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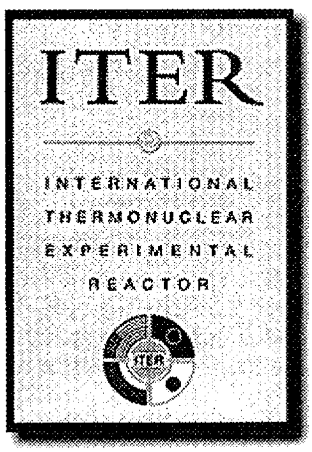
NEW ITER HOME PAGE RELEASED

Although the ITER Engineering Design Activities are very well known worldwide among the people associated with fusion research, those in other branches of science and technology and the general public have had limited access to information on ITER. The main regular source of general information about happenings within and around ITER has been this monthly ITER Newsletter, distributed to about 1500 addressees around the world. A year ago, it was complemented by the ITER brochure, which has so far been published in English and Japanese.

However, we are now happy to inform our readers that as of October a new ITER Home Page on the World Wide Web was released at www.ITER.org. So, if you get to this address you will be welcomed by the picture shown below and you will be able to read about aspects of ITER on many following pages.

Welcome to the ITER WWW Site.
Please enjoy your visit.



Worldwide collaboration for the next step in fusion energy development.

The page aims at providing an overall introduction to ITER and its related activities and features links to complementary pages from the many organisations and institutions participating in ITER. It is a living document which will be continually developed and widened and which covers the following major subjects:

What is ITER?	...describes ITER in terms of its background and origins, design, key technologies and underlying physics.
ITER Collaboration	...outlines the ITER organization and structure.
Fusion Research	...introduces nuclear fusion and gives information about the fusion programmes and links to other fusion-related sites.
What's New?	...brings the latest news about the ITER Project and links to other ITER publications.
More Information	...provides contact points for comments and questions.

Have a good time reading and getting better acquainted with ITER!

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ITER STAFF RECEIVE FUSION POWER ASSOCIATES 1977 AWARDS

Pietro Barabaschi with Stephen O. Dean, FPA President

Pietro BARABASCHI is the recipient of the **Fusion Power Associates (FPA) Excellence in Fusion Engineering Award** for 1997. Currently on assignment from the European Commission to the ITER Joint Central Team, he is Leader of the Systems Analysis Group at the ITER San Diego Joint Work Site.

Although Dr. Barabaschi is in the early part of his career, he has made outstanding contributions to the engineering of the ITER Project and has already earned the respect of his colleagues for outstanding technical work and his ability to lead others by performing the major analysis and design tasks for the Project.

FPA Excellence in Fusion Engineering Awards were established in 1987 in memory of MIT Professor David J. Rose and have been given annually since that time. Their purpose is to recognize individuals relatively early in their careers who have made outstanding technical contributions and shown leadership potential in the field of fusion engineering.

The recipient of the **FPA 1997 Distinguished Career Award** is **Marshall N. Rosenbluth**, Professor of Physics at the University of California, San Diego, currently on assignment to the ITER Joint Central Team in San Diego. A pioneer of the US Fusion Programme, Prof. Rosenbluth's lifelong contributions to fusion and plasma physics are legendary. While congratulating him on this honorable award, one should also note that Prof. Rosenbluth was recently selected by U.S. President Clinton to receive the National Medal of Science.

Items to be considered for inclusion in the ITER Newsletter should be submitted to B. Kouvchinnikov, ITER Office, IAEA, Wagramerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria, or Facsimile: +43 1 237762, or e-mail: c.basaldella@iaea.org (phone +43 1 206026392).

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COMBINED WORKSHOP OF THE ITER CONFINEMENT AND TRANSPORT EXPERT GROUP AND OF THE CONFINEMENT MODELING AND DATABASE EXPERT GROUP

by Dr. D. Boucher, ITER JCT; Dr. J. G. Cordey, JET Joint Undertaking; Dr. V. Mukhavatov, ITER JCT and Prof. M. Wakatani, Kyoto University

The combined Workshop of the Confinement and Transport and Confinement Modeling and Database Expert Groups (EGs) took place on 25-30 September at the Max-Planck-Institut für Plasmaphysik, Garching. The main results of the technical sessions of the Workshop are summarised as follows:

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At the Workshop Session on ITER, Dr. Perkins, ITER JCT, presented the comments from the Detailed Design Report Reviews undertaken by the ITER Parties. The issues relevant to the area of confinement and transport are generally addressed by the two confinement expert groups.

Dr. Boucher presented the latest results on ITER Performance projections and scenario development to be included in the Final Design Report. The issue of fusion performance projection from the global scaling expression or the local transport model is now largely addressed by the Expert Group and will be documented in the ITER Physics Basis. The issue of backup scenarios to recover the full target fusion power even under the most pessimistic confinement assumptions was addressed. Specific issues raised by these scenarios - for instance, operation at $q_{95} < 3$ and/or density well above the Greenwald density value - were brought to the attention of the expert groups.

Confinement Model Development

At the Workshop, significant attention was given to the Confinement Model Development. The session on this matter was concerned primarily with the development of theory-based 1-D transport models suitable for ITER confinement prediction. A report was given by W. Dorland on the "Cyclone" Project, a US Home Team effort to look at the reliability and physics basis of first principles transport codes such as IFS-PPPL and MMM.The focus of the effort to date has been to compare gyrofluid (GF) and gyrokinetic (GK) simulations of electrostatic ion temperature gradient turbulence.

The GF simulations have been well publicized (e.g. "Science" article) as indicating that ITER will not ignite. However, preliminary results from a GK flux tube code for a Cyclone benchmark case show thermal diffusivities about 0.3 of the GF results, enough to raise predicted ITER Q's (1.5 keV pedestal temperature assumed) from 2 to 9. Results from "full torus" GK codes give still smaller fluxes (about a factor 2.5 for a benchmark case). The GK codes, while in principle more exact than the GF codes, are more demanding, and questions of particle noise and boundary condition effects are being intensively studied by the Cyclone group. Regarding noise, a tentative conclusion (not yet a consensus conclusion) resulting from extensive test runs by the Cyclone team is that noise does not seem to be an issue for the GK runs with adequate, and quite feasible, particle number. As yet analysis of the benchmark runs has not revealed the source of the discrepancies between GF and GK or flux tube and full torus codes. Several new GK codes are now operating or being debugged including a Vlasov GK code which will not be subject to the same noise effects as the present delta-f GK codes.

While the "Cyclone" group judged it premature to evaluate the predictive capability of the IFS-PPPL model, the prospects appear good that agreed-upon predictions of electrostatic turbulence (ITG + TEM) driven transport will become available well before the end of the EDA. At this point it further seems quite possible that predicted transport for ITER will be much lower than the original IFS-PPPL prediction. To what extent the level of transport predicted by the IFS-PPPL model is able to fit the experiments is addressed by the model testing activity described below. However it appears that a lower transport predicted for ITG turbulence may also imply that other transport mechanisms, e.g. electromagnetic effects, with uncertain scaling properties, may need to be invoked to describe the present experimental results. After a trapped electron model, shaping and flow shear are added to the GK codes this will become clearer.

More surprising than the GF-GK discrepancies, and also favorable for ITER prospects, were new measurements and an analysis of pedestal temperature scaling presented by Loarte and Janeschitz. All observations agree that the edge gradients are close to the MHD stability limit $dp/dr \sim B^2/R$. Hence the pedestal temperature, critical for ITG mode predictions, can be determined if the edge width Δ is known.

Theoretical speculation (based on assuming that flow shear exceed ITG growth rates) predicted $\Delta \approx \rho_1$ and early ELM-free H-mode experiments on JT60-U seemed to confirm this gyroradius scaling which would imply low pedestal pressure (temperature) for ITER. Recent experiments on JET and D-III-D as analyzed by Loarte seem instead to indicate fixed β (or β_p) pedestals in the region of Type I ELMs. This implies $\Delta \approx R$ and would extrapolate to a 4 keV edge temperature for ITER. At this time no theoretical justification has been given for the ITG stability of such a thick pedestal and the data are fairly sparse and scattered. But the experimental evidence in favor of thicker pedestals seems to be strengthening, if not yet conclusive. Perhaps more realistic ITG calculations including edge geometry and the large electromagnetic effects of a marginally MHD stable layer could resolve the discrepancy with initial theoretical predictions. More experimental effort should certainly be devoted to expanding and better diagnosing the critical pedestal data base.

Based on this pedestal temperature model, there was a discussion of a semi-empirically determined possible operational space for ITER, above the L-H threshold and the Type III to Type I ELM transition with edge $n_e = 10^{14}/cm^3$ and $T_{e_p} = 4$ keV. If further experiments confirm that this high pedestal can be achieved, then confinement on ITER should be excellent.

Brief presentations at the session were made by Houlberg and Weiland who reported improved experimental agreement with variants and refinements of the Weiland Multi Mode Model of transport. This model continues to project good confinement for ITER, fits present experiments at least as well as other models and agrees reasonably well with the Cyclone GK results referred to above.

J. Connor gave first results from a 2 fluid electromagnetic simulation code which gave the confinement time as the gyrobohm time divided by pressure, i.e. $\tau_E \approx \tau_{GB}\beta^{-1}$ and seemed generally consistent with ITER 93 predictions. Thus, there are a number of indications that finite β (electromagnetic) effects may be critical for quantitative transport predictions.

H-mode Power Threshold

The threshold sessions were dedicated to the summary of latest experimental results, and to the discussion of edge parameters, the relation between confinement and power threshold and prediction uncertainties.

Since the last meeting in April 97, ASDEX Upgrade and JT60U started operation with new divertors with increased compression ratio for neutrals. This has, in both machines, a small effect on the power threshold. These results will be assessed during the coming months. The DT experiments in JET indicate an $A_i^{1.1}$ dependence of power threshold, which is favorable for ITER. Common experiments between tokamaks are limited by the experimental possibilities and will be defined in bilateral discussions during the coming months.

A reasonable quantity of edge data is available in the database from several machines. However, the different dependencies and the data scatter do not allow a reliable extrapolation to ITER at present. The question of which parameter is representative of the LH transition and where it should be measured in the different devices is not yet answered. Investigations are being carried out in single devices.

Analyses of confinement show that in most of the devices good confinement is possible at power close to the threshold power. Type III ELMs do not provide good confinement in DIIID and JET, but this does not hold in the other tokamaks. The region of good confinement and its relation to power threshold will be investigated until the next meeting.

Data from a few machines have been added to the database and corrections were made to existing time slices. This has a weak influence on the power threshold scaling and on the uncertainties. The data scatter is one of the important causes for the large uncertainties in the prediction and further work will be done to reduce it. The main factors causing the data scatter are: whether transition was triggered by a sewtooth; error on dW/dt; and wall conditioning. The effect of neutrals has been quantified in some devices (ASDEX Upgrade, DIIID and JT60U), showing, at intermediate to high densities, that the effect is small. Similar studies in the other devices would be very valuable. Statistical analyses of the discriminant type made for TCV data are promising and will be applied to the database in the coming months.

Global H-mode Database

Since the last meeting in San Diego, April 1997, the H mode database DB3 has been extended with new ELMy H-mode data from DIII D (ρ^*, ν^* and β scan data, ECRH and high density data achieved with pellet injection), JET (steady state and high current data), COMPASS D (ECRH and ohmic heated data) and TCV (ohmic heated data). The new version of the database is labelled DB3 version 5. A working dataset (subset) of this database has been defined which forms the basic dataset for the analysis to be included in the ITER Physics Basis.

During the meeting all the log linear scaling regressions using different open/closed divertor corrections to the PDX and ASDEX data, other subsets of the working dataset according to the type of heating used as well as using different weights, such as equal Tokamak weighting, were practically completed. The non-linear scaling analysis for the ITER Physics Basis will also be completed shortly.

Methods of estimating the uncertainty in the ITER projection was discussed in detail at the meeting. Greg Hammett presented the cross validation method and Otto Kardaun gave an overview of estimating ITER uncertainties and in particular the details of the Jackknife method. An interval estimate for the ITER projection based on DB3 version 5 will be established. The description of DB3 version 5, the new regression results and the interval estimate of the ITER projection based on the new database will be included in the ITER Physics Basis.

ITER Demonstration and Similarity Discharges

Experimental work has continued in determining the scaling of the confinement in ITER similarity discharges with the dimensionless parameters, ρ_*, β, ν_*, q and A (isotope mass number) on several tokamaks.

In Alcator C-MOD, the scaling with the dimensionless Larmor radius ρ^* was found to be close to gyro-Bohm $B\tau_E \propto \rho_*^{-3.1}$. The scaling with collisionality ν^* was found to be very strong, $B\tau_E \propto \nu_*^{-1}$, as compared with a weaker scaling $\nu_*^{-0.3}$, in DIII-D and JET.

The main effort on JET has been in determining the scaling of confinement with isotope in D-T plasmas with varying concentrations of tritium. The preliminary analysis of both the ELM-free and ELMy data indicates that τ_E is only very weakly dependent on the isotope mass contrary to the strong mass scaling of the ITERH93-P scaling ($\tau_E \propto A^{0.41}$). In fact, the ELM-free scaling has a small negative exponent ($\tau_E \propto A^{-0.2}$) which is similar to that expected for gyro-Bohm scaling. The ELMy scaling of the confined is essentially independent of A ($\tau_E \propto A^0$).

In DIII-D, the q dependence of confinement at fixed ρ_*, β, ν_* has been studied. For the case of fixed magnetic shear, $B\tau_E \propto q^{-2.6}$ whilst for the more usual case of fixed $q(0) B\tau_E \propto q^{-1.6}$. This result, together with previous scaling studies on DIII-D gives a scaling with the dimensionless parameters as follows: $B\tau_E \propto \rho_*^{-3.1} \beta^{0.15} \nu_*^{-0.37} q^{-1.6}$. The main difference between this scaling and the usual global confinement scaling expressions is in the β scaling ($\beta^{-1.2}$ in ITER93H-P). The reasons for this discrepancy between the two approaches is not fully understood. A possible reason is that there is collinearity in the database between β and ε. Another possible reason is errors in the determination of the exponents of β, ρ_* etc. obtained in dimensionless scaling approach.

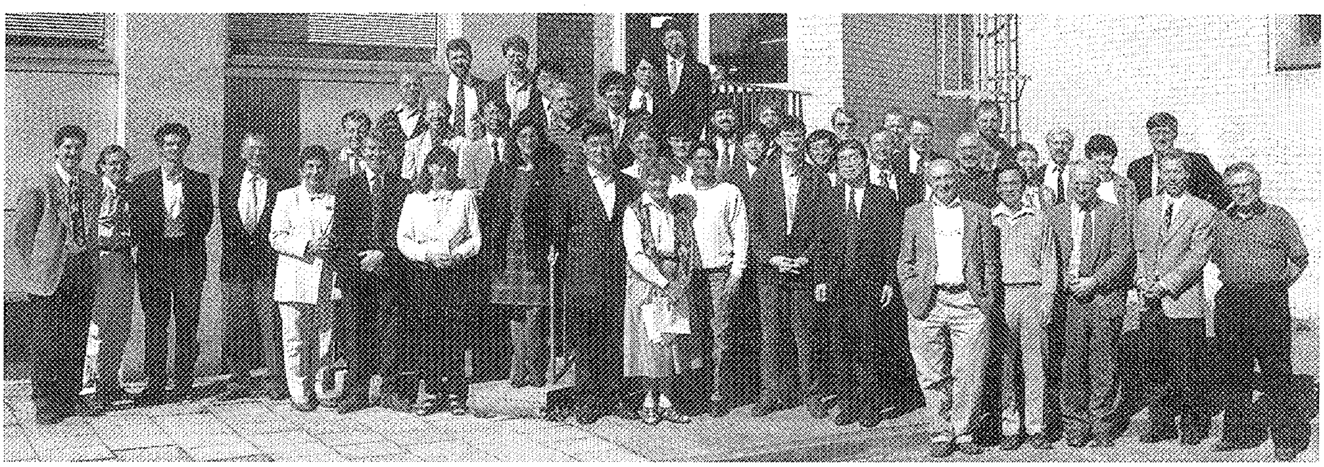
Profile Database and Model Testing

The database has been extended to include 141 discharges covering a variety of confinement modes including perturbative situations for testing models. Standardized procedures for testing models against the database are in place; they aim at providing unambiguous ways of defining models and reading data as well as using benchmarked transport codes for providing the simulations. This benchmarking activity has resulted in two codes agreeing closely; remaining discrepancies with other codes are expected to be resolved shortly. It has therefore been possible to establish figures of merit for many models when they are compared with a standard subset of the Profile Database using benchmarked codes. For example, the Multi-mode model achieves ~ 25% accuracy for the stored energy above the H-mode pedestal. The models have also been used to predict the performance of ITER using the pedestal temperature as a parameter. With the value of this temperature recommended by the Divertor Expert Group (~4 keV) most of the 7 models used show fusion powers in excess of 1100 MW; only if it falls to 1-2 KeV and ion temperature gradient models such as the IFS-PPPL model are used, are low values of power (~160-200 MW) predicted. The working sessions concentrated on the remaining steps needed to complete Section 8 of the ITER Physics Basis on the necessary time scale.

R. Waltz presented a joint work with J. Kinsey on the modeling of cold pulse propagation using various local transport models. The study showed that the Ti/Te dependence of the ITG based models (IFS-PPPL, MMM and GLF23) was able to reproduce the qualitative features of the cold pulse experiment from TEXT and that the IFS-PPPL model came closer to reproducing the quantitative features of this particular experiment. The TEXT experiment had been presented as evidence for non local heat transport in a tokamak. This work, however, indicates that this experiment might be explained using purely local transport models.

Modeling of L-H transition

M. Osipenko and co-workers have produced a model for the L-H transition, which uses a turbulence based description of the plasma edge region coupled to a core transport code. This model incorporates a number of experimentally observed features and recovers a plausible power threshold scaling. Work is expected to continue in this area.



Participants in the Workshop

Alternative Scenarios

Examination of alternative scenarios for ITER focused primarily on regimes with internal transport barriers (ITBs). Many results were presented on the characteristics and operational needs of the various regimes. Certain issues such as current profile control, electron transport, power threshold requirements and helium accumulation were prominent amongst the many issues that need to be resolved. Negative central magnetic shear is neither necessary nor sufficient for the production of ITBs as shown in high beta poloidal discharges in JT-60U with monotonic q(r) profiles and in RS discharges in TFTR which have reverse magnetic shear, but no ITBs. However, shear reversal and associated large Shafranov shifts are desirable to facilitate reduction of some instability growth rates as well as gaining access to second stability for ballooning modes. Also, control of the current profile to suppress sawteeth is desirable, which would otherwise lead to degradation of the ITB.

The variability of the electron transport in regimes with ITBs remains a very important issue. The absence of clear electron transport barriers in some machines with otherwise well defined transport barriers in the ion and particle density channels needs to be understood. To date, it appears that discharges with stronger NCS profiles, such as in JT-60U and in recent experiments in DIII-D, have stronger ITBs in the electron temperature profiles. However, much more work is required to clearly determine the requirements for reducing electron transport in the plasma core. This need is strengthened by results from TFTR which show significant reductions in the tritium and helium diffusivities near the neoclassical values in the region of reverse shear in ERS discharges. Therefore, such discharges coupled with no significant reduction in electron thermal transport would lead to substantial helium accumulation in the core with an energy sink through the electrons.

For increased stability to β limits, broader pressure profiles in a D-shaped configuration are preferred such as in ITBs coupled with an H-mode plasma edge in diverted discharges. The threshold power requirements for the formation of ITBs also still vary substantially between the various machines. Central heating is important for the production of ITBs as determined in high beta poloidal discharges in JT-60U. In TFTR, broader beam deposition profiles with tritium beams than for deuterium beams leads to higher threshold powers for ERS bifurcations with the tritium beams. It was suggested that calculations be made (together with the uncertainties) on the degree of ExB shearing rates required for effective suppression of core turbulence in ITER. Also, the need was expressed for studies of RF driven plasma flows which would alleviate some of the limitations to the momentum torque input by neutral beams. Further modeling is needed of the operational scenarios possible for ITER using data from present experiments, which was requested to be placed in the profile database. Experiments that have been completed in this task were noted and a list of further experiments to be performed was compiled.

ITER-relevant Conclusions

As the current EDA phase of ITER draws to a close, priorities for physics research must be identified and assigned in a new context. During the Discussion of Priorities for Confinement Physics Research at the Workshop, F. Perkins presented the concept of a possible extension of the EDA, with a "Readiness for Construction" assessment at the end of the second year. An update of the ITER Physics basis and of the Physics Design Description Document would be needed in approximately January 2000 to support the Readiness for Construction assessment. The Priorities for ITER Physics Research were prepared from this perspective.

Overall, confinement physics experiments as well as database and modeling activities have become highly coordinated worldwide and have achieved a good measure of progress. Nonetheless, there remains key research yet to be done which promises quantitative improvements in our ability to improve ITER projections, both by reducing uncertainties and by developing the scaling of advanced modes compatible with reactor-scale operation.

Next Workshops

It was agreed that 6th Workshop of the Confinement and Transport Expert Group and 8th Workshop of Confinement Database and Modeling Expert Group should be proposed for April 1998 in Princeton Plasma Physics Laboratory (Princeton, USA).

List of Participants

EU: Campbell D., Connor J.W., Cordey J.G., Loarte R., Martin Y., Parail V.V., Righi E., Ryter F., Solano E., Stober J., Suttrop W., Thomsen K., Turner M.F., Valovic M., Vlad G., Weiland J.
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