Bayesian Integrated Data Analysis of Fast-Ion Measurements by Velocity-Space Tomography

Bayesian integrated data analysis combines measurements from different diagnostics to jointly measure plasma parameters of interest such as temperatures, densities, and drift velocities. Integrated data analysis of fast-ion measurements has long been hampered by the complexity of the strongly non-Maxwellian fast-ion distribution functions. This has recently been overcome by velocity-space tomography. In this method two-dimensional images of the velocity distribution functions consisting of a few hundreds or thousands of pixels are reconstructed using the available fast-ion measurements. Here we present an overview and current status of this emerging technique at the ASDEX Upgrade tokamak and the JET tokamak based on fast-ion D-alpha spectroscopy, collective Thomson scattering, gamma-ray and neutron emission spectrometry, and neutral particle analyzers. We discuss Tikhonov regularization within the Bayesian framework. The implementation for different types of diagnostics as well as the uncertainties are discussed, and we highlight the importance of integrated data analysis of all available detectors.
Main-ion temperature and plasma rotation measurements based on scattering of electron cyclotron heating waves in ASDEX Upgrade: Paper

We demonstrate measurements of spectra of O-mode electron cyclotron resonance heating (ECRH) waves scattered collectively from microscopic plasma fluctuations in ASDEX Upgrade discharges with an ITER-like ECRH scenario. The measured spectra are shown to allow determination of the main ion temperature and plasma rotation velocity. This demonstrates that ECRH systems can be exploited for diagnostic purposes alongside their primary heating purpose in a reactor relevant scenario.

General information
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ISSN (Print): 0741-3335
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BFI (2018): BFI-level 1
We demonstrate the measurement of a 2D MeV-range ion velocity distribution function by velocity-space tomography at JET. Deuterium ions were accelerated into the MeV-range by third harmonic ion cyclotron resonance heating. We made measurements with three neutron emission spectrometers and a high-resolution γ-ray spectrometer detecting the γ-rays released in two reactions. The tomographic inversion based on these five spectra is in excellent agreement with numerical simulations with the ASCOT–RFOF and the SPOT–RFOF codes. The length of the measured fast-ion tail corroborates the prediction that very few particles are accelerated above 2 MeV due to the weak wave-particle interaction at higher energies.
Observation of short time-scale spectral emissions at millimeter wavelengths with the new CTS diagnostic on the FTU tokamak: Paper

On the FTU tokamak, the collective Thomson scattering (CTS) diagnostic was renewed for investigating the possible excitation of parametric decay instabilities (PDI) by electron cyclotron (EC) or CTS probe beams in presence of magnetic islands and measure their effects on the EC power absorption. The experiments were performed launching a gyrotron probe beam (140 GHz, 400 kW) and observing the scattered radiation in symmetric and asymmetric directions (with respect to the equatorial plane) in different conditions of plasma density and magnetic field (with or without the EC resonance in the plasma), and with magnetic islands generated by Neon injection. The acquisition with a fast digitizer allowed observing spectral features with very high time and frequency resolution. Shots were performed at 7.2 T, with the fundamental EC resonance out of the plasma region, at 4.7 T, with the resonance on the high field side of the plasma column, and at 3.6 T, in this last case with the plasma between the first and the second EC harmonics both lying outside the plasma volume. Several types of spectral features characterized by their frequency and their fast time evolution were identified in the observed signal after a proper treatment. The paper reports the observations in the different experimental cases and the correlation of the features with the existence of MHD modes as witnessed by magnetic probes signals and with macroscopic plasma parameters.

General information
State: Published
Organisations: Department of Physics, Plasma Physics and Fusion Energy, Consiglio Nazionale delle Ricerche, ENEA Centro Ricerche Frascati, Ecole Polytechnique Federale de Lausanne (EPFL), RAS - Institute of Applied Physics, Università degli Studi di Milano-Bicocca, Università degli Studi di Napoli Federico II
Number of pages: 8
Publication date: 2017
Main Research Area: Technical/natural sciences
Overview of ASDEX Upgrade results

The ASDEX Upgrade (AUG) programme is directed towards physics input to critical elements of the ITER design and the preparation of ITER operation, as well as addressing physics issues for a future DEMO design. Since 2015, AUG is equipped with a new pair of 3-strap ICRF antennas, which were designed for a reduction of tungsten release during ICRF operation. As predicted, a factor two reduction on the ICRF-induced W plasma content could be achieved by the reduction of the sheath voltage at the antenna limiters via the compensation of the image currents of the central and side straps in the antenna frame. There are two main operational scenario lines in AUG. Experiments with low collisionality, which comprise current drive, ELM mitigation/suppression and fast ion physics, are mainly done with freshly boronized walls to reduce the tungsten influx at these high edge temperature conditions. Full ELM suppression and non-inductive operation up to a plasma current of $I_p = 0.8$ MA could be obtained at low plasma density. Plasma exhaust is studied under conditions of high neutral divertor pressure and separatrix electron density, where a fresh boronization is not required. Substantial progress could be achieved for the understanding of the confinement degradation by strong D puffing and the improvement with nitrogen or carbon seeding. Inward/outward shifts of the electron density profile relative to the temperature profile effect the edge stability via the pressure profile changes and lead to improved/decreased pedestal performance. Seeding and D gas puffing are found to effect the core fueling via changes in a region of high density on the high field side (HFSHD). The integration of all above mentioned operational scenarios will be feasible and naturally obtained in a large device where the edge is more opaque for neutrals and higher plasma temperatures provide a lower collisionality. The combination of exhaust control with pellet fueling has been successfully demonstrated. High divertor enrichment values of nitrogen $E_{\text{N}} \geq 10$ have been obtained during pellet injection, which is a prerequisite for the simultaneous achievement of good core plasma purity and high divertor radiation levels. Impurity accumulation observed in the all-metal AUG device caused by the strong neoclassical inward transport of tungsten in the pedestal is expected to be relieved by the higher neoclassical temperature screening in larger devices.

General information

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Scopus rating (2016): CiteScore 1.62 SJR 1.01 SNIP 0.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.288 SNIP 1.43 CiteScore 1.88
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Overview of progress in European medium sized tokamaks towards an integrated plasma-edge/wall solution

Integrating the plasma core performance with an edge and scrape-off layer (SOL) that leads to tolerable heat and particle loads on the wall is a major challenge. The new European medium size tokamak task force (EU-MST) coordinates research on ASDEX Upgrade (AUG), MAST and TCV. This multi-machine approach within EU-MST, covering a wide parameter range, is instrumental to progress in the field, as ITER and DEMO core/pedestal and SOL parameters are not achievable simultaneously in present day devices. A two prong approach is adopted. On the one hand, scenarios with tolerable transient heat and particle loads, including active edge localised mode (ELM) control are developed. On the other hand, divertor solutions including advanced magnetic configurations are studied. Considerable progress has been made on both approaches, in particular in the fields of: ELM control with resonant magnetic perturbations (RMP), small ELM regimes, detachment onset and control, as well as filamentary scrape-off-layer transport. For example full ELM suppression has now been achieved on AUG at low collisionality with n=2 RMP maintaining good confinement $H_{98,y2}$.
Advances have been made with respect to detachment onset and control. Studies in advanced divertor configurations (Snowflake, Super-X and X-point target divertor) shed new light on SOL physics. Close field filamentary transport has been characterised in a wide parameter regime on AUG, MAST and TCV progressing the theoretical and experimental understanding crucial for predicting first wall loads in ITER and DEMO. Conditions in the SOL also play a crucial role for ELM stability and access to small ELM regimes.
RAMI analysis of the ITER LFS CTS system

This paper describes an initial RAMI analysis for the ITER Low Field Side Collective Thomson Scattering system (LFS CTS) based on its preliminary architecture at system design level. The benefits and challenges involved in this analysis since an early phase of the design are discussed together with the methodology pursued. The Functional Analysis, developed both at system and sub-system level, are the major inputs for the RAMI analysis. A systematic approach has been used, and significant design assumptions have been made due to the lack of knowledge and definition inherent to preliminary design stages. This study includes the Failure Mode, Effects and Criticality Analysis and the Reliability Block...
Diagram of the system. The results obtained for the system Availability and Reliability are presented and discussed, and criticality charts are developed to highlight the risk levels of the failure modes, regarding to their likelihood and effects on the Availability of the ITER machine. Mitigation actions are proposed to reduce these risk levels in case of impact on the ITER operation.

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BFI (2015): BFI-level 1
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Scopus rating (2014): SJR 0.709 SNIP 1.26 CiteScore 1.2
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BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.619 SNIP 1.454 CiteScore 1.35
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.636 SNIP 1.078 CiteScore 0.99
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.664 SNIP 1.755 CiteScore 1.4
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.44 SNIP 1.111
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.655 SNIP 1.272
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.557 SNIP 0.959
Scopus rating (2007): SJR 0.682 SNIP 1.265
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.386 SNIP 0.795
Scopus rating (2005): SJR 0.486 SNIP 1.375
Scopus rating (2004): SJR 0.963 SNIP 0.617
Scopus rating (2003): SJR 0.541 SNIP 0.975
Scopus rating (2002): SJR 0.954 SNIP 0.95
Scopus rating (2001): SJR 0.394 SNIP 1.051
Recent development of collective Thomson scattering for magnetically confined fusion plasmas

Here we review recent experimental developments within the field of collective Thomson scattering with a focus on the progress made on the devices TEXTOR and ASDEX Upgrade. We discuss recently discovered possibilities and limitations of the diagnostic technique. Diagnostic applications with respect to ion measurements are demonstrated. Examples include measurements of the ion temperature, energetic ion distribution function, and the ion composition.
Benchmark and combined velocity-space tomography of fast-ion D-alpha spectroscopy and collective Thomson scattering measurements

We demonstrate the combination of fast-ion D-alpha spectroscopy (FIDA) and collective Thomson scattering (CTS) measurements to determine a common best estimate of the fast-ion velocity distribution function by velocity-space tomography. We further demonstrate a benchmark of FIDA tomography and CTS measurements without using a numerical simulation as common reference. Combined velocity-space tomographies from FIDA and CTS measurements confirm that sawtooth crashes reduce the fast-ion phase-space densities in the plasma center and affect ions with pitches close to one more strongly than those with pitches close to zero.

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Organisations: Department of Physics, Plasma Physics and Fusion Energy, Max Planck Institute for Plasma Physics
Authors: Jacobsen, A. S. (Intern), Salewski, M. (Intern), Geiger, B. (Ekstern), Korsholm, S. B. (Intern), Leipold, F. (Intern), Nielsen, S. K. (Intern), Rasmussen, J. (Intern), Pedersen, M. S. (Intern), Weiland, M. (Ekstern)
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1 SJR 0.583 SNIP 0.617
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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.734 SNIP 0.864 CiteScore 1.1
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.318 SNIP 1.235 CiteScore 1.61
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.088 SNIP 1.227 CiteScore 1.54
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.391 SNIP 1.142 CiteScore 1.63
Collective Thomson scattering measurements of fast-ion transport due to sawtooth crashes in ASDEX Upgrade

Sawtooth instabilities can modify heating and current-drive profiles and potentially increase fast-ion losses. Understanding how sawteeth redistribute fast ions as a function of sawtooth parameters and of fast-ion energy and pitch is hence a subject of particular interest for future fusion devices. Here we present the first collective Thomson scattering (CTS) measurements of sawtooth-induced redistribution of fast ions at ASDEX Upgrade. These also represent the first localized fast-ion measurements on the high-field side of this device. The results indicate fast-ion losses in the phase-space measurement volume of about 50% across sawtooth crashes, in good agreement with values predicted with the Kadomtsev sawtooth model implemented in TRANSP and with the sawtooth model in the EBdyna_go code. In contrast to the case of sawteeth, we observe no fast-ion redistribution in the presence of fishbone modes. We highlight how CTS measurements can discriminate between different sawtooth models, in particular when aided by multi-diagnostic velocity-space tomography, and briefly discuss our results in light of existing measurements from other fast-ion diagnostics.

General information

State: Published

Organisations: Department of Physics, Plasma Physics and Fusion Energy, University of Seville, Max-Planck-Institut fur Plasmaphysik, FOM Dutch Institute for Fundamental Energy Research, Budapest University of Technology and Economics

Design of the Collective Thomson Scattering diagnostic for the next-generation fusion experiment ITER

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Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Developing diagnostic systems for ITER – the next step fusion energy experiment
Fusion energy research is moving to the next stage with the well progressed construction of one of the largest research infrastructures ever – ITER. The goal of ITER is to produce 500 MW of fusion power while heating the fuel –deuterium/tritium plasma – by 50 MW. This will confirm fusion energy to be a viable energy source. Fusion energy power plants will be safe and can be operated to supply the baseload of an energy system. The fuel resources are inexhaustible, and can be derived from sea water. Fusion energy is based on the nuclear reaction fusing hydrogen isotopes into helium – like in the Sun – and thus no CO2 is released in the energy production. The waste of the energy production is the irradiated steel of the core of the reactor, but this radioactivity will only last for about 100 years and no long-term radioactive waste storage is needed.

While the promise of safe, clean and abundant energy is the ultimate goal of fusion energy, the path towards this is challenging. A fusion plasma has a temperature of 200 mio. degrees (15 times that of the core of the Sun), and this is confined by a magnetic field generated by powerful superconducting magnets in a vacuum chamber of 1000 m³. Operating diagnostic systems in the environment of ITER is a challenge for many technologies, but due to robustness, microwave diagnostics will play an increasingly important role in burning plasma fusion energy experiments like ITER and beyond. The Collective Thomson Scattering (CTS) diagnostic to be installed at ITER is an example of such a diagnostic with great potential in present and future experiments. The ITER CTS diagnostic will inject a 1 MW 60 GHz beam of electromagnetic radiation from a gyrotron into the ITER plasma and observe the scattering off fluctuations in the plasma – to monitor the dynamics of the fast ions generated in the fusion reactions. This will provide important physics understanding of the behavior of the fusion plasma that can be used for optimizing future fusion power plants. A research team at DTU (DTU Physics and DTU Nutech) has been tasked by Fusion for Energy (the European coordinator for supplies to ITER) to develop the ITER CTS diagnostic in collaboration with Instituto Superior Técnico in Portugal. It is a 5 year effort of more than 50 man year total effort. This presentation will outline the prospects and the status of the development of fusion energy research and the CTS diagnostic system for ITER.

General information
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Organisations: Department of Physics, Plasma Physics and Fusion Energy, Center for Nuclear Technologies, Radiation Physics
Exploiting the energy source of the stars: Fusion energy research at DTU

With increasing energy demands and a limited supply of fossil fuels, the need for efficient, clean, and sustainable energy sources grows ever more pressing. Nuclear fusion – the process from which stars like the Sun derive their energy – holds the potential to help address this challenge. To mimic this process on earth, experimental fusion devices seek to confine and heat gas to millions of degrees (creating a fusion plasma). Learning how such plasmas behave is a crucial step towards realizing fusion as a sustainable energy source. At the Plasma Physics and Fusion Energy (PPFE) section at DTU Physics, we are exploring this issue, focusing on three areas of high priority on the way towards a working fusion power plant.

Fast-ion energy resolution by one-step reaction gamma-ray spectrometry

The spectral broadening of γ-rays from fusion plasmas can be measured in high-resolution gamma-ray spectrometry (GRS). We derive weight functions that determine the observable velocity space and quantify the velocity-space sensitivity of one-step reaction high-resolution GRS measurements in magnetized fusion plasmas. The weight functions suggest that GRS resolves the energies of fast ions directly without the need for tomographic inversion for selected one-step reactions at moderate plasma temperatures. The D(p,γ)tHe reaction allows the best direct fast-ion energy resolution. We illustrate our general formalism using reactions with and without intrinsic broadening of the γ-rays for the GRS diagnostic at JET.
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.62 SJR 1.01 SNIP 0.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.288 SNIP 1.43 CiteScore 1.88
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.705 SNIP 1.476 CiteScore 2.2
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.128 SNIP 1.129 CiteScore 1.83
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.397 SNIP 1.216 CiteScore 1.81
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 2.056 SNIP 2.366 CiteScore 3.78
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 2.307 SNIP 1.923
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 2.021 SNIP 2.457
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 2.076 SNIP 1.754
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.059 SNIP 2.02
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.068 SNIP 1.855
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.858 SNIP 1.949
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.633 SNIP 1.659
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.1 SNIP 1.665
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 2.836 SNIP 1.401
Scopus rating (2001): SJR 1.992 SNIP 2.174
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.589 SNIP 1.122
Scopus rating (1999): SJR 2.14 SNIP 1.559
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Gamma-ray spectrometry, Tokamak, Fast-ion diagnosis
Electronic versions:
GRB 980425 host: [C II], [O I], and CO lines reveal recent enhancement of star formation due to atomic gas inflow

Context. Accretion of gas from the intergalactic medium is required to fuel star formation in galaxies. We have recently suggested that this process can be studied using host galaxies of gamma-ray bursts (GRBs).

Aims. Our aim is to test this possibility by studying in detail the properties of gas in the closest galaxy hosting a GRB (980425).

Methods. We obtained the first ever far-infrared (FIR) line observations of a GRB host, namely Herschel/PACS resolved [C ii] 158 μm and [O i] 63 μm spectroscopy, and an APEX/SHeFI CO(2-1) line detection and ALMA CO(1-0) observations of the GRB 980425 host.

Results. The GRB 980425 host has elevated [C ii]/FIR and [O i]/FIR ratios and higher values of star formation rates (SFR) derived from line ([C ii], [O i], Hα) than from continuum (UV, IR, radio) indicators. [C ii] emission exhibits a normal morphology, peaking at the galaxy centre, whereas [O i] is concentrated close to the GRB position and the nearby Wolf-Rayet region. The high [O i] flux indicates that there is high radiation field and high gas density at these positions, as derived from modelling of photo-dissociation regions. The [C ii]/CO luminosity ratio of the GRB 980425 host is close to the highest values found for local star-forming galaxies. Indeed, its CO-derived molecular gas mass is low given its SFR and metallicity, but the [C ii]-derived molecular gas mass is close to the expected value.

Conclusions. The [O i] and H i concentrations and the high radiation field and density close to the GRB position are consistent with the hypothesis of a very recent (at most a few tens of Myr ago) inflow of atomic gas triggering star formation. In this scenario dust has not had time to build up (explaining high line-to-continuum ratios). Such a recent enhancement of star formation activity would indeed manifest itself in high SFR\textsubscript{line}/SFR\textsubscript{continuum} ratios because the line indicators are sensitive only to recent (∼ 10 Myr) activity, whereas the continuum indicators measure the SFR averaged over much longer periods (∼100 Myr). Within a sample of 32 other GRB hosts, 20 exhibit SFR\textsubscript{line}/SFR\textsubscript{continuum} > 1 with a mean ratio of 1.74 ± 0.32. This is consistent with a very recent enhancement of star formation that is common among GRB hosts, so galaxies that have recently experienced inflow of gas may preferentially host stars exploding as GRBs. Therefore GRBs may be used to select a unique sample of galaxies that is suitable for the investigation of recent gas accretion.

General information

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Organisations: Department of Physics, Plasma Physics and Fusion Energy, University of Edinburgh, European Space Agency, University of Copenhagen, Nicolaus Copernicus University, Universidad de Lisboa, Leiden University, Osservatorio Astrofisico Di Arcetri, Florence, Universiteit Gent, Instituto de Astrofísica de Andalucia, Vrije Universiteit, European Space Astronomy Centre and European Space Agency, Thüringer Landessternwarte Tautenburg, Centro de Astrobiología , National Institute for Astrophysics, Max-Planck-Institut fur extraterrestrische Physik, Stockholm University, Chinese Academy of Sciences
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.68 SJR 2.246 SNIP 1.16
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
High-definition velocity-space tomography of fast-ion dynamics

Velocity-space tomography of the fast-ion distribution function in a fusion plasma is usually a photon-starved tomography method due to limited optical access and signal-to-noise ratio of fast-ion D$_\alpha$ (FIDA) spectroscopy as well as the strive for high-resolution images. In high-definition tomography, prior information makes up for this lack of data. We restrict the target velocity space through the measured absence of FIDA light, impose phase-space densities to be non-negative, and encode the known geometry of neutral beam injection (NBI) sources. We further use a numerical simulation as prior information to reconstruct where in velocity space the measurements and the simulation disagree. This alternative approach is demonstrated for four-view as well as for two-view FIDA measurements. The high-definition tomography tools allow us to study fast ions in sawtoohing plasmas and the formation of NBI peaks at full, half and one-third energy by time-resolved tomographic movies.

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Organisations: Department of Physics, Plasma Physics and Fusion Energy, Department of Applied Mathematics and Computer Science, Scientific Computing, Max-Planck-Institut fur Plasmaphysik, University of California at Irvine, University of Milano Bicocca
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Scopus rating (2015): SJR 1.288 SNIP 1.43 CiteScore 1.88
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.705 SNIP 1.476 CiteScore 2.2
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.128 SNIP 1.129 CiteScore 1.83
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.397 SNIP 1.216 CiteScore 1.81
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 2.056 SNIP 2.366 CiteScore 3.78
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 2.307 SNIP 1.923
Web of Science (2010): Indexed yes
High power microwave diagnostic for the fusion energy experiment ITER

Microwave diagnostics will play an increasingly important role in burning plasma fusion energy experiments like ITER and beyond. The Collective Thomson Scattering (CTS) diagnostic to be installed at ITER is an example of such a diagnostic with great potential in present and future experiments. The ITER CTS diagnostic will inject a 1 MW 60 GHz gyrotron beam into the ITER plasma and observe the scattering off fluctuations in the plasma — to monitor the dynamics of the fast ions generated in the fusion reactions.

General information

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Source: PublicationPreSubmission
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Publication: Research - peer-review › Poster – Annual report year: 2016

Inflow of atomic gas fuelling star formation
Gamma-ray burst host galaxies are deficient in molecular gas, and show anomalous metal-poor regions close to GRB positions. Using recent Australia Telescope Compact Array (ATCA) HI observations we show that they have substantial atomic gas reservoirs. This suggests that star formation in these galaxies may be fuelled by recent inflow of metal-poor atomic gas. While this process is debated, it can happen in low-metallicity gas near the onset of star formation because gas cooling (necessary for star formation) is faster than the HI-to-H₂ conversion.

General information
State: Published
Organisations: Department of Physics, Plasma Physics and Fusion Energy, University of Edinburgh, Universiteit Gent, University of Copenhagen, University of California at Santa Cruz, University of Leicester, University of Sydney, Aix Marseille Universite, Max-Planck-Institut fur extraterrestrische Physik, European Space Agency, Osservatorio Astronomico di Roma, Osservatorio Astrofisico Di Arcetri, Florence, Thüringer Landessternwarte Tautenburg, Laboratoire AIM-Paris-Saclay, National Institute for Astrophysics, University of Calabria, IT University of Copenhagen, Osservatorio Astronomico di Brera, Leiden University
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Conference: XXIXth IAU General Assembly, Honolulu, HI, United States, 03/08/2015 - 03/08/2015
Main Research Area: Technical/natural sciences
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BFI (2018): BFI-level 1
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Inversion methods for fast-ion velocity-space tomography in fusion plasmas

Velocity-space tomography has been used to infer 2D fast-ion velocity distribution functions. Here we compare the performance of five different tomographic inversion methods: truncated singular value decomposition, maximum entropy, minimum Fisher information and zeroth and first-order Tikhonov regularization. The inversion methods are applied to fast-ion Dα measurements taken just before and just after a sawtooth crash in the ASDEX Upgrade tokamak as well as to synthetic measurements from different test distributions. We find that the methods regularizing by penalizing steep gradients or maximizing entropy perform best. We assess the uncertainty of the calculated inversions taking into account photon noise, uncertainties in the forward model as well as uncertainties introduced by the regularization which allows us to distinguish regions of high and low confidence in the tomographies. In high confidence regions, all methods agree that ions with pitch values close to zero, as well as ions with large pitch values, are ejected from the plasma center by the sawtooth crash, and that this ejection depletes the ion population with large pitch values more strongly.

General information
State: Published
Organisations: Department of Physics, Plasma Physics and Fusion Energy, Max Planck Institute for Plasma Physics, University of California, Irvine
Authors: Jacobsen, A. S. (Intern), Stagner, L. (Ekstern), Salewski, M. (Intern), Geiger, B. (Ekstern), Heidbrink, W. (Ekstern), Korsholm, S. B. (Intern), Leipold, F. (Intern), Nielsen, S. K. (Intern), Rasmussen, J. (Intern), Pedersen, M. S. (Intern), Thomsen, H. (Ekstern), Weiland, M. (Ekstern)
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Publication information
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1 SJR 0.583 SNIP 0.617
Web of Science (2016): Indexed yes
Measuring main-ion temperatures in ASDEX upgrade using scattering of ECRH radiation

We demonstrate that collective Thomson scattering of millimeter wave electron cyclotron resonance heating radiation can be used for measurements of the main-ion temperature in the ASDEX Upgrade tokamak.

Original language: English

Measuring main-ion temperatures in ASDEX upgrade using scattering of ECRH radiation

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Original language: English

Measuring main-ion temperatures in ASDEX upgrade using scattering of ECRH radiation

We demonstrate that collective Thomson scattering of millimeter wave electron cyclotron resonance heating radiation can be used for measurements of the main-ion temperature in the ASDEX Upgrade tokamak.

Original language: English
Millimeter-wave receiver design for plasma diagnostics

Scattered millimeter waves entering from the collective Thomson scattering diagnostic at ASDEX Upgrade fusion device are generally elliptically polarized. In order to convert the millimeter waves to linearly polarized waves (required for the detector), birefringent window assemblies (sapphire) have been developed to replace grooved metal mirrors. This allows a significantly more compact receiver design which is less susceptible to misalignment. The setup has been tested and implemented at ASDEX Upgrade.

Numerical and experimental study of the redistribution of energetic and impurity ions by sawteeth in ASDEX Upgrade:

Paper

In the non-linear phase of a sawtooth, the complete reconnection of field lines around the $q = 1$ flux surface often occurs resulting in a radial displacement of the plasma core. A complete time-dependent electromagnetic model of this type of reconnection has been developed and implemented in the EBdyna_go code. This contribution aims at studying the behaviour of ions, both impurity and fast particles, in the pattern of reconnecting field lines during sawtoothing plasma experiments in the ASDEX Upgrade tokamak by using the newly developed numerical framework. Simulations of full reconnection with tungsten impurity that include the centrifugal force are achieved and recover the soft x-ray measurements. Based on this full-reconnection description of the sawtooth, a simple tool dedicated to estimate the duration of the reconnection is introduced. This work then studies the redistribution of fast ions during several experimentally observed sawteeth. In some cases of sawteeth at ASDEX Upgrade, full reconnection is not always
observed or expected so the code gives an upper estimate of the actual experimental redistribution. The results of detailed simulations of the crashes are compared with measurements from various diagnostics such as collective Thomson scattering and fast-ion D-alpha (FIDA) spectroscopy, including FIDA tomography. A convincing qualitative agreement is found in different parts of velocity space.

**General information**

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Organisations: Department of Physics, Plasma Physics and Fusion Energy, FOM Dutch Institute for Fundamental Energy Research, Max Planck Institute for Plasma Physics
Authors: Jaulmes, F. (Ekstern), Geiger, B. (Ekstern), Odstrčil, T. (Ekstern), Weiland, M. (Ekstern), Salewski, M. (Intern), Jacobsen, A. S. (Intern), Rasmussen, J. (Intern), Pedersen, M. S. (Intern), Nielsen, S. K. (Intern), Westerhof, E. (Ekstern)
Number of pages: 12
Publication date: 2016
Main Research Area: Technical/natural sciences

**Publication information**

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- BFI (2018): BFI-level 1
- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 1
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 1.62 SJR 1.01 SNIP 0.942
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): SJR 1.288 SNIP 1.43 CiteScore 1.88
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 1.705 SNIP 1.476 CiteScore 2.2
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 1.128 SNIP 1.129 CiteScore 1.83
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 1.397 SNIP 1.216 CiteScore 1.81
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): SJR 2.056 SNIP 2.366 CiteScore 3.78
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 2.307 SNIP 1.923
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 2.021 SNIP 2.457
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 1
- Scopus rating (2008): SJR 2.076 SNIP 1.754
- Web of Science (2008): Indexed yes
- Scopus rating (2007): SJR 2.059 SNIP 2.02
We present sigame (SImulator of GAlaxy Millimetre/submillimetre Emission), a new numerical code designed to simulate the $^{12}$CO rotational line spectrum of galaxies. Using sub-grid physics recipes to post-process the outputs of smoothed particle hydrodynamics (SPH) simulations, a molecular gas phase is condensed out of the hot and partly ionized SPH gas. The gas is subjected to far-UV radiation fields and cosmic ray ionization rates which are set to scale with the local star formation rate volume density. Level populations and radiative transport of the CO lines are solved with the 3D radiative transfer code lime. We have applied sigame to cosmological SPH simulations of three disc galaxies at $z=2$ with stellar masses in the range $0.5–2 \times 10^{11} \, M_\odot$ and star formation rates $40–140 \, M_\odot \, yr^{-1}$. Global CO luminosities and line ratios are in agreement with observations of disc galaxies at $z=2$ up to and including $J=3–2$ but falling short of the few existing $J=5–4$ observations. The central 5kpc regions of our galaxies have CO $3–2/1–0$ and $7–6/1–0$ brightness temperature ratios of $\sim 0.55–0.65$ and $\sim 0.02–0.08$, respectively, while further out in the disc the ratios drop to more quiescent values of $\sim 0.5$ and $\lesssim 0.01$. Global CO-to-H$_2$ conversion ($\alpha_{\text{CO}}$) factors are $\sim 1.5 M_\odot pc^{-2} (\text{Kkm} s^{-1})^{-1}$, i.e. $\sim 2–3$ times below the typically adopted values for disc galaxies, and $\alpha_{\text{CO}}$ increases with radius, in agreement with observations of nearby galaxies. Adopting a top-heavy Giant Molecular Cloud (GMC) mass spectrum does not significantly change the results. Steepening the GMC density profiles leads to higher global line ratios for $J \geq 3$ and CO-to-H$_2$ conversion factors $[\sim 3.6 M_\odot pc^{-2} (\text{Kkm} s^{-1})^{-1}]$. 

General information
State: Published
Organisations: IT Service, Department of Physics, Plasma Physics and Fusion Energy, University of Copenhagen, University College London
Authors: Olsen, K. P. (Ekstern), Greve, T. R. (Ekstern), Brinch, C. (Intern), Sommer-Larsen, J. (Ekstern), Rasmussen, J. (Intern), Toft, S. (Ekstern), Zirm, A. (Ekstern)
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Web of Science (2017): Indexed Yes
Three-wave interaction during electron cyclotron resonance heating and current drive
Non-linear wave-wave interactions in fusion plasmas, such as the parametric decay instability (PDI) of gyrotron radiation, can potentially hamper the use of microwave diagnostics. Here we report on anomalous scattering in the ASDEX Upgrade tokamak during electron cyclotron resonance heating experiments. The observations can be linked to parametric decay of the gyrotron radiation at the second harmonic upper hybrid resonance layer.

General information
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ISSN: 2162-2027
Main Research Area: Technical/natural sciences
DOIs: 10.1109/IRMMW-THz.2016.7758400
Source: FindIt
Source-ID: 2349437031
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

Velocity-space tomography of fusion plasmas by collective Thomson scattering of gyrotron radiation
We propose a diagnostic capable of measuring 2D fast-ion velocity distribution functions 푓2퐷푣 in the MeV-range in magnetized fusion plasmas. Today velocity-space tomography based on fast-ion D훼 spectroscopy is regularly used to measure 푓2퐷푣 for ion energies below 100 keV. Unfortunately, the signal-to-noise ratio becomes fairly low for MeV-range ions. Ions at any energy can be detected well by collective Thomson scattering of mm-wave radiation from a high-power gyrotron. We demonstrate how collective Thomson scattering can be used to measure 푓2퐷푣 in the MeV-range in reactor relevant plasmas such as in the tokamaks ITER or DEMO.

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Main Research Area: Technical/natural sciences
DOIs: 10.1109/IRMMW-THz.2016.7758534
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016
Bulk Ion Heating with ICRF Waves in Tokamaks

Heating with ICRF waves is a well-established method on present-day tokamaks and one of the heating systems foreseen for ITER. However, further work is still needed to test and optimize its performance in fusion devices with metallic high-Z plasma facing components (PFCs) in preparation of ITER and DEMO operation. This is of particular importance for the bulk ion heating capabilities of ICRF waves. Efficient bulk ion heating with the standard ITER ICRF scheme, i.e. the second harmonic heating of tritium with or without $^3$He minority, was demonstrated in experiments carried out in deuterium-tritium plasmas on JET and TFTR and is confirmed by ICRF modelling. This paper focuses on recent experiments with $^3$He minority heating for bulk ion heating on the ASDEX Upgrade (AUG) tokamak with ITER-relevant all-tungsten PFCs. An increase of 80% in the central ion temperature $T_i$ from 3 to 5.5 keV was achieved when 3 MW of ICRF power tuned to the central $^3$He ion cyclotron resonance was added to 4.5 MW of deuterium NBI. The radial gradient of the $T_i$ profile reached locally values up to about 50 keV/m and the normalized logarithmic ion temperature gradients $R/LT_i$ of about 20, which are unusually large for AUG plasmas. The large changes in the $T_i$ profiles were accompanied by significant changes in measured plasma toroidal rotation, plasma impurity profiles and MHD activity, which indicate concomitant changes in plasma properties with the application of ICRF waves. When the $^3$He concentration was increased above the optimum range for bulk ion heating, a weaker peaking of the ion temperature profile was observed, in line with theoretical expectations.

General information

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Organisations: Department of Physics, Plasma Physics and Fusion Energy, Catalan Institution for Research and Advanced Studies, Max-Planck-Institut fur Plasmaphysik, Istituto di Fisica del Plasma, KTH - Royal Institute of Technology

Authors: Mantsinen, M. J. (Ekstern), Bilato, R. (Ekstern), Bobkov, V. V. (Ekstern), Kappatou, A. (Ekstern), McDermott, R. M. (Ekstern), Nocente, M. (Ekstern), Odstrcil, T. (Ekstern), Tardini, G. (Ekstern), Bernert, M. (Ekstern), Dux, R. (Ekstern), Hellsten, T. (Ekstern), Mantica, P. (Ekstern), Maraschek, M. (Ekstern), Nielsen, S. K. (Intern), Noterdaeme, J. (Ekstern), Rasmussen, J. (Intern), Ryter, F. (Ekstern), Pedersen, M. S. (Intern), Stober, J. (Ekstern), Tardocchi, M. (Ekstern)

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Main Research Area: Technical/natural sciences

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BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.21 SJR 0.163 SNIP 0.236
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.179 SNIP 0.217 CiteScore 0.18
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.165 SNIP 0.191 CiteScore 0.17
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.16 SNIP 0.173 CiteScore 0.16
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.17 SNIP 0.176 CiteScore 0.14
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.153 SNIP 0.141 CiteScore 0.12
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.16 SNIP 0.144
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.157 SNIP 0.137
BFI (2008): BFI-level 1
Consistency between real and synthetic fast-ion measurements at ASDEX Upgrade

Internally consistent characterization of the properties of the fast-ion distribution from multiple diagnostics is a prerequisite for obtaining a full understanding of fast-ion behavior in tokamak plasmas. Here we benchmark several absolutely-calibrated core fast-ion diagnostics at ASDEX Upgrade by comparing fast-ion measurements from collective Thomson scattering, fast-ion spectroscopy, and neutron rate detectors with numerical predictions from the TRANSP/NUBEAM transport code. We also study the sensitivity of the theoretical predictions to uncertainties in the plasma kinetic profiles. We find that theory and measurements generally agree within these uncertainties for all three diagnostics during heating phases with either one or two neutral beam injection sources. This suggests that the measurements can be described by the same model assuming classical slowing down of fast ions. Since the three diagnostics in the adopted configurations probe partially overlapping regions in fast-ion velocity space, this is also consistent with good internal agreement among the measurements themselves. Hence, our results support the feasibility of combining multiple diagnostics at ASDEX Upgrade to reconstruct the fast-ion distribution function in 2D velocity space.
Determining fast-ion velocity-space distribution functions using velocity-space tomography

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Organisations: Department of Physics, Plasma Physics and Fusion Energy, Max Planck Institute for Plasma Physics, University of California, Irvine, Uppsala University
Authors: Jacobsen, A. S. (Intern), Salewski, M. (Intern), Geiger, B. (Ekstern), Stagner, L. (Ekstern), Eriksson, J. (Ekstern), Nielsen, S. K. (Intern), Heidbrink, W. (Ekstern), Korsholm, S. B. (Intern), Leipold, F. (Intern), Rasmussen, J. (Intern), Pedersen, M. S. (Intern), Weiland, M. (Ekstern)
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Publication date: 2015
Doppler tomography in fusion plasmas and astrophysics

Doppler tomography is a well-known method in astrophysics to image the accretion flow, often in the shape of thin discs, in compact binary stars. As accretion discs rotate, all emitted line radiation is Doppler-shifted. In fast-ion Dα (FIDA) spectroscopy measurements in magnetically confined plasma, the Dα-photons are likewise Doppler-shifted ultimately due to gyration of the fast ions. In either case, spectra of Doppler-shifted line emission are sensitive to the velocity distribution of the emitters. Astrophysical Doppler tomography has lead to images of accretion discs of binaries revealing bright spots, spiral structures and flow patterns. Fusion plasma Doppler tomography has led to an image of the fast-ion velocity distribution function in the tokamak ASDEX Upgrade. This image matched numerical simulations very well. Here we discuss achievements of the Doppler tomography approach, its promise and limits, analogies and differences in astrophysical and fusion plasma Doppler tomography and what can be learned by comparison of these applications.
First operations with the new Collective Thomson Scattering diagnostic on the Frascati Tokamak Upgrade device

Anomalous emissions were found over the last few years in spectra of Collective Thomson Scattering (CTS) diagnostics in tokamak devices such as TEXTOR, ASDEX and FTU, in addition to real CTS signals. The signal frequency, down-shifted with respect to the probing one, suggested a possible origin in Parametric Decay Instability (PDI) processes correlated with the presence of magnetic islands and occurring for pumping wave power levels well below the threshold predicted by conventional models. A threshold below or close to the Electron Cyclotron Resonance Heating (ECRH) power levels could limit, under certain circumstances, the use of the ECRH in fusion devices. An accurate characterization of the conditions for the occurrence of this phenomenon and of its consequences is thus of primary importance. Exploiting the front-steering configuration available with the real-time launcher, the implementation of a new CTS setup now allows studying these anomalous emission phenomena in FTU under conditions of density and wave injection geometry that are more similar to those envisaged for CTS in ITER. The upgrades of the diagnostic are presented as well as a few preliminary spectra detected with the new system during the very first operations in 2014.
Massive stars formed in atomic hydrogen reservoirs: H i observations of gamma-ray burst host galaxies

Long gamma-ray bursts (GRBs), among the most energetic events in the Universe, are explosions of massive and short-lived stars, so they pinpoint locations of recent star formation. However, several GRB host galaxies have recently been
found to be deficient in molecular gas (H$_2$), believed to be the fuel of star formation. Moreover, optical spectroscopy of GRB afterglows implies that the molecular phase constitutes only a small fraction of the gas along the GRB line of sight. Here we report the first ever 21 cm line observations of GRB host galaxies, using the Australia Telescope Compact Array, implying high levels of atomic hydrogen (HI), which suggests that the connection between atomic gas and star formation is stronger than previously thought. In this case, it is possible that star formation is directly fuelled by atomic gas (or that the H1-to-H$_2$ conversion is very efficient, which rapidly exhaust molecular gas), as has been theoretically shown to be possible. This can happen in low-metallicity gas near the onset of star formation because cooling of gas (necessary for star formation) is faster than the H1-to-H$_2$ conversion. Indeed, large atomic gas reservoirs, together with low molecular gas masses, stellar, and dust masses are consistent with GRB hosts being preferentially galaxies which have very recently started a star formation episode after accreting metal-poor gas from the intergalactic medium. This provides a natural route for forming GRBs in low-metallicity environments. The gas inflow scenario is also consistent with the existence of the companion HI object with no optical counterpart ~19 kpc from the GRB 060505 host, and with the fact that the HI centroids of the GRB 980425 and 060505 hosts do not coincide with optical centres of these galaxies, but are located close to the GRB positions.

General information
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Organisations: Department of Physics, Plasma Physics and Fusion Energy, University of Edinburgh, Universiteit Gent, University of Copenhagen, University of California, Santa Cruz, University of Leicester, Australia Telescope National Facility, University of Sydney, Max-Planck Institut für Extraterrestrische Physik, European Space Astronomy Centre and European Space Agency, ASI Science Data Center, National Institute for Astrophysics, Thüringer Landessternwarte Tautenburg, University Paris Diderot - Paris 7, University of Calabria, Stockholm University, Leiden University, Aix Marseille Université
Authors: Michałowski, M. J. (Ekstern), Gentile, G. (Ekstern), Hjorth, J. (Ekstern), Krumholz, M. R. (Ekstern), Tanvir, N. R. (Ekstern), Kamphuis, P. (Ekstern), Burlon, D. (Ekstern), Baes, M. (Ekstern), Basa, S. (Ekstern), Berta, S. (Ekstern), Castro Cerón, J. M. (Ekstern), Crosby, D. (Ekstern), D’Elia, V. (Ekstern), Elliott, J. (Ekstern), Greiner, J. (Ekstern), Hunt, L. K. (Ekstern), Klose, S. (Ekstern), Koprowski, M. P. (Ekstern), Le Floc’h, E. (Ekstern), Malesani, D. (Ekstern), Murphy, T. (Ekstern), Nicuesa Guelbenzu, A. (Ekstern), Palazzi, E. (Ekstern), Rasmussen, J. (Intern), Rossi, A. (Ekstern), Savaglio, S. (Ekstern), Schady, P. (Ekstern), Solierman, J. (Ekstern), de Ugarte Postigo, A. (Ekstern), Watson, D. (Ekstern), van der Werf, P. (Ekstern), Vergani, S. D. (Ekstern), Xu, D. (Ekstern)
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Main Research Area: Technical/natural sciences

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BFI (2016): BFI-level 2
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2016): CiteScore 3.68 SJR 2.246 SNIP 1.16
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.543 SNIP 1.189 CiteScore 3.5
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.823 SNIP 1.219 CiteScore 2.82
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.544 SNIP 1.058 CiteScore 2.01
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.585 SNIP 1.295 CiteScore 3.14
ISI indexed (2012): ISI indexed yes
Collective Thomson scattering (CTS) can provide measurements of the confined fast-ion distribution function resolved in space, time and 1D velocity space. On ASDEX Upgrade, the measured spectra include an additional signal which previously has hampered data interpretation. A new set-up using two independent heterodyne receiver systems enables subtraction of the additional part from the total spectrum, revealing the resulting CTS spectrum. Here we present CTS measurements from the plasma centre obtained in L-mode and H-mode plasmas with and without neutral beam injection (NBI). For the first time, the measured spectra agree quantitatively with the synthetic spectra in periods with and without NBI heating. For the discharges investigated, the central velocity distribution of neutral beam ions can be described by classical slowing down. These results will have a major impact on ITER physics exploration, since CTS is presently the only diagnostic to measure the confined alpha particles produced by the fusion reactions.
Overview of the JET results
Since the installation of an ITER-like wall, the JET programme has focused on the consolidation of ITER design choices and the preparation for ITER operation, with a specific emphasis given to the bulk tungsten melt experiment, which has been crucial for the final decision on the material choice for the day-one tungsten divertor in ITER. Integrated scenarios have been progressed with the re-establishment of long-pulse, high-confinement H-modes by optimizing the magnetic configuration and the use of ICRH to avoid tungsten impurity accumulation. Stationary discharges with detached divertor conditions and small edge localized modes have been demonstrated by nitrogen seeding. The differences in confinement and pedestral behaviour before and after the ITER-like wall installation have been better characterized towards the development of high fusion yield scenarios in DT. Post-mortem analyses of the plasma-facing components have confirmed the previously reported low fuel retention obtained by gas balance and shown that the pattern of deposition within the divertor has changed significantly with respect to the JET carbon wall campaigns due to the absence of thermally activated chemical erosion of beryllium in contrast to carbon. Transport to remote areas is almost absent and two orders of magnitude less material is found in the divertor.
Plasma rotation and ion temperature measurements by collective Thomson scattering at ASDEX Upgrade

We present the first deuterium ion temperature and rotation measurements by collective Thomson scattering at ASDEX Upgrade. The results are in general agreement with boron-based charge exchange recombination spectroscopy measurements and consistent with neoclassical simulations for the plasma scenario studied here. This demonstration opens the prospect for direct non-perturbative measurements of the properties of the main ion species in the plasma core with applications in plasma transport and confinement studies.
Recent ASDEX Upgrade research in support of ITER and DEMO

Recent experiments on the ASDEX Upgrade tokamak aim at improving the physics base for ITER and DEMO to aid the machine design and prepare efficient operation. Type I edge localized mode (ELM) mitigation using resonant magnetic perturbations (RMPs) has been shown at low pedestal collisionality. In contrast to the previous high ν* regime, suppression only occurs in a narrow RMP spectral window, indicating a resonant process, and a concomitant confinement drop is observed due to a reduction of pedestal top density and electron temperature. Strong evidence is found for the ion heat flux to be the decisive element for the L–H power threshold. A physics based scaling of the density at which the minimum PLH occurs indicates that ITER could take advantage of it to initiate H-mode at lower density than that of the final Q = 10 operational point. Core density fluctuation measurements resolved in radius and wave number show that an increase of R/LTe introduced by off-axis electron cyclotron resonance heating (ECRH) mainly increases the large scale fluctuations. The radial variation of the fluctuation level is in agreement with simulations using the GENE code. Fast particles are shown to undergo classical slowing down in the absence of large scale magnetohydrodynamic (MHD) events and for low heating power, but show signs of anomalous radial redistribution at large heating power, consistent with a broadened off-axis neutral beam current drive current profile under these conditions. Neoclassical tearing mode (NTM) suppression experiments using electron cyclotron current drive (ECCD) with feedback controlled deposition have allowed to test several control strategies for ITER, including automated control of (3,2) and (2,1) NTMs during a single discharge. Disruption mitigation studies using massive gas injection (MGI) can show an increased fuelling efficiency with high field side injection, but a saturation of the fuelling efficiency is observed at high injected mass as needed for runaway electron suppression. Large locked modes can significantly decrease the fuelling efficiency and increase the asymmetry of radiated power during MGI mitigation. Concerning power exhaust, the partially detached ITER divertor scenario has been demonstrated at Psep/R = 10 MW m⁻¹ in ASDEX Upgrade, with a peak time averaged target load around 5 MW m⁻², well consistent with the component limits for ITER. Developing this towards DEMO, full detachment was achieved at Psep/R = 7 MW m⁻¹ and stationary discharges with core radiation fraction of the order of DEMO requirements (70% instead of the 30% needed for ITER) were demonstrated. Finally, it remains difficult to establish the standard ITER Q = 10 scenario at low q₉₅ = 3 in the all-tungsten (all-W) ASDEX Upgrade due to the observed poor confinement at low βN. This is mainly due to a degraded pedestal performance and hence investigations at shifting the operational point to higher βN by lowering the current have been started. At higher q₉₅, pedestal performance can be recovered by seeding N₂ as well as CD₄, which is interpreted as improved pedestal stability due to the decrease of bootstrap current with increasing Zeff. Concerning advanced scenarios, the upgrade of ECRH power has allowed experiments with central ctrl-ECCD to modify the q-profile in improved H-mode scenarios, showing an increase in confinement at still good MHD stability with flat elevated q-profiles at values between 1.5 and 2.

General information

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Organisations: Department of Physics, Plasma Physics and Fusion Energy, Institute for Magnetic Fusion Research, VTT - Technical Research Centre of Finland, Aalto University, FOM Dutch Institute for Fundamental Energy Research, Instituto de Plasmas e Fusão Nuclear, Culham Science Centre, EURATOM Association, Max-Planck-Institut fur Plasmaphysik
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Publication information
Star formation suppression in compact group galaxies: a new path to quenching?
We present CO(1-0) maps of 12 warm H-2-selected Hickson Compact Groups (HCGs), covering 14 individually imaged warm H2 bright galaxies, with the Combined Array for Research in Millimeter Astronomy. We found a variety of molecular gas distributions within the HCGs, including regularly rotating disks, bars, rings, tidal tails, and possibly nuclear outflows, though the molecular gas morphologies are more consistent with spirals and earlytype galaxies than mergers and interacting systems. Our CO-imaged HCG galaxies, when plotted on the Kennicutt-Schmidt relation, shows star formation (SF) suppression of $S > 10 \pm 5$, distributed bimodally, with five objects exhibiting suppressions of $S$ greater than or similar to 10 and depletion timescales greater than or similar to 10 Gyr. This SF inefficiency is also seen in the efficiency per freefall time of Krumholz et al. We find that HCGs have normal gas-to-dust ratios. It is likely that the cause of the apparent suppression in these objects is associated with shocks injecting turbulence into the molecular gas, supported by the fact that the required turbulent injection luminosity is consistent with the bright $H_2$ luminosity reported by Cluver et al. Galaxies with high SF suppression ($S > 10$) also appear to be those in the most advanced stages of transition across both optical and infrared color space. This supports the idea that at least some galaxies in HCGs are transitioning objects, where a disruption of the existing molecular gas in the system suppresses SF by inhibiting the molecular gas from collapsing and forming stars efficiently. These observations, combined with recent work on poststarburst galaxies with molecular reservoirs, indicates that galaxies do not need to expel their molecular reservoirs prior to quenching SF and transitioning from blue spirals to red early-type galaxies. This may imply that SF quenching can occur without the need to starve a galaxy of cold gas first.
Velocity-space observation regions of high-resolution two-step reaction gamma-ray spectroscopy

High-resolution γ-ray spectroscopy (GRS) measurements resolve spectral shapes of Dopplerbroadened γ-rays. We calculate weight functions describing velocity-space sensitivities of any two-step reaction GRS measurements in magnetized plasmas using the resonant nuclear reaction $^{9}$Be($\alpha$, $n\gamma$)$^{12}$C as an example. The energy-dependent cross sections of this reaction suggest that GRS is sensitive to alpha particles above about 1.7 MeV and highly sensitive to alpha particles at the resonance energies of the reaction. Here we demonstrate that high-resolution two-step reaction GRS measurements are not only selective in energy but also in pitch angle. They can be highly sensitive in particular pitch angle ranges and completely insensitive in others. Moreover, GRS weight functions allow rapid calculation of γ-ray energy spectra from fast-ion distribution functions, additionally revealing how many photons any given alpha-particle velocity-space region contributes to the measurements in each γ-ray energy bin.

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Organisations: Department of Physics, Plasma Physics and Fusion Energy, University of Milano Bicocca, Culham Science Centre, Max Planck Institute for Plasma Physics, Consiglio Nazionale delle Ricerche
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Velocity-space sensitivity of neutron spectrometry measurements

Neutron emission spectrometry (NES) measures the energies of neutrons produced in fusion reactions. Here we present velocity-space weight functions for NES and neutron yield measurements. Weight functions show the sensitivity as well as the accessible regions in velocity space for a given range of the neutron energy spectrum. Combined with a calculated fast-ion distribution function, they determine the part of the distribution function producing detectable neutrons in a given neutron energy range. Furthermore, we construct a forward model based on weight functions capable of rapidly calculating neutron energy spectra. This forward model can be inverted and could thereby be used to directly measure the fast-ion phase-space distribution functions, possibly in combination with other fast-ion diagnostics. The presented methods and results can be applied to neutron energy spectra measured by any kind of neutron spectrometer and to any neutron yield measurement.

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ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.397 SNIP 1.216 CiteScore 1.81
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Web of Science (2012): Indexed yes
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Improved Collective Thomson Scattering measurements of fast ions at ASDEX Upgrade

Understanding the behaviour of the confined fast ions is important in both current and future fusion experiments. These ions play a key role in heating the plasma and will be crucial for achieving conditions for burning plasma in next-step fusion devices. Microwave-based Collective Thomson Scattering (CTS) is well suited for reactor conditions and offers such an opportunity by providing measurements of the confined fast-ion distribution function resolved in space, time and 1D velocity space. We currently operate a CTS system at ASDEX Upgrade using a gyrotron which generates probing radiation at 105 GHz. A new setup using two independent receiver systems has enabled improved subtraction of the background signal, and hence the first accurate characterization of fast-ion properties. Here we review this new dual-receiver CTS setup and present results on fast-ion measurements based on the improved background characterization. These results have been obtained both with and without NBI heating, and with the measurement volume located close to the centre of the plasma. The measurements agree quantitatively with predictions of numerical simulations. Hence, CTS studies of fast-ion dynamics at ASDEX Upgrade are now feasible. The new background subtraction technique could be important for the design of CTS systems in other fusion experiments.
Measurement of a 2D fast-ion velocity distribution function by tomographic inversion of fast-ion D-alpha spectra

We present the first measurement of a local fast-ion 2D velocity distribution function $f(v_\parallel, v_\perp)$. To this end, we heated a plasma in ASDEX Upgrade by neutral beam injection and measured spectra of fast-ion Dα (FIDA) light from the plasma centre in three views simultaneously. The measured spectra agree very well with synthetic spectra calculated from a TRANSP/NUBEAM simulation. Based on the measured FIDA spectra alone, we infer $f(v_\parallel, v_\perp)$ by tomographic inversion. Salient features of our measurement of $f(v_\parallel, v_\perp)$ agree reasonably well with the simulation: the measured as well as the simulated $f(v_\parallel, v_\perp)$ are lopsided towards negative velocities parallel to the magnetic field, and they have similar shapes. Further, the peaks in the simulation of $f(v_\parallel, v_\perp)$ at full and half injection energies of the neutral beam also appear in the measurement at similar velocity-space locations. We expect that we can measure spectra in up to seven views simultaneously in the next ASDEX Upgrade campaign which would further improve measurements of $f(v_\parallel, v_\perp)$ by
tomographic inversion.

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- ISI indexed (2012): ISI indexed yes  
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- BFI (2011): BFI-level 1  
- Scopus rating (2011): SJR 2.056 SNIP 2.366 CiteScore 3.78  
- ISI indexed (2011): ISI indexed yes  
- Web of Science (2011): Indexed yes  
- BFI (2010): BFI-level 1  
- Scopus rating (2010): SJR 2.307 SNIP 1.923  
- Web of Science (2010): Indexed yes  
- BFI (2009): BFI-level 1  
- Scopus rating (2009): SJR 2.021 SNIP 2.457  
- Web of Science (2009): Indexed yes  
- BFI (2008): BFI-level 1  
- Scopus rating (2008): SJR 2.076 SNIP 1.754  
- Web of Science (2008): Indexed yes  
- Scopus rating (2007): SJR 2.059 SNIP 2.02  
- Web of Science (2007): Indexed yes  
- Scopus rating (2006): SJR 2.068 SNIP 1.855  
- Web of Science (2006): Indexed yes
On velocity-space sensitivity of fast-ion D-alpha spectroscopy

The velocity-space observation regions and sensitivities in fast-ion Dα (FIDA) spectroscopy measurements are often described by so-called weight functions. Here we derive expressions for FIDA weight functions accounting for the Doppler shift, Stark splitting, and the charge-exchange reaction and electron transition probabilities. Our approach yields an efficient way to calculate correctly scaled FIDA weight functions and implies simple analytic expressions for their boundaries that separate the triangular observable regions in (v‖, v⊥)-space from the unobservable regions. These boundaries are determined by the Doppler shift and Stark splitting and could until now only be found by numeric simulation.

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1 SJR 0.583 SNIP 0.617
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.734 SNIP 0.864 CiteScore 1.1
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Resolving the bulk ion region of millimeter-wave collective Thomson scattering spectra at ASDEX Upgrade

Collective Thomson scattering (CTS) measurements provide information about the composition and velocity distribution of confined ion populations in fusion plasmas. The bulk ion part of the CTS spectrum is dominated by scattering off fluctuations driven by the motion of thermalized ion populations. It thus contains information about the ion temperature, rotation velocity, and plasma composition. To resolve the bulk ion region and access this information, we installed a fast acquisition system capable of sampling rates up to 12.5 GS/s in the CTS system at ASDEX Upgrade. CTS spectra with frequency resolution in the range of 1 MHz are then obtained through direct digitization and Fourier analysis of the CTS signal. We here describe the design, calibration, and operation of the fast receiver system and give examples of measured bulk ion CTS spectra showing the effects of changing ion temperature, rotation velocity, and plasma composition.
Spatially-resolved dust properties of the GRB 980425 host galaxy

Gamma-ray bursts (GRBs) have been proposed as a tool to study star formation in the Universe, so it is crucial to investigate whether their host galaxies and immediate environments are in any way special compared with other star-forming galaxies. Here we present spatially resolved maps of dust emission of the host galaxy of the closest known GRB 980425 at z=0.0085 using our new high-resolution observations from Herschel, APEX, ALMA and ATCA. We modeled the spectral energy distributions of the host and of the star-forming region displaying the Wolf-Rayet signatures in the spectrum (WR region), located 800 pc away from the GRB position. The host is characterised by low dust content and high fraction of UV-visible star-formation, similar to other dwarf galaxies. Such galaxies are abundant in the local universe, so it is not surprising to find a GRB in one of them, assuming the correspondence between the GRB rate and star-formation. The WR region contributes substantially to the host emission at the far-infrared, millimeter and radio wavelengths and we propose this to be a consequence of its high gas density. If dense environments are also found close to the positions of other GRBs, then the ISM density should also be considered as an important factor influencing whether a given stellar population can produce a GRB, in a similar way as metallicity.
BFI (2017): BFI-level 2
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.68 SJR 2.246 SNIP 1.16
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 2.543 SNIP 1.189 CiteScore 3.5
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 2.823 SNIP 1.219 CiteScore 2.82
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 2.544 SNIP 1.058 CiteScore 2.01
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 2.585 SNIP 1.295 CiteScore 3.14
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.373 SNIP 1.231 CiteScore 3.42
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.74 SNIP 1.444
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.879 SNIP 1.404
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.923 SNIP 1.297
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.816 SNIP 1.34
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 3.224 SNIP 1.349
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.891 SNIP 1.355
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.63 SNIP 1.462
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.967 SNIP 1.373
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.742 SNIP 1.346
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.555 SNIP 0.727
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 2.178 SNIP 1.039
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 2.489 SNIP 1.076
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Strong far-infrared cooling lines, peculiar CO kinematics, and possible star-formation suppression in Hickson compact group 57

We present [C II] and [O I] observations from Herschel and CO(1-0) maps from the Combined Array for Research in Millimeter Astronomy (CARMA) of the Hickson compact group HCG 57, focusing on the galaxies HCG 57a and HCG 57d. HCG 57a has been previously shown to contain enhanced quantities of warm molecular hydrogen consistent with shock or turbulent heating. Our observations show that HCG 57d has strong [C II] emission compared to L-FIR and weak CO(1-0), while in HCG 57a, both the [C II] and CO(1-0) are strong. HCG 57a lies at the upper end of the normal distribution of the [C II]/CO and [C II]/FIR ratios, and its far-infrared (FIR) cooling supports a low-density, warm, diffuse gas that falls close to the boundary of acceptable models of a photon-dominated region. However, the power radiated in the [C II] and warm H$_2$ emissions have similar magnitudes, as seen in other shock-dominated systems and predicted by recent models. We suggest that shock heating of the [C II] is a viable alternative to photoelectric heating in violently disturbed, diffuse gas.

The existence of shocks is also consistent with the peculiar CO kinematics in the galaxy, indicating that highly noncircular motions are present. These kinematically disturbed CO regions also show evidence of suppressed star formation, falling a factor of 10-30 below normal galaxies on the Kennicutt-Schmidt relation. We suggest that the peculiar properties of both galaxies are consistent with a highly dissipative, off-center collisional encounter between HCG 57d and 57a, creating ring-like morphologies in both systems. Highly dissipative gas-on-gas collisions may be more common in dense groups because of the likelihood of repeated multiple encounters. The possibility of shock-induced star-formation suppression may explain why a subset of these HCG galaxies has been found previously to fall in the mid-infrared green valley.

General information
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Organisations: Department of Physics, Plasma Physics and Fusion Energy, California Institute of Technology, Universidad De Granada, Universidad Nacional Autonoma de Mexico, Universite Paris-Sud, University of Crete, Australian National University, Stockholm University, Instituto de Astrofísica de Andalucía, University of Massachusetts, University of Cape Town
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Scopus rating (2015): CiteScore 4.8
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.57
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Strong scattering of mm-waves in tokamaks

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Source-ID: 99593238
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Towards fusion energy as a sustainable energy source: Activities at DTU Physics

Nuclear fusion – the process from which the Sun derives its energy – holds the potential to become a clean, safe, highly efficient, and virtually inexhaustible energy source for the future. To mimic this process on earth, experimental fusion devices seek to heat gas to millions of degrees (creating a fusion plasma) and to confine it within magnetic fields. Learning how such plasmas behave and can be controlled is a crucial step towards realizing fusion as a sustainable energy source. At the Plasma Physics and Fusion Energy (PPFE) section at DTU Physics, we are exploring these issues, focusing on areas of high priority on the way towards a working fusion power plant. On the theoretical front, we are simulating plasma turbulence and transport of heat and particles in fusion plasmas (Fig. 1a). These issues play a key role in determining how the plasma behaves globally and how well it remains confined in the magnetic field of the fusion device. Understanding this is important for optimizing plasma performance and for controlling the heat load onto the walls of the confining vessel. Experimentally, we operate equipment to measure key plasma properties in experimental fusion devices such as ASDEX Upgrade in Germany (Fig. 1b+c). Using a technique called collective Thomson scattering (CTS), we can infer the plasma composition and the dynamics of energetic ions in the plasma. Control of these parameters is vital for achieving a high fusion yield in future power plants. We are also designing CTS equipment for the next-step fusion device ITER (Fig. 1d), in which plasma temperatures will exceed 200 million C. This machine is currently being built in France in a large international effort to experimentally demonstrate fusion as a viable energy source and pave the way for the first fusion power plant.

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Velocity-space interrogation regions of neutron spectrometers

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Velocity-space sensitivity of the time-of-flight neutron spectrometer at JET

The velocity-space sensitivities of fast-ion diagnostics are often described by so-called weight functions. Recently, we formulated weight functions showing the velocity-space sensitivity of the often dominant beam-target part of neutron energy spectra. These weight functions for neutron emission spectrometry (NES) are independent of the particular NES diagnostic. Here we apply these NES weight functions to the time-of-flight spectrometer TOFOR at JET. By taking the instrumental response function of TOFOR into account, we calculate time-of-flight NES weight functions that enable us to directly determine the velocity-space sensitivity of a given part of a measured time-of-flight spectrum from TOFOR.
How to compute velocity-space tomographies using several fast-ion diagnostics

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Measuring the total and baryonic mass profiles of the very massive CASSOWARY 31 strong lens: A fossil system at z ≃ 0.77
We investigate the total and baryonic mass distributions in deflector number 31 (CSWA 31) of the Cambridge And Sloan Survey Of Wide ARcs in the skY (CASSOWARY). We confirm spectroscopically a four-image lensing system at redshift 1.4870 with Very Large Telescope/X-shooter observations. The lensed images are distributed around a bright early-type galaxy at redshift 0.683, surrounded by several smaller galaxies at similar photometric redshifts. We use available optical and X-ray data to constrain the deflector total, stellar and hot gas mass through, respectively, strong lensing, stellar population analysis and plasma modelling. We derive a total mass projected within the Einstein radius R-Ein = 70 kpc of (40 +/- 1) x 10(12) M-circle dot, and a central logarithmic slope of -1.7 +/- 0.2 for the total mass density. Despite a very high stellar mass and velocity dispersion of the central galaxy of (3 +/- 1) x 10(12) M-circle dot and (450 +/- 80) km s(-1), respectively, the cumulative stellar-to-total mass profile of the deflector implies a remarkably low stellar mass fraction of 20
per cent (3-6 per cent) in projection within the central galaxy effective radius $R_e = 25$ kpc ($R = 100$ kpc). We also find that the CSWA 31 deflector has properties suggesting it to be among the most distant and massive fossil systems studied so far. The unusually strong central dark matter dominance and the possible fossil nature of this system render it an interesting target for detailed tests of cosmological models and structure formation scenarios.

**General information**

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Authors: Grillo, C. (Forskerdatabase), Christensen, L. (Ekstern), Gallazzi, A. (Forskerdatabase), Rasmussen, J. (Intern)
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.175 SNIP 1.289 CiteScore 4.79
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 3.113 SNIP 1.218 CiteScore 5.1
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
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Scopus rating (2012): SJR 3.159 SNIP 1.401 CiteScore 4.89
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BFI (2011): BFI-level 2
Scopus rating (2011): SJR 2.902 SNIP 1.355 CiteScore 4.63
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.035 SNIP 1.34
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.527 SNIP 1.444
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 3.611 SNIP 1.287
Scopus rating (2007): SJR 3.347 SNIP 1.283
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.948 SNIP 1.225
Scopus rating (2004): SJR 4.035 SNIP 1.372
Velocity-space tomography of the fast-ion distribution function

Fast ions play an important role in heating the plasma in a magnetic confinement fusion device. Fast-ion Dα (FIDA) spectroscopy diagnoses fast ions in small measurement volumes. Spectra measured by a FIDA diagnostic can be related to the 2D fast-ion velocity distribution function. A single FIDA view probes certain regions in velocity-space, determined by the geometry of the set-up. Exploiting this, the fast-ion distribution function can be inferred using a velocity-space tomography method. This poster contains a tomography calculated from measured spectra from three different FIDA views at ASDEX Upgrade. The quality of the tomography improves with the number of FIDA views simultaneously measuring the same volume. To investigate the potential benefits of including additional views (up to 18), tomographies are inferred from synthetic spectra calculated from a simulated distribution function. The number of experimentally available views can be increased by combining different types of diagnostics in a joint velocity-space tomography. Using this, up to 7 views are available at ASDEX Upgrade from 2014.

General information
State: Published
Organisations: Department of Physics, Plasma Physics and Fusion Energy, Max Planck Institute, University of Seville, University of California, Irvine
Publication date: 2013
Main Research Area: Technical/natural sciences

Publication information
Volume: 58
Issue number: 16
ISSN (Print): 0003-0503
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ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
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Original language: English
Publication: Research - peer-review > Conference abstract in journal – Annual report year: 2013

Velocity-space tomography using many-view CTS or FIDA systems

General information
State: Published
Organisations: Department of Physics, Plasma Physics and Fusion Energy, Max Planck Institute, Universidad de Sevilla, University of California
Number of pages: 4
Activities:

**Monitoring the state of a nuclear fusion plasma - the role of energetic ions**
Period: 30 Jan 2018
Jesper Rasmussen (Speaker)
Department of Physics
Plasma Physics and Fusion Energy

**Energetic particles in burning plasmas**
Period: 26 Sep 2017 → 28 Sep 2017
Jesper Rasmussen (Lecturer)
Department of Physics
Plasma Physics and Fusion Energy

**Velocity space tomography: Methods and results**
Period: 16 Jun 2017
Jesper Rasmussen (Speaker)
Department of Physics
Plasma Physics and Fusion Energy
Related event

2nd Joint Nordic Fusion Energy Seminar
15/06/2017 → 16/06/2017
Activity: Talks and presentations › Conference presentations

The DTU fusor – Fusion power at your fingertips
Period: 22 May 2017
Jesper Rasmussen (Speaker)
Department of Physics
Plasma Physics and Fusion Energy

Related event

Danish Physical Society Annual Meeting 2017
22/05/2017 → 23/05/2017
Activity: Talks and presentations › Conference presentations

Diagnosing fusion-born alpha particles in ITER (and DEMO?)
Period: 26 Sep 2016 → 30 Sep 2016
Jesper Rasmussen (Lecturer)
Department of Physics
Plasma Physics and Fusion Energy

Description
PhD lectures given at the 7th Sino-Danish Autumn School on Fusion Plasma Physics and Technology, Hefei, China

Related event

7th Sino-Danish Autumn School on Fusion Plasma Physics and Technology
26/09/2016 → 30/09/2016
Hefei, China
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

Hot enough for you? Monitoring the health of a nuclear fusion plasma
Period: 6 Jun 2016 → 7 Jun 2016
Jesper Rasmussen (Speaker)
Department of Physics
Plasma Physics and Fusion Energy

Description
Contributed talk, Danish Physical Society Annual Meeting 2016, Middelfart, Denmark. Awarded "Best Talk" at the meeting.

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

Fast ion properties in fusion plasmas: Theory and measurements
Period: 14 Sep 2015 → 18 Sep 2015
Jesper Rasmussen (Lecturer)
Department of Physics
Plasma Physics and Fusion Energy

Description
PhD lectures given at the 6th Sino-Danish Autumn School on Fusion Plasma Physics and Technology, Hefei, China
Related event

6th Sino-Danish Autumn School on Fusion Plasma Physics and Technology
14/09/2015 → 18/09/2015
Hefei, China
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

Investigating fast-ion transport due to sawtooth crashes using Collective Thomson Scattering
Period: 31 Aug 2015 → 4 Sep 2015
Jesper Rasmussen (Speaker)
Department of Physics
Plasma Physics and Fusion Energy

Description
Contributed talk, 14th IAEA Technical Meeting on Energetic Particles in Magnetic Confinement Systems, Vienna, Austria

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Fusionsenergi - efterligning af stjernernes energikilde
Period: 29 Jul 2015
Jesper Rasmussen (Lecturer)
Department of Physics
Plasma Physics and Fusion Energy

Description
Public lecture presented to high-school students at the UNF Fysik Camp 2015

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Talks and presentations in private or public companies and organisations

Fast ion properties in fusion plasmas: Theory and measurements
Period: 15 Sep 2014 → 19 Sep 2014
Jesper Rasmussen (Lecturer)
Department of Physics
Plasma Physics and Fusion Energy

Description
PhD lectures given at the 5th Sino-Danish Autumn School on Fusion Plasma Physics and Technology, Hefei, China

Related event
5th Sino-Danish Autumn School on Fusion Plasma Physics and Technology
15/09/2014 → 19/09/2014
Hefei, China
Activity: Talks and presentations › Guest lectures, external teaching and course activities at other universities

Prizes:

Best talk at DFS 2016
Jesper Rasmussen (Recipient)
Department of Physics, Plasma Physics and Fusion Energy
Award for "Best talk" (DKK 2500) at the Annual Meeting of the Danish Physical Society 2016

**Details**
Awarded date: 7 Jun 2016
Degree of recognition: National
Granting Organisations: Danish Physical Society
Prize: Prizes, scholarships, distinctions