003

44 - *"Signal processing techniques based on singular value decomposition applied to modulated ECH experiments"*
Manini, A., J.-Moret, F. Ryter and the ASDEX Upgrade Team
Nuclear Fusion, 43**,** (6), 490, 2003

45 - *"Scaling of the marginal β_p of neoclassical tearing modes during power ramp-down experiments in ASDEX Upgrade"*
Maraschek, M., O. Sauter, S. Günter, H. Zohm and ASDEX Upgrade Team
Plasma Physics and Controlled Fusion, 45, 1369, 2003

46 - *"Accessibility and properties of ELMy H-mode and ITB plasmas in TCV"*
Martin, Y.R., M.A. Henderson, S. Alberti, P. Amorim, Y. Andrebe, K. Appert, G. Arnoux, R. Behn, P. Blanchard, P. Bosshard, A. Bottino, Y. Camenen, R. Chavan, S. Coda, I. Condrea, A.W. Degeling, V.N. Dokouka, B.P. Duval, D. Fasel, A. Fasoli, J-Y Favez, S. Ferrando, T.P. Goodman, J-P Hogge, J. Horacek, P. Isoz, B. Joye, A. Karpushov, R.R. Khayrutdonov, I. Klimanov, J.B. Lister, X. Llobet, V.E. Lukash, T. Madeira, B. Marletaz, P. Marmillod, A.A. Martynov, S. Yu Medvedev, J-M Moret, E. Nelson-Melby, P. Nikkola, P.J. Paris, A. Perez, R.A. Pitts, A. Pochelon, L. Porte, O. Sauter, A. Scarabosio, E. Scavino, S-H Seo, U. Siravo, G. Tonetti, M.Q. Tran, L. Villard, H. Weisen, M. Wischmeier, A. Zabolotsky and G. Zhuang.
Plasma Physics and Controlled Fusion, 45**,** (12A), A351, 2003

47 - *"Steady-state and transient power handling in JET"*
Matthews, G.F., P. Andrew, T. Eich, W. Fundamenski, A. Herrmann, A. Loarte, V. Riccardo and JET EFDA contributers.
Nuclear Fusion, 43**,** (9), 999, 2003

48 - *"Active control of the current density profile in JET"*
Mazon, D., X. Litaudon, D. Moreau, V. Pericoli-Ridolfini, L. Zabeo, F. Crisanti, P De Vries, R. Felton, E. Joffrin, A. Murari, M. Riva, G. Tresset, K.D. Zastrow and contributers to the EFDA-JET Workprogramme.
Plasma Physics and Controlled Fusion, L47, 2003

49 - *"Development of active control systems on ASDEX Upgrade in view of ITER discharge scenarios"*
Mertens, V., J. Hobirk, A. Kallenbach, P. Lang, A. Mück, G. Pautasso, G. Raupp, A. Sips, J. Stober, H. Zohm, ASDEX Upgrade Team
Fusion Engineering and Design, 66-68, 119, 2003

50 - *"Real-time control of the q-profile in JET for steady state advanced tokamak operation"*
Moreau, D., F. Crisanti, X. Litaudon, D. Mazon, P. De Vries, R. Felton, E. Joffrin, L. Laborde, M. Lennholm, A. Murari, V. Pericoli-Ridolfini, M. Riva,T. Tala, G. Tresset, L. Zabeo, K.D. Zastrow and contributers to the EFDA-JET Workprogramme
Nuclear Fusion, 43**,** (9), 870, 2003

51 - *"Triggering of neo-classical tearing modes by mode coupling"*
Nave, M.F.F., E. Lazzaro, R. Coelho, P. Belo, D. Borba, R.J. Buttery, S. Nowak, F. Serra and EFDA-JET Contributers.
Nuclear Fusion, 43**,** (3), 179, 2003

52 - *"Role of sawtooth in avoiding impurity accumulation and maintaining good confinement in JET radiative mantle discharges"*
Nave, M.F.F., J. Rapp, T. Bolzonella, R. Dux, M.J. Mantsinen, R. Budny, P. Dumortier, M. von Hellermann, S. Jachmich, H.R. Koslowski, G. Maddison, A. Messiaen, P. Monier-Garbet, J. Ongena, M.E. Puiatti, J. Strachan, G. Telesca, B. Unterberg, M. Valisa and P. de Vries
Nuclear Fusion, 43**,** (10), 1204, 2003

53 - *"Evaluation of the incident angle of the beam into 30º electrostatic energy analyzer directly during HIBP operation in plasma experiments"*
Nedzelskiy, I.S., A. Malaquias, B. Gonçalves, C.A.F. Varandas, J.A.C. Cabral, N.B. Dreval, S.M. Khrebtov, A.D. Komarov, A.L. Kozachok and L.I. Krupnik
Review of Scientific Instruments, 74, (3), 1850, 2003

54 - *"Heating, current drive and energetic particle studies on JET in preparation of ITER operation"*
Noterdaeme, J.-M., R. Budny, A. Cardinali, C. Castaldo, R. Cesario, F. Crisanti, J. De Grassie, D.A.D'Ippolito, F. Durodié, A. Ekedahl, A. Figueiredo, C. Ingesson, E. Joffrin, D. Hartmann, J. Heikkinen, T. Hellsten, T. Jones, V. Kiptily, Ph. Lamalle, X. Litaudon, F. Nguyen, J. Mailloux, M. Mantsinen, M. Mayoral, D. Mazon, F. Meo, I. Monakhon, J.R. Myra, J. Paméla, V. Pericoli, Yu. Petrov, O. Sauter, Y. Sarazin, S.E. Sharapov, A.A. Tuccillo, D. Van Eester and JET EFDA Contributers.
Nuclear Fusion, 43**,** (3), 202, 2003

55 - *"Spatially resolved toroidal plasma rotation with ICRF on JET"*
Noterdaeme, J.-M., E. Righi, V. Chan, J. de Grassie, K. Kirov, M. Mantsinen, M.F.F. Nave, D. Testa, K.-D. Zastrow, R. Budny, R. Cesario, A. Gondhalekar, N. Hawkes, T. Hellsten, Ph. Lamalle, F. Meo, F. Nguyen, and EFDA-JET-EFDA contributers
Nuclear Fusion, 43**,** (4), 274, 2003

56 - *"Emissivity toroidal asymmetries induced by ECRH driven convective fluxes in the TJ-II stellarator"*
Ochando, M.A., F. Medina and the TJ-II Team
Plasma Physics and Controlled Fusion, 45**,** (3), 221, 2003

57 - *"Turbulent transport reduction by E×B velocity shear during edge plasma biasing: recent experimental results"*
Oost, G. Van, J Adámek, V. Antoni, P. Balan, J.A. Boedo, P. Devynck, I. Duran, L. Eliseev, J.P. Gunn, M. Hron, C. Ionita, S. Jachmich, G.S. Kirnev, E. Martines, A. Melnikov, R. Schrittwieser, C. Silva, J. Stöckel, M. Tendler, C. Varandas, M. Van Schoor, V. Vershkov and R.R. Weynants
Plasma Physics and Controlled Fusion, 45**,** (5), 621, 2003

58 - *"Overview of JET results"*
Paméla, J., Emília R. Solano and JET EFDA Contributors
Nuclear Fusion, 43, (12) 1540, 2003

59 - *"Overview of JET results, near term plans"*
Paméla, J., J. Rapp, JET EFDA contributers
Fusion Engineering and Design, 66-68, 25, 2003

60 - *"Electron temperature determination and subsequent analysis of short time-scale variation of plasma parameters in ISTTOK discharges"*
Plyusnin, V.V., J.A.C. Cabral, H. Figueiredo, and C.A.F. Varandas
Review of Scientific Instruments, 74, (3), 1807, 2003

61 - *"Runaway effects at the plasma boundary in ISTTOK"*
Plyusnin, V.V., J.A.C. Cabral, H. Figueiredo, C.A.F. Varandas
Journal of Nuclear Materials, 313-316, 1052, 2003

62 - *"Simulation of the time behaviour of impurities in JET Ar-seeded discharges and its relation with sawtoothing and RF heating"*
Puiatti, M.E., M Valisa, M Mattioli, T Bolzonella, A Bortolon, I Coffey, R Dux, M von Hellermann, P Monier-Garbet, M F F Nave, J Ongena and contributors to the EFDA-JET Workprogramme
Plasma Physics and Controlled Fusion, 45, (12) 2011, 2003

63 - *"Disruptions and disruption mitigation"*
Riccardo, V. and JET EFDA contributors
Plasma Physics and Controlled Fusion, 45, (12A), A269, 2003

64 - *"Controlling confinement with induced toroidal current in the flexible Heliac TJ-II"*
Romero, J.A., D. López-Bruna, A. López-Fraguas, E. Ascasibar and the TJ-II Team
Nuclear Fusion, 43**,** (6), 387, 2003

65 - *"Electron heat transport in ASDEX Upgrade: Experiment and modelling"*
Ryter, F., G. Tardini, F. de Luca, H.-U. Fahrbach, F. Imbeaux, A Jacchia, K. Kirov, F. Leuterer, P. Mantica, A.G. Peeters, G. Pereverzev, W. Suttrop and ASDEX Upgrade Team
Nuclear Fusion, 43**,** 1396, 2003

66 - *"MHD stability analysis of type II ELMs in ASDEX Upgrade"*
Saarelma, S., S. Günter, L.D. Horton, and ASDEX Upgrade Team
Nuclear Fusion, 43**,** (4), 262, 2003

67 - *"Plasma position measurements from ordinary FM-CM reflectometry on ASDEX Upgrade"*
Santos, J., M. Manso, P. Varela, J. Neuhauser, and ASDEX Upgrade Team
Review of Scientific Instruments, 74, (3), 1489, 2003

68 - *"Simulation of amplitude and phase variations induced by magnetic islands with turbulence on reflectometry signals"*
Silva, F. da, S. Heuraux, S. Hacquin, and M. Manso
Review of Scientific Instruments, 74, (3), 1497, 2003

69 - *"Limiter Biasing Experiments on the Tokamak ISTTOK"*
Silva, C., I. Nedzelskiy, H. Figueiredo, J.A.C. Cabral, C.A.F. Varandas, J. Stockel
Czech. J. Phys., 53, 937, 2003

70 - *"Dependence of particle transport on heating profiles in ASDEX Upgrade"*
Stober, J., R. Dux, O. Gruber, L.D. Horton, P.T. Lang, R. Lorenzini, C. Maggi, F. Meo, R. Neu, J.-M. Noterdaeme, A.G. Peeters, G.V. Pereverzev, F. Ryter, A.C.C. Sips, A. Stäbler, H. Zohm and ASDEX Upgrade Team
Nuclear Fusion 43, 1265, 2003

71 - *"JET carbon screening experiments using methane gas puffing and its relation to intrinsic carbon impurities"*
Strachan, J.D., W. Fundamenski, M. Charlet, G. Corrigan, K. Erents, J. Gafert, C. Giroud, C. Gowers, M. von Hellermann, L.D. Horton, G.F. Matthews, G. McCracken, V. Philipps, J. Spence, M.F. Stamp, K.-D Zastrow and contributers to the EFDA-JET Workprogramme
Nuclear Fusion, 43**,** (9), 922, 2003

72 - *"Spectroscopic Diagnostics for ITER"*
Sugie, T., A. Costley, A. Malaquias, C. Walker
Journal of Plasma and Fusion Research, 79, 10, 1051, 2003

73 - *"ELM-free stationary H-mode plasmas in the ASDEX Upgrade tokamak"*
Suttrop, W., M. Maraschek, G.D. Conway, H-U Fahrbach, G. Haas, L.D. Horton, T. Kurki-Suonio, C.J. Lasnier, A.W. Leonard, C.F. Maggi, H. Meister, A. Mück, R. Neu, I. Nunes, Th Pütterich, M. Reich, A.C.C. Sips and the ASDEX Upgrade Team.
Plasma Physics and Controlled Fusion, 45**,** (8), 1399, 2003

74 - *"Experimental test of damping models for n=1 toroidal Alfvén eigenmodes in JET"*
Testa, D., G.Y. Fu, A. Jaun, A. Fasoli, O. Sauter and JET-EFDA contributers
Nuclear Fusion, 43**,** (6), 479, 2003

75 - *"Measurement of the damping rate of the n=1 toroidal Alfven eigenmodes as a function of the neutral beam heating power and plasma (beta) on JET"*
Testa, D., A Fasoli, Jaun A, JET-EFDA Contributors
Nuclear Fusion, 43, (8), 724, 2003

76 - *"The new ASDEX upgrade real-time control and data acquisition system"*
Treutterer, W., K. Behler, R. Cole, J. Hobirk, M. Jakobi, A. Lohs, K. Lüddecke, G. Neu, G. Raupp, W. Suttrop, D. Zasche, T. Zehetbauer, M. Zilker, ASDEX Upgrade Team
Fusion Engineering and Design, 66-68, 755, 2003

77 - *"Conceptual design of the charge exchange recombination spectroscopy diagnostic for ITER"*
Tugarinov, S., A. Krasilnikov, V. Dokouka, R. Khayrutdinov, I. Beigman, I. Tolstikhina, L. Vainshtein, M. von Hellermann, and A. Malaquias
Review of Scientific Instruments, 74, (3), 2075, 2003

78 - *"Energy and particle losses during type-I ELMy H-mode in ASDEX Upgrade"*
Urano, H., W. Suttrop, L.D. Horton, A. Herrmann, J.C. Fuchs and ASDEX Upgrade Team
Plasma Physics and Controlled Fusion, 45**,** (9), 1571, 2003

79 -*"High resolution edge density measurements in ASDEX Upgrade H-mode discharges with broadband reflectometry"*
Varela, P., M.E.Manso, G.D. Conway, W. Suttrop, H. Zohm, and ASDEX Upgrade Team
Review of Scientific Instruments, 74, (3), 1493, 2003

80 - *"Magnetic Diagnostics for ITER / BPX Plasmas"*
Vayakis, G., C. Walker and the ITER International Team and Participant Teams ITER International Team
Rev. Sci. Instrum.. 74, 4, 2409, 2003

81 - *"Neutral point detection in JET"*
Villone, F., V. Ricardo, R. Albanese, F. Sartori, A. Cenedese, Contributors to the EFDA-JET Workpro-gramme
Fusion Engineering and Design, 66-68, 709, 2003

82 - *"Overview of ASDEX Upgrade results"*
Zohm, H., C. Angioni, R. Arslanbekov, C. Atanasiu, G. Becker, W. Becker, K. Behringer, A. Bergmann, R. Bilato, V. Bobkov, D. Bolshukhin, T. Bolzonella, K. Borrass, M. Brambilla, F. Braun, A. Buhler, A. Carlson, G.D. Conway, D.P. Coster, R. Drube, R. Dux, S. Egorov, T. Eich, K. Engelhardt, H.-U. Fahrbach, U. Fantz, H. Faugel, K.H. Finken, M. Foley, P. Franzen, J.C. Fuchs, J. Gafert, K.B. Fournier, G. Gantenbein, O. Gehre, A. Geier, J. Gernhardt, T. Goodman, O. Gruber, A. Gude, S. Günter, G. Haas, D. Hartmann, B. Heger, B. Heinemann, A. Herrmann, J. Hobirk, F. Hofmeister, H. Hohenöcker, L.D. Horton, V. Igochine, A. Jacchia, M. Jakobi, F. Jenko, A. Kallenbach, O. Kardaun, M. Kaufmann, A. Keller, A. Kendl, J.-W. Kim, K. Kirov, R. Kochergov, H. Kollotzek, W. Kraus, K. Kriger, T. Kurki-Suonio, B. Kurzan, P.T. Lang, C. Lasnier, P. Lauber, M. Laux, A.W. Leonard, F. Leuterer, A. Lohs, A. Lorentz, R. Lorenzini, C. Maggi, H. Maier, K. Mank, M.E. Manso, P. Mantica, M. Maraschek, E. Martines, K.F. Mast, P. McCarthy, D. Meisel, H. Meister, F. Meo, P. Merkel, R. Merkel, D. Merkl, V. Mertens, F. Monaco, A. Mück, H.W. Müller, M. Münich, H. Murmann, Y.S. Na, G. Neu, R. Neu, J. Neuhauser, F. Nguyen, D. Nishimura, J. –M. Noterdaeme, I. Nunes, G. Pautasso, A.G. Peeters, G. Pereverzev, S.D. Pinches, E. Poli, M. Proschek, R. Pugno, E. Quigley, G. Raupp, M. Reich, T. Ribeiro, R. Riedl, V. Rohde, J. Roth, F. Ryter, S. Saarelma, W. Sandmann, A. Savtchkov, O. Sauter, S. Schade, H.-B. Schilling, W. Schneider, G. Schramm, E. Schwarz, J. Schweinzer, B.D. Scott, U. Seidel, F. Serra, S. Sesnic, C. Sihler, A. Silva, A.C.C. Sips, E. Speth, A. Stäbler, K.-H. Steuer, J. Stober, B. Streibl, E. Strumberger, W. Suttrop, A. Tabasso, A. Tanga, G. Tardini, C. Tichmann, W. Treutterer, M. Troppmann, H. Urano, P. Varela, O. Vollmer, D. Wagner, U. Wenzel, F. Wesner, E. Westerhof, R. Wolf, E. Wolfrum, E. Würsching, S.-W. Yoon, Q. Yu, D. Zasche, T. Zehetbauer and H.-P. Zehrfeld.
Nuclear Fusion, 43**,** (12), 1570, 2003

83 - *"Characterization of ion heat conduction in JET and ASDEX Upgrade plasmas with and without internal transport barriers"*
Wolf, R.C., Y. Baranov, X. Garbet, N. Hawkes, A.G. Peeters, C. Challis, M. de Baar, C. Giroud, E. Joffrin, M. Mantsinen, D. Mazon, H. Meister, W. Suttrop, K-D Zastrow and the ASDEX Upgrade team and contributers to the EFDA-JET Workprogramme
Plasma Physics and Controlled Fusion, 45**,** (9), 1757, 2003

4.4.3. Papers in international conferences

- **6th International Reflectometry Workshop, May 5-7, 2003, San Diego, USA**

1 - *"2D reflectometry simulation as a tool for evaluating data processing capabilities"*
Silva, F. da, S. Heuraux, P. Varela and M. Manso.

- **15th Top. Conf. on RF Power in Plasmas, May 19-21, 2003, Grand Teton National Park, Moran, Wyoming, USA**

2 - *"Recent ^{3}He Radio Frequency Heating Experiments On JET"*
Eester, D. Van, F. Imbeaux, P. Mantica, M. Mantsinen, M. de Baar, P. de Vries, L.-G. Eriksson, R. Felton, A. Figueiredo, J.Harling, E. Joffrin, K. Lawson, H. Leggate, X. Litaudon, V. Kiptily, J.-M. Noterdaeme, V. Pericoli, E. Rachlew, A. Tuccillo, K.-D. Zastrow & JET-EFDA contributors

- **17th International Conference on Technologies and Combustion for a Clean Environment, Julho de 2003, Portugal**

3 - *Fusion: a Safe, Clean and Sustainable Energy for the Future*
Varandas, C.A.F.

- **30th EPS Conference on Plasma Physics and Controlled Fusion, 7-11 July 2003, St. Petersburg, Rússia**

4 - "*The Fibber Optic Multiplexed Thomson Scattering Diagnostic for the ETE Tokamak"*
Alonso, M. P., L. A. Berni e E. D. Bosco

5 - "*Design Study for X-ray and VUV Spectroscopy on ITER"*
Barnsley, R., L.C. Ingesson, A. Malaquias, M. O'Mullane and Contributors to the EFDA-JET Work Program

6 - "*Destabilisation of TAE modes using ICRH in ASDEX Upgrade"*
Borba, D., G.D.Conway, S. Günter, G.T.A.Huysmans, S. Klose, M. Maraschek, A. Mück, I. Nunes, S. D. Pinches, F. Serra and the ASDEX Upgrade Team

7 - "*Non-linear model for the plasma column macroscopic oscillations in the tokamak ISTTOK"*
Borba, D., B. Carvalho, C. Silva, H. Figueiredo, H. Fernandes, C.A.F. Varandas

8 - "*Radial electric fields and confinement in the TJ-II Stellarator"*
Chmyga, A.A., N.B. Dreval, S.M. Khrebtov, A.D. Komarov, A.S. Kozachok, L.I. Krupnik, L. Eliseev, A.V. Melnikov, B. Gonçalves, I.S. Nedzelskiy, C.A.F. Varandas, T. Estrada, C. Hidalgo, J. López, E. de la Luna, B. van Milligen, M.A. Pedrosa, E. Sánchez e V. Tribaldos

9 - "*Bifurcation of generic metastable tearing modes interacting with resonant magnetic fields"*
Coelho, R., and E. Lazzaro

10 - *"Ideal stability of an elliptical plasma column in the presence of external feedback currents"*
Coelho, R. and F. Porcelli

11 - *"Long pulse operation in ITER: issues for diagnostics"*
Costley, A.E., K. Itami, T. Kondoh, A. Malaquias, T. Sugie, G.Vayakis e C. I. Walker

12 - *"Effects of Mgnetic Field Perturbations on the Reconstruction of Density Profiles from X-mode and Combined O/X-Modes Reflectometry"*
Fattorini, L. and M.E. Manso

13 - *"Lower Hybrid Ray-tracing Calculations on Toroidal Plasmas with Magnetic Ripple: Nonlinear Oscillations and Spectral Gap"*
Ferreira, J.S. and J.P.S. Bizarro

14 - *"Time–Frequency Analysis of Non-Stationary Signals in Fusion Plasmas Using the Choi-Williams Distribution"*
Figueiredo, A.C.A., M.F.F. Nave and Contributors to the EFDA-JET Work Program

15 - *"On the probability density function of the radial structure of turbulence in fusion plasmas"*
Gonçalves, B., C. Hidalgo, C. Silva, M.A. Pedrosa, K. Erents e G. Matthews

16 - *"Effect of the Poloidal Rotation of the Turbulence in Reflectometry Measurements"*
Hacquin, S., S. Heuraux, F. Silva, G. Leclert and M. Manso

17 - *"Active Beam Spectroscopy for ITER"*
Hellermann, M. von, C. Giroud, R. Jaspers, A. Krasilnikov, P. Lotte, G. McKee, A. Malaquias, M. O'Mullane, S. Tugarinov e K-D. Zastrow

18 - *"Effects of the density fluctuation characteristics on the phase fluctuation spectrum obtained from a reflectometer"*
Heuraux, S., L. Vermare, F. da Silva, G. Leclert, F. Clairet, S. Hacquin, R. Sabot.

19 - *"Experimental investigation of dynamical coupling between turbulent transport and parallel flows in the JET plasma boundary region"*
Hidalgo, C., B. Gonçalves, C. Silva, M.A. Pedrosa, K. Erents, M. Hron e G. F. Matthews

20 - *"Improved confinement regimes induced by limiter biasing in the TJ-II Stellarator"*
Hidalgo, C., M.A. Pedrosa, N. Dreval, L. Eliseev), K. J. McCarthy, M.A. Ochando, T. Estrada, I. Pastor, E. Ascasíbar, C. Alejaldre, J. Alonso, L. Almoguera, F. de Aragón, A. Baciero, R. Balbín, E. Blanco, B. Brañas, E. Calderón, A. Cappa, R. Carrasco, F. Castejón, A.A. Chmyga, J. Encabo, S. Eguilior, A. Fernández, J. de la Gama, A. García, B. Gonçalves, J. Herranz, A. Hidalgo, J. A. Jiménez, I. Kirpitchev, S.M. Khrebtov, A.D. Komarov, A.S. Kozachok, L. Krupnik, F. Lapayese, D. López-Bruna, A. López-Fraguas, J. López-Rázola, A López-Sánchez, E. de la Luna, A.V.Melnikov, P. Méndez, F. Medina, B. van Milligen, L. Pacios, A. de la Peña, A. Portas, E. Sánchez, J. Sánchez, C. Silva, F. Tabarés, D. Tafalla, V. Tribaldos and J. Vega

21 - *"Assessment of the derivation of the plasma rotation and ion temperature profiles from an ITER X-ray crystal spectrometer"*
Ingesson, L.C., R. Barnsley e A. Malaquias

22 - *Toroidal interferometer/polarimeter density measurement system for long pulse operation on ITER"*
Kondoh, T., Y. Kawano, A. Costley, A. Malaquias, T. Sugie e C. Walker

23 - *"Active edge localized mode (ELM) frequency control with pellets"*
Lang, P.T., A. Kallenbach, L. Fattorini, L.D. Horton, J. Neuhauser, H. Urano and ASDEX Upgrade Team

24 - *"Modification of EXB shear near rational surfaces in response to magnetic driven reconnection due to mode coupling or external fields"*
Lazzaro, E., E. Joffrin, P. Zanca, R.Coelho, G. Gervasini, P. Mantica, A.I.Smolyakov, M.C. Varischetti, and the EFDA JET contributors

25 - *"Polarization and reflectivity changes on mirror based viewing systems during long pulse operation"*
Malaquias, A., M. von Hellermann, P. Lotte, S.Tugarinov and V.S.Voitsenya

26 - "*Update on integration of vacuum coupled, spectroscopic and microwave diagnostics in ITER"*
Malaquias, A., C. Walker, A. Costley, T. Kondoh, T. Sugie and G. Vayakis

27 - "*Recent developments on diagnostic integration in ITER"*
Malaquias, A., C. Walker, A. Costley, T. Kondoh, T. Sugie and G. Vayakis

28 - *"Accessibility and Properties of ELMy H-mode and ITB Plasmas in TCV"*
Martin, Y.R., S.Alberti, P.Amorim, Y.Andrebe, K.Appert, G.Arnoux, R.Behn, P.Blanchard, P.Bosshard, A.Bottino, Y.Camenen, R.Chavan, S.Coda, I.Condrea, A.W.Degeling, B.P.Duval, D.Fasel, A.Fasoli, J.-Y.Favez, S.Ferrando, T.P.Goodman, M.A.Henderson, J.-P.Hogge, J.Horacek, P.Isoz, B.Joye, A.Karpushov, I.Klimanov, J.B.Lister, X.Llobet, T.Madeira, B.Marletaz, P.Marmillod, A.Martynov, J.-M.Moret, E.Nelson-Melby, P.Nikkola, P.J.Paris, A.Perez, R.A.Pitts, A.Pochelon, L.Porte, O.Sauter, A.Scarabosio, E.Scavino, S.-H.Seo, U.Siravo, G.Tonetti, M.Q.Tran, L.Villard, H.Weisen, M.Wischmeier, A.Zabolotsky e G.Zhuan.

29 - *"Study of ELM density crash in ASDEX Upgrade"*
Nunes, I., G.D. Conway, A. Loarte, M. Manso, G. Saibene, R. Sartori, F. Serra, W. Suttrop, and the CFN and ASDEX Upgrade Teams

30 - "*Runaway Electrons in JET Disruptions"*
Plyusnin, V.V., V. Riccardo, R. Jaspers, M.F. Johnson, V.G. Kiptily, F. Salzedas, T. C. Hender, E. de La Luna and Contributors to the EFDA-JET Work Program

31 - "*Flux surface geometry for turbulence computation on open field lines"*
Ribeiro, T., B. Scott, D. Coster e F. Serra

32 - *"Noniterative Magnetic Equilibrium Reconstruction in Axisymmetric, Large-Aspect-Ratio, Low-Beta Tokamak Plasmas"*
Rodrigues, P. and J. P. S. Bizarro

33 - *"Behavior of Density Fluctuations and Electron Temperature Profiles in JET Density Limit Disruptions"*
Salzedas, F., L. Meneses, E. de La Luna, V. Plyusnin, V. Riccardo, R. Jaspers, T. C. Hender, F. Serra and Contributors to the EFDA-JET Work Program

34 - "*Biasing Experiments on the Tokamak ISTTOK"*
Silva, C., H. Figueiredo, I. Nedzelsky, J.A.C. Cabral e C.A.F. Varandas

35 - "*Spectroscopic Measurement System for ITER Divertor Plasma: Divertor Impurity Monitor"*
Sugie, T., A. Costley, A. Malaquias, A. Medvedeve e C. Walker

36 - "*ELM-free stationary H-mode plasmas in ASDEX UPGRADE"*
Suttrop, W., M. Maraschek, G. D. Conway, H.-U. Fahrbach, L. Fattorini, G. Haas, L. D. Horton, S. Klose, T. Kurki-Suoniob, C. F. Maggi, P. J. McCarthyc, H. Meister, A. Mück, R. Neu, I. Nunes, Th. Pütterich, M. Reich, A. C. C. Sips and ASDEX Upgrade Team

37 - "*ITER Generic Diagnostic Components and Systems for Integration"*
Walker, C.I., A.Costley, K. Itami, T.Kondoh, A.Malaquias, T.Sugie and G.Vayakis

- **Workshop on the Electric Fields, Structures and Relaxation in Edge Plasmas, St. Petersburg, Russia, July 13–14, 2003**

38 - *"Statistical properties of turbulence: a new approach to characterize transport in fusion plasmas"*
Gonçalves, B., C. Hidalgo, C. Silva, M.A. Pedrosa, K. Erents, M. Hron, A. Loarte, G. Matthews, R. Pitts

- **4th IAEA Technical Committee Meeting on Control, Data Acquisition and Remote Participation on Fusion Research, 21-23 de Julho de 2003, San Diego, USA**

39 - *"Real-Time Motional Stark Effect in JET"*
Alves, D., A. Stephen, N. Hawkes, S. Dalley, A. Goodyear, R.Felton, E. Joffrin, H. Fernandes and EFDA-JET work programme contributers.

40 - *"A test-bench for the JET Real Time Project"*
Batista, A. J. N., H. Fernandes, J. Sousa, C. A. F. Varandas, E. Joffrin, R. Felton e J. Farthing

41 - *"Real-Time DSP-based Shape Determination and Plasma Position in the ISTTOK Tokamak"*
Carvalho, B., H. Fernandes, C. Silva, D. Borba e C.A.F. Varandas

42 - *"A PCI transient recorder module for the JET magnetic proton recoil neutron spectrometer"*
Combo, A., R. Pereira, J. Sousa, N. Cruz, P. Carvalho, C.A.F. Varandas, S. Conroy, J. Källne and M. Weiszflog

43 -*"A Low-Cost Galvanic Isolated Fast PCI Transient Recorder with Signal Processing Capabilities"*
Correia, M., A. J. N. Batista, A. Combo, N.Cruz, P.
Carvalho, Carlos Correia, J. Sousa e C.A.F. Varandas

44 - *"A Large Memory VME Data Acquisition System for the Jet Heterodyne Radiometer Upgrade"*
Cruz, N., J. Sousa, R. Pereira, A. Combo, C.A.F. Varandas, M. Beldishevski, S. Dorling, B. Alper and EFDA-JET work programme contributers.

45 - "*A PCI time digitizer for the new JET time-of-flight neutron spectrometer*"
Sousa, J., A.J.N. Batista, A. Combo, R. Pereira, N. Cruz, P. Carvalho, C.A.F. Varandas, S. Conroy, G. Ericsson and J. Källne

- **3º Congresso Luso Moçambicano de Engenharia, 19-21 de Agosto 2003, Maputo, Moçambique**

46 - *"Perspectivas do ensino em Portugal da Engenharia Física Tecnológica"*
Varandas, C.A.F.

- **10th International Conference on Ion Sources, Dubna, Russia, September 8-13, 2003**

47 - *"High intensity alkaly ion sources for plasma diagnostics"*
Bondarenko, I.S., O.O. Chmuga, M.B. Dreval, S.M. Khrebtov, O.D. Komarov, O.S. Kozachok, L.I. Krupnik, I.S. Nedzelskiy

- **14th International Stellarator Workshop, September 22 - 26, 2003, Greifswald - Germany**

48 - *"Statistical description of transport in terms of probability distribution functions: experiments in tokamaks (JET) and stellarators (TJ-II)"*
Gonçalves, B., C. Hidalgo, M.A. Pedrosa, C. Silva, K. Erents, G. F.Matthews

49 - *"Comparative studies of biasing improved confinement regimes in stellarators (TJ-II) and tokamaks (T-10)"*

Melnikov, A.V., C. Hidalgo, A.A. Chmyga, N. Dreval, L. Eliseev, B. Gonçalves, G.Kirnev, S.M. Khrebtov, A.D. Komarov, A.S. Kozachok, L. Krupnik, M.A. Pedrosa, G. van Oost, C. Silva

- **9th IAEA Technical Meeting on H-mode Physics and Transport Barriers, San Diego, USA 24-26-September, 2003**

50 - *"Dimensionless pedestal identity experiments in JT-60U and JET in ELMy H-mode plasmas"*
Saibene, G., T. Hatae, D.J. Campbell, J.C. Cordey, E. de la Luna, C. Giraud, K. Guenther, Y. Kamada, M.A.H. Kempenars, A. Loarte, J. Lonnroth, D. McDonald, M.F. Nave, N. Oyama , V.V. Parail, R. Sartori, J. Stober, T. Suzuki, M. Takech, K. Toi

51 - *"Search in JET for the Quiescent H-mode regime"*
Suttrop, W., R. A. Pitts, M. Maraschek, B. Alper, P. Gohil, S. Hacquin, M. Kempenaars, H. R. Koslowski, C. J. Lasnier, P. J. Lomas, G. Maddison, M. F. Nave, S. E. Sharapov, K-D Zastrow and EFDA-JET workprogramme contributors

- **11th International Symposium on Laser-Aided Plasma Diagnostics, LAPD11, 28 Sep. - 02 Oct. 2003, Les Houches - France**

52 - *"The Fiber Optic Multiplexed Upgraded Thomson Scattering Diagnostic for the ISTTOK Tokamak"*
Alonso, M. P., L. A. Berni

- **8th IAEA TCM on Energetic Particles in Magnetic Confinement Systems 6 - 8 October 2003, San Diego, California USA**

53 - *"Super-thermal and runaway electrons at reconnection events during JET disruptions"*
Plyusnin, V.V., B. Alper, P. Helander, R.J. Hastie, F. Salzedas, F. Serra, R. Jaspers, T.C. Hender, V.G. Kiptily, M.F. Johnson, E de La Luna and JET EFDA contributers.

- **45th Annual Meeting of Division of Plasma Physics 27-31 October 2003, Albuquerque, N.M., USA**

54 - *"Modelling comparison of divertor radiation from N and Ar for heat flux mitigation in JET ELMy H-modes"*
Monier-Garbet, P., J. Hogan, Y. Corre, P. R Thomas, Ph. Andrew, D. Coster, P. Dumortier, Th. Eich, A. Huber, R. Koslowski, K. Lawson, A. Messiaen, M.F Nave, J. Ongena, J. Rapp, J. Stober and JET-EFDA contributors

55 - *"Core and edge MHD studies in JET experiments with reversed B"*
Nave, M.F.F., R. Buttery, C. Challis, S. Coda, J. Graves, R. Koslowski, A. Loarte, P. Lomas, M. Marascheck, G. Matthews, C. Perez, S. Pinches, R. Pitts, O.Sauter, M.Stamp, W. Suttrop and JET-EFDA contributors

56 - *"Steady state impurity seeded discharges in JET by simultaneous feedback control of confinement enhancement and radiation fraction"*
Ongena, J., P. Dumortier, Y. Corre, R. Felton, E. Joffrin, J. Hardling, A. Messiaen, J. Strachan, A. Huber, H.R. Koslowski, A. Kreter, G. Maddison, P. Monier-Garbet, M.F.F. Nave, M.E. Puiatti, B. Untenberg, M. Valisa Suttrop and JET-EFDA contributors

57 - *"Modelling of impurity penetration through the edge and core transport barriers in JET"*
Parail, V., P. Belo, G. Corrigan and JET-EFDA contributors

- **EPMESC IX – The 9th International Conference on Enhancement and Promotion of Computational Methods in Engineering and Science, 25-28 November, Macau, China**

58 - *"2D FDTD full-wave code for simulating the diagnostic of fusion plasmas with microwave reflectometry"*
Silva, F. da, S. Heuraux, P. Varela and M.E. Manso

59 - *"Computer based techniques to design antennas in microwave diagnostics for fusion plasmas"*
Manso, M.E., J. Borreicho, L. Farinha, S. Hacquin, F. Silva e P. Varela

- **10th Latin American Workshop On Plasma Physics (X LAWPP) and Seventh Brazilian Meeting on Plasma Physics (7th EBFP), 1 - 5 December 2003, S. Paulo, Brazil**

60 - *Thomson Scattering Diagnostic on the ETE Tokamak: Status and Progress*
Berni, L.A., E. Del Bosco, J.G. Ferreira, R.M. Oliveira and M. P. Alonso

- **11th European Fusion Physics Workshop, 8-10 December 2003, Heraklion, Crete**

61 - *"Cross-field SOL transport: the role of turbulence"*
Gonçalves, B.

- **Fusion Meeting at the Department of Electrical and Computer Engineering of Kumamoto University, 19 December 2003, Kumamoto, Japan**

62 - *"The tokamak ISTTOK and its Thomson scattering diagnostics"*
Alonso, M.P. and the ISTTOK Team

5. OTHER ACTIVITIES OF CENTRO DE FÍSICA DOS PLASMAS

5.1. GoLP – Group of Lasers and Plasmas

5.1.1. PhD Thesis

1 - *"Nonlinear Dust Particle Dynamics and Collective Effects in Complex Plasmas"*
Gianfranco Sorasio
Umea University, Suécia, 2003.

2 - *"Particle Acceleration in Plasmas and in Vacuum"*
Madalena Eloy Santos
Universidade Técnica de Lisboa, 2003.

5.1.2. Master Thesis

1 - *"Deposizione e trasporto di energia in bersagli solidi per la fusione inerziale rápida"*
Sergio Amorini
Politecnico di Torino, Itália, Maio 2003, MSc em Engenharia Nuclear

2 - *"Ion acceleration in overdense targets"*
Michael Marti
Universidade de Berna, Suíça, MSc em Física

5.1.3. Participation in the management of the Fusion Programme

- Prof. Tito Mendonça is a member of the "Coordinating Committee of the Activities on Inertial Fusion Energy".

5.1.4. Articles in scientific journals

1 - *"Cyclotron Maser Radiation from Astrophysical Shocks"*
Bingham R., B.J. Kellet, R.A. Cairns, J. Tonge and J.T. Mendonça
The Astrophysical Journal, 595, 279, 2003.

2 - *"Collective Plasma Effects in Scattering of Radiation in Astrophysical Plasmas"*
Bingham, R., V.N. Tsytovich, U. de Angelis, A. Forlani and J.T. Mendonça
Physics of Plasmas, 10, 3297, 2003.

3 - *"High Energy Plasma Accelerators"*
Bingham, R., J.T. Mendonça and P.K. Shukla,
(invited review article), Plasma Physics and Controlled Fusion, accepted (2003).

4 - *"Classical mode conversion description of neutrino oscillations in dense magnetized plasmas"*
Bingham, R., L. O. Silva, R. A. Cairns, V. B. Semikoz, and V. N. Oraevsky
Phys. Plasmas, 10, 4903 (2003)

5 - *"Optimal state discrimination using particle statistics"*
Bose, S., A. Ekert, Y. Omar, N. Paunkovic, and V. Vedral
Phys. Rev. A 68, 052309 (2003)

6 - *"Electric and magnetic field generation and target heating by laser-generated fast electrons"*
Davies, J. R.
Phys. Rev. E 68, 056404, 2003.

7 - *"Magnetic-field-limited currents"*
Davies, J. R.
Phys. Rev. E 68, 037501, 2003.

8 - *"The Alfvén limit in fast ignition"*
Davies, J. R.
submitted to Phys. Rev. E, 2003.

9 - *"Explosion of Plasma Foils in the Petawatt Regime: Generation of MeV Particle Beams"*
Eloy, M., A. Guerreiro, J.T. Mendonça and R. Bingham
AIP Conf. Proc., 669, 784, 2003.

10 - *"Focusing XUV coherent beams with unprecedented energy density"*
Fajardo, M. P. Mercère, G. Faivre, S. Kazamias, C. Valentin, D. Douillet, P. Zeitoun, Ph. Balcou, F. Auge, L. Altucci
Submitted to *Optics Letters*, 2003.

11 - *"Hydrodynamic simulation of XUV laser-produced plasmas"*
Fajardo, M., P. Zeitoun, J.-C. Gauthier
Accepted for publication in Europ. Phys. Journal D, 2003

12 - *"Three dimensional Weibel instability in astrophysical scenarios "*
Fonseca, R. A., L. O. Silva, J. W. Tonge, J. M. Dawson, W. B. Mori
Phys. Plasmas, 10, 1979 (2003)

13 - ***"****Ion acceleration from the shock front induced by hole-boring in ultra-intense laser plasma interactions"*
Habara, H., K. L. Lancaster, S. Karsch, C. D. Murphy, P. A. Norreys, R. G. Evans, M. Borghesi, L. Romagnani, M. Zepf, T. Norimatsu, Y. Toyama, R. Kodama, J. A. King, R. Snavely, K. Akli, B. Zhang, R. Freeman, S. Hatchett, A. J. MacKinnon, P.Patel, M. H. Key, C. Stoeckl, R. B. Stephens, R. A. Fonseca, and L. O. Silva,
To appear in the Physical Review Letters, 2004.

14 - *"Plasma channels produced by a laser-triggered high-voltage discharge"*
Lopes, N. C., G. Figueira, L. O. Silva, J. M. Dias, R. Fonseca,L. Cardoso, C. Russo, C. Carias, G. Mendes, J. Vieira, and J. T. Mendonça
Phys. Rev. E 68, 035402(R), 2003

15 - *“Laser pulse frequency upshifts by relativistic ionization fronts”*
Lopes, N. C., G. Figueira, J. M. Dias, L. O. Silva, J. T. Mendonça, P. Balcou, C. Stenz,
accepted for publication in *Europhysics Letters*, 2003.

16 - *"Sliding Resonance of Parametric Optical Processes",*
Mendonça, J.T. and H. Crespo
Optics Communications, 222, 405, 2003.

17 - *"Resonant Quasi-particles in Plasma Turbulence"*
Mendonça, J.T., R. Bingham and P.K. Shukla
Physical Review E, 68, 016406, 2003.

18 - *"Temporal beam splitter and temporal interference"*
Mendonça, J.T., A.M. Martins and A. Guerreiro
Physical Review A, 68, 043801, 2003.

19 - *"Self-phase modulation of spherical gravitational waves"*
Mendonça, J.T., V. Cardoso, M. Marklund, M. Servin and G. Brodin
Physical Review D, 68, 084025, 2003.

20 - *"Quantum Mechanisms of Laser Wakefield Acceleration"*
Mendonça, J.T. and E. Ribeiro
Accepted for publication in Physica Scripta, 2003.

21 - *"Nonlinear phase-locking of parametric optical processes: the sliding resonace effect"*
Mendonça, J.T. and H. Crespo
in *Ultrafast Optics IV*, ed. by F. Krausz et al., Springer-Verlag, N.Y. accepted (2003).

22 - *"Photon Kinetic Theory in Plasmas and in Optics"*
Mendonça, J.T.
Accepted for publication in Laser and Particle Beams, 2003.

23 - **“***Global model for laser-driven MeV electrons in fast ignition”*
Ren, C., M. Tzoufras, F. S. Tsung, W. B. Mori, S. Amorini, R. A. Fonseca, L. O. Silva, J.C.-Adam, and A. Heron
To appear in Physical Review Letters, 2004

24 - *“New low-frequency waves and negative mass instability in dusty plasmas”*
Resendes, D. P., R. Bingham, A. Guerreiro, et al.
J. Plasma Phys., 69, 439 (2003)

25 - *"Nonlinear self-interaction of plane gravitational waves"*
Servin, M., M. Marklund, G. Brodin, J.T. Mendonça and V. Cardoso
Physical Review D, 67, 987501, 2003.

26 - *“Proton Shock Acceleration in Laser-Plasma Interactions”*
Silva, L. O., M. Marti, J. R. Davies, R. A. Fonseca, C. Ren, F. Tsung, W. B. Mori
Physical Review Letters 92, 027201, 2003;

27 - *"Neutrino-Beam-Plasma Interactions"*
Silva, L.O., R. Bingham, J.T. Mendonça, W.B. Mori and P.K. Shuhla
Accepted for publication in Physica Scripta, 2003.

28 - *“Interpenetrating plasma shells: near-equipartition magnetic field generation and nonthermal particle accelerations”*

Silva, L. O., R. A. Fonseca, J. W. Tonge, W. B. Mori, J. M. Dawson, and M. Medvedev
Astrophysical Journal Letters, 596, L121-L124 Oct 10 (2003)

29 - *"Electroweak interactions in dense plasmas"*
Silva, L. O., R. Bingham, and W. B. Mori
AIP Conf. Proc., 669, 449 (2003)

30 - *"Longitudinal coherence measurements of the transient collisional X-ray laser"*
Smith, R., S. Hubert, M. Fajardo, Ph. Zeitoun, J. Dunn, J. Hunter, C. Remond, L. Vanbostal, S. Jaquemot, J. Nilsen, C. Lewis, R. Marmoret,
Optics Letters 28, 2261, 2003

31 - *"Instability of shear waves in a nonuniform dusty plasma"*
Sorasio, G., P. K. Shukla, D. P. Resendes
New J. Phys. 5, Art N. 81 July 2 (2003)

32 - *"Experimental study of proton emission from 60-fs, 200-mJ high-repetition-rate tabletop-laser pulses interacting with solid targets"*
Spencer, I., K. W. D. Ledingham, P. McKenna, T. McCanny, R. P. Singhal, P. S. Foster, D. Neely, A. J. Langley, E. J. Divall, C. J. Hooker, R. J. Clarke, P. A. Norreys, E. L. Clark, K. Krushelnick, and J. R. Davies
Phys. Rev. E 67, 046402, 2003.

33 - *"Near-GeV-energy laser-wakefield acceleration of self-injected electrons in cm-scale plasma channel"*
Tsung, F., R. Narang, W. B. Mori, C. Joshi, R. A. Fonseca, and L. O. Silva
To appear in Physical Review Letters, 2004

34 - *"Time-resolved study of the spectral characteristics of supercontinuum pulses propagating in scattering media"*
Weigand, R., H. Crespo, A. dos Santos, P. Balcou
Appl. Phys. B – Lasers and Optics, 77, 253 (2003)

5.2. Space Plasmas Group

5.2.1. Articles in scientific journals

1 - *"On the generation of Totem Pole emissions"*
Brinca, A.L., F.J. Romeiras, L. Gomberoff, and M.H. Marçal
J. Geophys. Res., accepted for publication, 2003.

2 - *"On wave generation by perpendicular currents"*
Brinca, A.L., F.J. Romeiras, and L. Gomberoff,
J. Geophys. Res.,108 (A1),1038, doi:10.1029/2002JA009375, 2003.

3 - *"Stimulation of electron Bernstein modes by perpendicular ion beams"*
Brinca, A.L., F.J. Romeiras, and L. Gomberoff,
Geophys. Res. Lett, 30 (22), 2175, doi:10.1029/2003GL017501, 2003.

4 - *"Behavior of linear beam-plasma instabilities in presence of finite amplitude circularly polarized waves"*
Gomberoff, L., J. Hoyos, and A.L. Brinca,
Brazilian J. Phys., accepted for publication, 2003.

5 - *"The effect of a large-amplitude circularly polarized wave on linear beam-plasma electromagnetic instabilities"*
Gomberoff, L., J. Hoyos, and A.L. Brinca,
J. Geophys. Res., 108 (A12), 1472, doi:10.1029/2003JA010144, 2003.

5.3. Gas Discharges and Gaseous Electronics

5.3.1. PhD Thesis

Aurel Salabas, PhD Thesis, Universidade Técnica de Lisboa, 2003: *Fluid model for charged particle transport in capacitively coupled radio-frequency discharges*.

5.3.2. Book chapters

1 - Guerra, V. and J. Loureiro, *Dynamical Monte-Carlo Simulation of Surface Kinetics*, in A. Ketsdever e E. P. Muntz (editors), *Rarefied gas dynamics*, American Institute of Physics, AIP Conference Proceedings - Volume 663, Melville, New York, U.S.A., 2003

5.3.3. Articles in scientific journals

1 - *"Nonequilibrium positive column revisited"*
Alves, L. L., G. Gousset and S. Vallée,
IEEE Transactions on Plasma Science, 31, 572, 2003.

2 - *"Iterative method of evaluating the electron energy distribution function from probe measurements under collisional conditions"*
Dias, F. M. and Tsv. K. Popov,

3 - *"Modeling of wave driven molecular (H_2, N_2, N_2-Ar)"*
Ferreira, C. M., E. Tatarova, V. Guerra, B. Gordiets, J. Henriques, F. M. Dias e M. Pinheiro,
IEEE Transactions on Plasma Science, 31, 645, 2003.

4 - *"Wave driven molecular discharges as sources of active species"*
Ferreira, C. M., E. Tatarova, F. M. Dias, V. Guerra, J. Henriques and M. Pinheiro
Vacuum, 69, 183, 2003.

5 - *"Electron and metastale kinetics in the nitrogen afterglow"*
Guerra, V., P. A. Sá e J. Loureiro,
Plasma Sources Sci. and Technol. 12, S8, 2003.

6 - *"Time-dependence of the electron energy distribution function in the nitrogen afterglow"*
Guerra, V., F. M. Dias, J. Loureiro, P. A. Sá, P. Supiot, C. Dupret e T. Popov,
IEEE Transactions on Plasma Science, 31, 542, 2003.

7 - *"Dissociation mechanisms in nitrogen discharges"*
Guerra, V., E. Galiaskarov and J. Loureiro,
Chem. Phys. Lett. 371, 576-581, 2003.

8 - *"Kinetics of metastable atoms and molecules in N_2 microwave discharges"*
Guerra, V., E. Tatarova e C. M. Ferreira
Vacuum, 69, 171, 2003.

9 - *"Nitrogen dissociation in N_2–Ar microwave plasmas"*
Henriques, J., E. Tatarova, V. Guerra and C. M. Ferreira,
Vacuum, 69, 177, 2003.

10 - *"Charged particle transport modelling in silane-hydrogen radio-frequency capacitively coupled discharges"*
Salabas, A., G. Gousset and L. L. Alves,
Vacuum, 69, 213-219, 2003.

11 - *"Emission Spectroscopy of a Surface Wave Sustained N_2-H_2 Discharge"*
Tatarova, E., F. M. Dias, H. van Kuijk and C. M. Ferreira
Vacuum, 69, 189-193, 2003.

12 - *"Optical emission spectroscopy and Langmuir probe characterisation of the plasma during hight-pressure sputter deposition of high-T_c superconducting $YBa_2Cu_3O_{7-x}$ thin film"*
Tsaneva, V. N., Tsv. Popov, F. M. Dias, E. J. Tarte, M. G. Blamire, J. E. Evetts and Z. H. Barber,
Vacuum, 69, 261-266, 2003.

5.3.4. Papers in international conferences

16th International Symposium on Plasma Chemistry (ISPC 16), Taormina, Itália, 2003.

1 - "*Molecular Dissociation in N_2-H_2 Wave Driven Microwave Discharge*"
E. Tatarova, F. M. Dias, B. Gordiets e C. M. Ferreira

16th International Symposium on Plasma Chemistry (ISPC 16), Vol. IV, Pág. 1357, Taormina, Itália, 2003.

2 - "*Large-area Surface Wave Excites N_2-Ar Overdense Plasma"*
Tatarova, E. F. M. Dias, J. Henriques e C. M. Ferreira

23rd International Conference on Photonic, Electronic and Atomic Collisions, Vol. II, Estocolmo, Suécia, July 23-29, 2003.

3 - "*Kinetics of Molecular Dissociation in N_2-H_2 and N_2-Ar Microwave Discharges"*
Ferreira, C. M., E. Tatarova, B. Gordiets, J. Henriques e F.M. Dias

Vth International Workshop On Microwave Discharges: Fundamentals and Applications, Pag. 29, Greifswald, Alemanha, 2003.

4 - "*A Large-Volume (N2-Ar) Microwave Plasma Source Based On Surface Waves"*
Henriques, J., C.M. Ferreira, E. Tatarova e F.M. Dias

Vth International Workshop On Microwave Discharges: Fundamentals and Applications, Pag. 57, Greifswald, Alemanha, 2003.

5 - "*Large-Scale Ar Plasma Excited By Tm330 Surface Mode"*
Dias, F.M., C.M. Ferreira, E. Tatarova e J. Henriques

Thirteenth International School on Vacuum, Electron and Ion Technologies, Pag. 31, Varna, Bulgária, 2003.

6 - "*Wave Driven N_2-O_2 Discharge For Plasma Sterilization*"
Henriques, J., E. Tatarova, V. Guerra, C.M. Ferreira e A.Ricard

Thirteenth International School on Vacuum, Electron and Ion Technologies, Pag. 31-32, Varna, Bulgária, 2003.

7 - "*A Large-Volume (N_2-Ar) Microwave Plasma Source Based on Surface Waves"*
Tatarova, E., J. Henriques, F.M. Dias e C.M. Ferreira

56th Gec - Gaseous Electronics Conference", Vol 48, Pag. 31, São Francisco, E.U.A., 2003.

8 - "*Wave Driven N_2-O_2 Discharges as Sources Of Active Species*"
Henriques, J., E. Tatatova, C.M. Ferreira e A. Ricard

56th GEC (Annual Gaseous Electronics Conference), San Francisco, Califórnia, E.U.A., Outubro de 2003. Bull. Am. Phys. Soc. 48 (2003) 31.

9 - "*Influence of electron collisions with $N_2(A\,^3\Sigma_u^+)$ metastables in the nitrogen afterglow"*
Guerra, V., P. A. Sá e J. Loureiro

56th GEC (Annual Gaseous Electronics Conference), San Francisco, Califórnia, E.U.A., Outubro de 2003. *Bull. Am. Phys. Soc.* 48 (2003) 31.

10 - "*Characterization of a large-area microwave plasma in N_2-O_2*"
Tatarova, E., F. M. Dias, V. Guerra e C. M. Ferreira,

ISPC 16 (International Symposium on Plasma Chemistry), pag 143, Taormina, Itália, Junho de 2003.

11 - *"Dissociation mechanisms in nitrogen discharges"*
Guerra, V., E. Galiaskarov e J. Loureiro

ISPC 16 (International Symposium on Plasma Chemistry), pag 153, Taormina, Itália, Junho de 2003.

12 - "*Modelling of a microwave flowing post-discharge in N_2-O_2"*
Pintassilgo, C. D., T. Belmonte, J. Loureiro e V. Guerra

ISPC 16 (International Symposium on Plasma Chemistry), pag 174, Taormina, Itália, Junho de 2003.

13 - *Temporal evolution of the electron energy distribution function in the nitrogen afterglow"*
Guerra V., P. A. Sá e J. Loureiro

ISPC 16 (International Symposium on Plasma Chemistry), pag 175, Taormina, Itália, Junho de 2003.

14 - "*Large-scale surface-wave discharges in N_2-O_2*"
Guerra, V. E. Tatarova, F. M. Dias e C. M. Ferreira

14th International Pulsed Power Conference, Dallas-Texas (USA) 2003.

15 - *"The electron beam and pinch effect characteristics of double discharge pulsed electron beam generator"*
Goktas, H., A. Alacakir, G. Oke, A. Esendemir, I. Yildiz, H. Kirkici, M. Udrea e J. Loureiro

8th Spacecraft Charging Technology Conference, Huntsville-Alabama (USA) 2003.

16 - "*Physical problems of artificial magnetospheric propulsion*"
Mendonça, J. T., A. L. Brinca, R. Fonseca, J. Loureiro, L. O. Silva e I. Vieira,

16th International Symposium in Plasma Chemistry, June 2003, Taormina, Sicilia, Itália.

17 - "*Low pressure nitrogen glow discharge with graphite electrodes*"
Pinheiro, M. J., B. F. Gordiets, Z. Donkó , K. Kutasi e N. Pinhão

Gaseous Electronic Conference, October 2003, San Francisco, USA.

18 - *"Low pressure nitrogen glow discharge with graphite electrodes"*
Ferreira, C. M., B. Gordiets e M. J. Pinheiro

Gaseous Electronic Conference, October 21-24 2003, San Francisco, E.U.A.

19 -"*Comparison of kinetic calculation techniques for a pulsed Townsend discharge at low to moderate E/N values*"
Pinhão, N., Z. Donkó, D. Loffhagen, M. J. Pinheiro, E. A. Richley

Frontiers in Low Temperature Plasma Diagnostics V, Villaggio Cardigliano, Italy, 144-147, 2003.

20 - *Wave fields, probe, and spectroscopic measurements of a large-volume, top-excited surface wave discharge*"
Dias, F. M., A. Martins e E. Tatarova

Thirteenth International Summer School, 15-19 September, Varna, Bulgaria, 12-13, 2003.

21 - "*Local Diagnostics in Gas Discharges*" Invited talk
Dias, F. M. e Tsv. Popov

14th International Colloquium on Plasma Processes (CIP'2003), Antibes, França 2003.

22 - "*Fluid description of the energy absorption in microwave discharges: a new perspective*"
Alves, L.L.

Vth International Workshop on Microwave Discharges: Fundamental and Applications (invited papers), (A. Ohl, ed.), Greifswald, Alemanha 2003.

23 - "*Wave-plasma energy coupling in cylindrical surface wave discharges*"
Alves, L.L. e G. Gousset,

Vth International Workshop on Microwave Discharges: Fundamental and Applications, Greifswald, Alemanha 2003.

24 - "*Self-consistent electromagnetic modelling of cylindrical surface wave discharges*"
Alves, L.L. e G. Gousset

8th ISPC, International Symposium on Plasma Chemistry (R. D'Agostino, P. Favia, F. Fracassi e F. Palumbo, eds.), Taormina, Itália 2003.

25 - "*Influence of vibrational kinetics in a low pressure radio-frequency hydrogen discharge"*
Marques, L., A. Salabas, G. Gousset, J. Jolly e L.L. Alves