EFDA WORKPROGRAMME 2010

Call for Participation

(Part of the EFDA WP, Transport TG)

Transport

Deadline for Responses: 20th November 2009

Topical Group Chair: Carlos Hidalgo

Topical Group Vice-Chairs: Clemente Angioni, Clarisse Bourdelle and Peter de Vries

EFDA CSU contact person: Boris Weyssow

This Call for Participation aims to implement the EFDA Work Programme for 2010 on Transport under Task Agreements as foreseen in the new EFDA Art. 5

Introduction

At its meeting in Prague on 12 March 2009, the EFDA Steering Committee approved elements of the EFDA 2010 Work Programme, including a set of tasks relating to the EFDA Topical Groups on Heating & Current Drive & Fuelling, MHD, Transport and Diagnostics.

This Call covers the Transport programme implemented under Task Agreements on the basis of the provisions given in Article-5 of the EFDA Agreement. No JET related activities are meant to be implemented as a result of this call. JET related activities are implemented under EFDA Article-6. However some JET activities are mentioned for information when they closely relate to the activity implemented under Article-5. JET data collected and analysed under the JET part of the EFDA WP can be brought together with other data under EFDA Article-5 Task Agreements when relevant for the progress of the work or used in multi-machine modelling activities. The activities to be implemented following this call for participation will be organised as follows:

Task Agreement WP10-TRA-01: L-H transition physics

- Triggering of the L-H transition
- Role of multi-scale mechanisms in the L-H transition
- Pedestal width physics
- L-H power threshold and ELM control techniques
- Hysteresis L-H versus H-L transition
- Role of atomic physics mechanisms

Task Agreement WP10-TRA-02: Turbulent electron transport

- H&CD mix effect on Electron transport
- Diagnostics for high-k and low-k instabilities
- ETG threshold
- Simulation of multi-scale transport

Task Agreement WP10-TRA-03: Particle and impurity transport in standard and advanced tokamak scenarios

- Experiments on impurity transport
- Internal heat transport barrier
- Central electron heating and plasma dynamics

Task Agreement WP10-TRA-04: Role of neoclassical and turbulent mechanisms in plasma rotation

- Diagnostics for plasma rotation
- Experiments and theory of plasma rotation

Task Agreement WP10-TRA-05: Statistical properties of edge turbulent transport

- Turbulent structures and intermittency
- Diagnostics for edge turbulence

Theory and modelling of edge turbulence

- Test particle experiments

1. Physics of L-H Transition:

Task Agreement WP10-TRA-01:
Physics of L-H Transition

1.1 Introduction

The edge H-mode pedestal and transition remain unexplained and the large uncertainties still present in the L-H transition power threshold have significant implications in the overall research programme of ITER. At present most experimental evidences strongly support the paradigm of sheared electric field suppression of turbulence to explain pedestal transport, although the underlying mechanisms that generate the electric fields remains an open issue.

1.2 Objectives

This physics activity focuses on the triggering mechanism (e.g. sheared flow), on the plasma turbulence, and on the profiles behaviour during the L-H transition.

Significant diagnostic developments are needed to progress on this issue, including:

- Pedestal width and height with focus on ion temperature measurements
- Edge Plasma current with appropriate spatial and time resolution
- Neutral density profiles with high spatial (1%) and time resolution (0.1ms)
- Radial electric field Er with high spatial (1%) and time resolution (0.1ms) and independent plasma rotation in view of analysing the role of ExB shear on edge turbulence suppression, the Er evolution during the L-H transition and the edge momentum role on confinement
- Turbulence diagnostics in view of analysing the suppression of turbulence and improved edge confinement: fluctuation levels of plasma potential, density, temperature and magnetic signals, correlation lengths (radial, poloidal and long range toroidal).

This topic is given the highest priority in terms of Priority Support within the Transport Topical Group.

1.3 Work Description and Breakdown

Work Breakdown

WP10-TRA-01-01

Triggering of the L-H transition

Improvement of the diagnostic capabilities for DC and fluctuation radial electric fields and measurements during edge transport bifurcations.

Investigation of the role of the DC/fluctuating electric field on the L-H transition and transport barrier formation.

WP10-TRA-01-02

Role of multi-scale mechanism in the L-H transition

Experimental and modelling studies of the underlying physics mechanisms linking DC electric fields and the development of zonal flows (in continuation of WP 2008/09 studies showing the amplification of multi-scale mechanisms by externally imposed electric fields in stellarators and tokamaks), role of magnetic configuration (e.g. safety factor, resonant magnetic perturbation, magnetic shear) and plasma parameters (e.g. collisionality) on long range correlations and influence of multi-scale mechanisms on edge transport.

WP10-TRA-01-03

Pedestal width physics

Multi-machine experiments with simultaneous measurements of profile and fluctuation, to quantify the importance of turbulence / neoclassical mechanisms in setting the pedestal structure (relation between electron, ion, density and Er widths with / without external resonant magnetic perturbations (RMPs), the pedestal and Er evolution in between ELMs and the role of turbulence spreading).

Development of pedestal structure modelling

WP10-TRA-01-04

L-H power threshold and ELM control techniques

Experimental investigation of L-H power threshold with ergodic divertor / resonant magnetic perturbation with different n number; density and Bt dependence; Tokamak-stellarators comparative studies (in particular role of magnetic shear and q).

WP10-TRA-01-05

Hysteresis L-H versus H-L transition

Comparative studies in different plasma regimes and description of the transitions in terms of local / global plasma parameters.

WP10-TRA-01-06

Role of atomic physics mechanisms

Investigation of the underlying mechanisms linking wall conditions (clean vs dirty plasmas, neutrals, ….) and isotope effect on L-H transition conditions.

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Resources

Baseline Support: manpower 6 ppy

Priority Support: manpower 4 ppy, 300 keuro of hardware

1.4 Scientific and Technical Reports

R&D Progress reports

At the end of each calendar year, during the Topical Group annual meeting, the Task Coordinator shall present a report on activities under the Task Agreement to the EFDA

Leader for his approval. These reports shall integrate the progress made by each Association on each activity, and they shall indicate the level of achievement of the objectives, the situation of the activities, the allocation of resources and recommendations for the next year when applicable. The EURATOM financial contribution will be made through the usual procedures for baseline support through the Contract of Association.

R&D Report of achievements under Priority Support

Achievement of Priority Support deliverables will be reported separately to the EFDA Leader. A final report (and intermediate reports marking substantial progress in the achievement of deliverables, if the EFDA Leader so requests) shall be prepared by the Task Coordinator and submitted to the EFDA Leader. Each participating Association will have to report in one subsection on the degree to which the deliverables of their Task have been achieved, and shall include a breakdown of expenditure. The Task Coordinator will collect the individual subsections into the final report for Priority Support activities addressing the milestones. The EURATOM financial contribution will be made after approval by the EFDA Leader of these reports.

Milestones and Deliverables

Milestones:

- Mid 2010 Activity Meetings: Collection and discussion of results obtained from the evaluation of theoretical work and experiments performed in 2009 and early 2010.
- End second trimester 2010 Annual meeting of the EU Transport Topical Group: coordinated presentation of the results from the theoretical work and experimental campaigns in 2010.
- December 2010 Final report sent to EFDA-CSU.

Deliverables:

- Diagnostics hardware for improved measurements of key parameters related to the L-H transition in support of detailed physics studies.
- Co-ordinated experiments
- Provide synthetic analysis by the group of experts involved, recommendation for future work and implications for ITER.

2. Turbulent electron transport:

Task Agreement WP10-TRA-02:
Turbulent electron transport: experimental search of turbulence and transport at small scales

2.1 Introduction

Ion transport in a wide range of operation scenarios can qualitatively be explained by theory-based models. Transport in other channels, in particular the electron transport, are not understood with the same level of confidence. From a theoretical point of view, two instabilities contribute: large ion scale (ITG/TEM) and smaller electron scale (ETG) instabilities, as well as the interplay of these scales (this is a great challenge for both diagnostics and simulations). In addition, magnetic instabilities like microtearing or Alfvenic modes could also provide a channel of electron heat transport in high beta scenarios. This topic is particularly relevant when electron heating dominates as eventually in ITER burning plasmas or ECRH dominated scenarios.

2.2 Objectives

Electron transport studies in various heating schemes and magnetic geometries.

Feasibility studies of plasma diagnostics for high k instabilities.

Interplay between high k and low k instabilities.

Use of existing diagnostics and development of new systems for small-scale fluctuations.

Characterization of plasma conditions which exceed or not the predicted linear ETG thresholds.

Numerical simulations of multi-scale turbulence and transport, which include kinetic effects at realistic mass ratio, relevant for comparisons with the experimental measurements.

2.3 Work Description and Breakdown

Work Breakdown

WP10-TRA-02-01

H&CD mix effect on Electron transport

Perform experiments and analysis of experiments performed in view of understanding the role of H&CD mix on electron transport.

WP10-TRA-02-02

Diagnostics for high-k and low-k instabilities

Perform feasibility studies of plasma diagnostics for high-k and low-k instabilities

WP10-TRA-02-03

ETG threshold

Perform experiments and analysis of experiments to identify plasma conditions which exceed or not the predicted linear ETG thresholds.

WP10-TRA-02-04

Simulation of multi-scale transport

Perform simulations of multi-scale transport

Develop simulation tools of turbulence and transport to characterize the role of small scales turbulence on electron transport.

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Resources

Baseline Support: manpower 3 ppy

Priority Support: manpower 1.5 ppy, 70 keuro of hardware.

2.4 Scientific and Technical Reports

R&D Progress reports

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- December 2010 Final report sent to EFDA-CSU.

Deliverables:

- Diagnostics hardware for improved measurements of key parameters related to electron transport in support of detailed physics studies in particular perform feasibility studies of plasma diagnostics for high k instabilities
- Co-ordinated experiments.
- Development of simulation tools of turbulence and transport to characterize the role of small scales turbulence on electron transport
- Provide synthetic analysis by the group of experts involved, recommendation for future work and implications for ITER.

3. Particle and impurity transport :

Task Agreement WP10-TRA-03:
Particle and impurity transport in standard and advanced tokamak scenarios

3.1 Introduction

The present understanding of impurity sources and accumulation is still insufficient to predict the behaviour of elements over the wide Z range from He to W. More intense comparison between theory and experiments is needed amongst different devices: scaling of transport with Z (to discriminate between turbulent and neoclassical transport in the core); experimental tracking of the ITG to TEM transition (anomalous convection expected to depend on the type of turbulence); impurity accumulation studies in regimes with ITBs; interplay between turbulence in the SOL and edge with impurity and particle source.

3.2 Objectives

Continuation and extension of the study the impurity transport (in combination with fluctuation measurements, when experimentally feasible) from standard to advanced tokamak scenarios, with particular focus on the behaviour of electrons, light and heavy impurities in the presence of an ITB. These studies are of particular interest in scenarios were a large fraction of non-inductive current is achieved.

3.3 Work Description and Breakdown

Work Breakdown

WP10-TRA-03-01

Experiments on impurity transport
Coordinated experiments on impurity transport to validate the paradigm of the ITG / TEM / ETG theory, by performing impurity transport measurements, profile measurements and fluctuations.

WP10-TRA-03-02

Internal heat transport barrier

Explore experimentally the behaviour of the electron density profile and impurity transport before, during and after internal heat transport barriers with different strength and at different temperature ratios.

WP10-TRA-03-03

Central electron heating and plasma dynamics

Impact of central electron heating, as expected in ITER alpha heated discharges, on the strength of the barrier, on both electron and ion temperatures as well as on particle and impurity densities

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Resources

Baseline Support: manpower 3 ppy

Priority Support: manpower 0.5 ppy.

3.4 Scientific and Technical Reports

R&D Progress reports

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Milestones and Deliverables

Milestones:

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- December 2010 Final report sent to EFDA-CSU.

Deliverables:

- Diagnostics hardware for improved measurements of key parameters related to impurity transport in support of detailed physics studies.
- Coordinated experiments on impurity transport to validate the paradigm of the ITG / TEM / ETG theory, by performing impurity transport, profile and fluctuation measurements.
- Explore experimentally the behaviour of the electron density profile and impurity transport before, during and after internal heat transport barriers evolution with different strength and at different temperature ratios.
- Impact of central electron heating - auxilliary and alpha produced in ITER - on the strength of the barrier, on both electron and ion temperatures, as well as on particle and impurity densities.

4. Plasma rotation:

Task Agreement WP10-TRA-04:
Role of neoclassical and turbulent mechanisms in plasma rotation

4.1 Introduction

Sheared rotation can lead to quenching of turbulence and a subsequent improvement in confinement. Toroidal rotation also increases stability against pressure limiting resistive wall modes. Transport of toroidal / poloidal momentum remains less understood than heat or particle transport. Extrapolating reliably toroidal rotation, in magnitude and profile shape to future tokamaks, such as ITER, remains a challenge, as neither momentum transport nor sources are known precisely and toroidal rotation driven by momentum from neutral beam injection (NBI) will be limited. It is essential to study the other mechanisms which can drive and transport plasma rotation (plasma turbulence, fast particles and neoclassical mechanisms).

4.2 Objectives

The work programme 2008/09 should lead to improved diagnostic capabilities for rotation measurements. The workprogramme 2010 and the following ones shall develop this research activity taking advantage of the new diagnostics capability.

4.3 Work Description and Breakdown

Work Breakdown

WP10-TRA-04-01

Diagnostics for plasma rotation
Develop diagnostics allowing systematic comparisons between experimental measurements of rotation with neoclassical and turbulent mechanisms (L-, H- and improved confinement modes).

WP10-TRA-04-02

Experiments and theory of plasma rotation

Perform systematic comparisons between experimental measurements of rotation with neoclassical and turbulent mechanisms (L-, H- and improved confinement modes).

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Resources

Baseline Support: manpower 3 ppy

Priority Support: manpower 0.5 ppy.

4.4 Scientific and Technical Reports

R&D Progress reports

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Deliverables:

- Systematic comparisons between experimental measurements of rotation with neoclassical and turbulent mechanisms (L-, H- and improved confinement modes).
- Provide synthetic analysis by the group of experts involved, recommendation for future work and implications for ITER.

5. Statistical properties of edge turbulent transport:

Task Agreement WP10-TRA-05:
Statistical properties of edge turbulent transport

5.1 Introduction

The impact of power loadings on material surfaces is one of the constraints on the design of future fusion devices such as ITER and DEMO. The deposition of this power is determined by the nature of transport processes at the plasma edge and scrape-off-layer (SOL). It has long been known from Langmuir probe measurements that this transport is turbulent, producing intermittent fluxes of energy and particles. Statistical analysis of these signals has been performed on many fusion devices using increasingly sophisticated methods, finding some similarities to fluid turbulence. Though much information can be extracted from these measurements, they are limited in that they only sample a small region of the plasma. The development of complementary non-invasive diagnostic, which can collect data from a large region of the plasma at high resolution, is a challenge.

5.2 Objectives

A research project is proposed to understand the processes that determine the edge transport in different confinement regimes and to study how these processes are linked to core transport. Development of improved or new diagnostics as well as physics studies combining diagnostics and statistical techniques in a relevant way will be considered.

5.3 Work Description and Breakdown

Work Breakdown

WP10-TRA-05-01

Turbulent structures and intermittency
Investigation of filamentary structures and nature (electrostatic and magnetic), the mechanisms behind their formation and propagation and their role in transporting energy and particles to the wall (L and H-mode regimes).

WP10-TRA-05-02

Diagnostics for edge turbulence

Improving edge plasma diagnostics to characterize edge transport/particle sources to have access to the relevant physics, including the upgrade of edge diagnostics to allow ion temperature and/or plasma potential measurements

WP10-TRA-05-03

Theory and modelling of edge turbulence

Theory and modelling (kinetic and fluid models) of edge turbulence, particle (including impurity and particles sources) transport and ELMs (eg kinetic vs fluid) and comparison with experimental results.

WP10-TRA-05-04

Test particle experiments

Development of test particle approach to study thermal test particles (using gas-puffing and tracer pellets) and the supra-thermal test particles (using fast ion sources).

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought in particular if investigation of edge transport and related plasma-wall studies in different confinement regimes (e.g. using combined studies with IR and fast visible diagnostics) is envisaged.

Resources

Baseline Support: manpower 3 ppy

Priority Support: manpower 0.5 ppy.

5.4 Scientific and Technical Reports

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Deliverables:

- Characterise the filamentary and intermittent edge and SOL turbulence in various devices (RFP,Tokamaks and Stellarators).
- Model the edge turbulent transport and compare with experimental results.

- Develop test particle experiments in basic plasma devices to assess the importance of diffusive and non-diffusive transport mechanisms.
- Provide synthetic analysis by the group of experts involved, recommendation for future work and implications for ITER.