INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR

ITER EDA NEWSLETTER

VOL.4, NO. 4 APRIL 1995

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, AUSTRIA

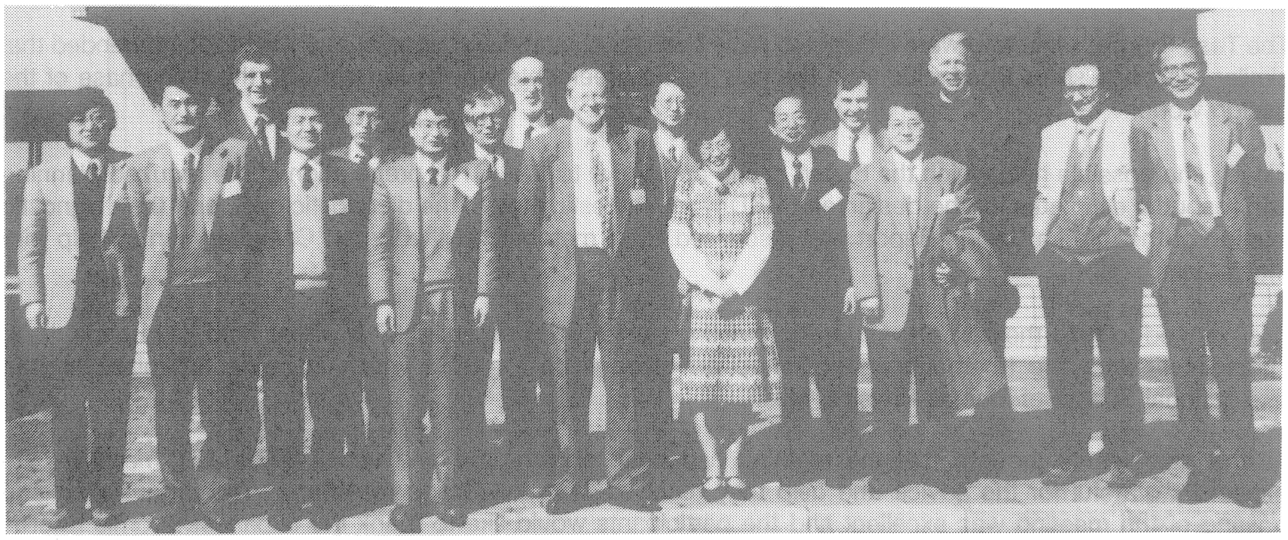
ISSN 1024-5642

SECOND MEETING OF THE ITER PHYSICS EXPERT GROUP ON DIAGNOSTICS

by Dr. A.E. Costley, ITER Joint Central Team, and Dr. K.M. Young, Princeton Plasma Physics Laboratory

The second meeting of the ITER Physics Expert Group on Diagnostics was held at the Japanese Atomic Energy Research Institute, Naka, Japan, on February 8-10, 1995. The meeting was held jointly with a Technical Meeting on Diagnostics, so that all matters of importance to ITER diagnostics could be addressed. The reports on the two meetings are here combined. The meetings were attended by most members of the Expert Group. In addition, several diagnostic specialists attended by special invitation.

The first meeting of the Expert Group was held in July 1994, and at this meeting an initial selection of the plasma parameters that should be measured on ITER was made. The parameters were categorized according to their role in the operation of the machine and evaluation of the plasma performance, and for each parameter candidate diagnostic techniques were identified. Target measurement accuracies and resolutions were determined. Since this meeting, this material has been reviewed by diagnostic specialists in the Home Teams working under a Task Agreement to ITER, and some initial proposals for candidate diagnostics techniques have been developed. The results of the work have been presented at a series of Task Progress Meetings. A primary objective of the Second Meeting of the Expert Group and the Technical Meeting was to review this initial work on ITER diagnostics and, if appropriate, to make recommendations to the JCT for changes in the measurement requirements. Other objectives were to make an initial selection of the diagnostic techniques that are to be included in the ITER diagnostic system and, for each technique, to determine the work that has to be done during the EDA; to provide advice on key areas requiring R&D funding to demonstrate feasibility of a diagnostic concept; and to assess the designs of diagnostic generic access routes. Finally, the preparation of the diagnostic section of the Interim Design Report, and organizational matters such as the possibility of teaming of groups within different parties in carrying out design tasks were to be discussed.



Participants in the Meeting

Since the last Expert Group meeting there have been some changes in the design of ITER. The first part of the meeting, therefore, was devoted to informing the Expert Group of the changes and, particularly, the consequences for diagnostics. Comments received on the minutes of the first meeting were then discussed. Dr. Young gave a report on the ITER Physics Committee Meeting which was held at the end of 1994 and at which diagnostics was briefly considered. Dr. Young reported that the ITER Physics Committee concurred with the approach taken by the Diagnostic Expert group in contributing to the specification and the design of the ITER diagnostics. In particular, the ITER Physics Committee supports the Diagnostic Expert Group's list of plasma parameters that have to be measured for ITER operation and the categorization of the measurements.

Under the initial Task Agreement there have been five Task Progress Meetings dealing with the areas of spectroscopy; neutron and fusion product systems; Thomson scattering, interferometry and polarimetry; microwave systems; and divertor diagnostics. In addition, since the first Expert Group Meeting there has been an IAEA TCM on Magnetic Diagnostics and an ITER Task Force Meeting on Plasma Control. There is also a parallel design Task Agreement under which generic access routes are being studied. The output of these meetings and studies was considered carefully, along with comments received from a few of the Chairmen of the other Expert Groups on the tables of measurement requirements drawn up at the First Expert Group meeting, and recommendations were made for minor changes. Few further changes are expected in the revised list of measurement requirements during the remainder of the EDA.

On the basis of the material presented at the Task Progress Meetings, the JCT members proposed a list of diagnostics for which some level of design is necessary during the EDA. The list was discussed in detail and some changes were recommended. The level of design which must be completed for each system during the EDA (e.g., detailed design close to the tokamak, sketch for other components) was determined. Some of the systems require dedicated R&D, and an initial determination of the necessary work was made under the headings "Physics R&D" and "Technology R&D". In general, it was felt that the technology R&D should wait until the system designs have advanced further and the needs are better defined. The exceptions are the radiation effects on in-vessel components and the development of suitable hard-sealed windows to meet all the vacuum boundary specifications. The information was collected together in a new table entitled "scope of Diagnostic Work During the EDA". This table summarizes the work required for ITER diagnostics during the EDA.

It was apparent at the Task Progress Meetings, sometimes explicitly and sometimes implicitly, that there are specific areas of interest amongst the four Parties in diagnostic scope. There appears to be a satisfactory spread of interest so that each diagnostic area can probably be usefully shared between the four Home Teams. It was recommended that the JCT should now discuss with the four Task Area Leaders and identify specific diagnostics of interest to their respective Parties to design during the EDA. It was proposed that the JCT members, together with the Task Area Leaders, should estimate the effort required to complete the design work at the necessary level so that the JCT can consider whether more manpower is required or whether the overall scope must be reduced.

A few technical areas of concern were discussed specifically, as shown in the box on the next page.

The Task Progress Meeting were thought to have been an outstanding success, and it was recommended that similar meetings should be included in the new Task Agreements which will deal with the next phase of the design work.

Finally, the possible help which the Expert group could give to the JCT in preparation of the required planning and resource estimates for the design and R&D work, the estimates of the diagnostic cost, and the diagnostic section of the Interim Design Report was discussed. The members of the Expert Group agreed to help with these tasks.

It is planned to hold the next Expert Group meeting on 4-5 September 1995. It will be held in Varenna, Italy, immediately after the International Workshop on diagnostics for ITER which is being organized by the International School of Plasma Physics, Milan.

All the participants thought that the meeting had been constructive and useful. The JCT members are especially grateful for the advice and help they received from the Group members. The organization and hosting of the meeting was excellent and the participants would like to thank the Japanese Atomic Energy Research Institute for its kind hospitality.

__Collective Scattering for Alpha-Particle Measurements:__ collective scattering, which is seen to be a potentially viable method for measuring the alpha-particle distribution in the plasma core was not well addressed at the Progress Meetings. A variety of different wavelengths for the scattered beam are espoused by different specialists, and it is necessary that a determination of the optimum wavelength and scattering geometry be made before a design task is issued. It was agreed that it was reasonable to expect some voluntary physics effort to be devoted to preparing positions to present at a meeting in the autumn of 1995.

__Diagnostic Neutral Beam:__ It is apparent that neutral beams are necessary for some of the measurements including helium density at the core, plasma current density, ion temperature and plasma rotation. Motional Stark effect measurement of the current density favours a high-energy beam, while the other measurements require a high intensity, ≈100 keV, beam, A study should be made of the feasibility of using the fast heating beams for the motional Stark effect measurement. The need for core measurement of the helium ash should be addressed with the physics community and concurrently some further specification of the low-energy beam should be carried out.

__Impurity Pellet Injection:__ A charge exchange diagnostic makes use of impurity pellets in obtaining the alpha-particle energy distribution. The requirements for such an injector to give reasonable penetration should be evaluated, while it is also determined if such an injector could be integrated into the fuelling pellet housing with sufficiently good sightlines.

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SUMMARY OF THE SECOND WORKSHOP OF THE CONFINEMENT MODELLING AND DATABASE EXPERT GROUP

by Dr. D. Boucher, ITER JCT and Dr. J.G. Cordey, JET Joint Undertaking

The second Workshop of the Confinement Modelling and Database Expert Group was held at the ITER San Diego JWS from Monday, 13 March, to Wednesday, 15 March 1995. It concentrated on the urgent tasks previously defined within the ITER R&D Physics Research needs with particular emphasis on the Profile Database, H-mode power Threshold Database and 1D Modelling. Analysis and improvements of the global L- and H-mode confinement databases were also discussed.

1. Profile Database

The primary use of this database is to support the 1D modelling activity by allowing modellers to access a sufficiently large number of well documented reference discharges containing profile data from tokamak experiments of the four ITER Parties.

The activity is well under way with at least fifteen well documented discharges now publicly available on the ftp server presently kept at the ITER San Diego JWS. The transfer tools at a number of laboratories (in particular, GA, PPPL, JET and KFA Juelich) are now fully operational and these labs are now able to send well documented discharges on a regular basis to the server. A significant effort from other laboratories not equipped with such tools has been made to develop the needed software. Some of them have asked for more time because of shortage in resources, but made it clear that they will eventually be able to participate.

Since the last Workshop of the group in Seville six months ago, modellers have had the opportunity to use five discharges from the database. They gave their comments on the organization of the database and whether the data provided satisfied their needs. The discussion focused mostly on clarification and amendments to the description document that defines the format and list of signals for discharges on the server. An updated version of the description document was issued in April 1995.

2. 1D Modelling

At the previous Workshop of the Expert Group a workplan for testing and validating 1D transport models for use in ITER simulations was agreed. This involved initial targets for registration and testing of transport models, using agreed criteria, against this database. This workshop provided an opportunity to assess progress against these targets and to plan the next stages of this activity, with the objective of measuring how well a model fits existing experiments and then making extrapolations to ITER.

There were some twelve reports with contributions from all four Parties on model testing: some based on first principle calculations of the transport coefficients -- e.g, ion temperature gradient turbulence and pressure gradient driven turbulence models -- others based on a mixture of physics principles and empirical features and some purely empirical. These were tested against the five discharges from the ITER Profile Database (three from DIII-D, one from TFTR and one from JET). Though no model was entirely successful, useful insights emerged from this exercise, for instance, the difficulty in resolving whether transport is Bohm or Gyro Bohm and the importance of edge boundary conditions. However, the main purpose of this initial round of model testing was to establish the procedure and remove problems prior to more extensive testing against a wider ITER-relevant database which will require the use of H-mode and sawteeth models in the transport simulations.

An action plan was agreed on to extend the profile database to more than 40 discharges and to carry out a systematic validation of models against these data. Projections to ITER would then be made by using these models. The results of this work will then be presented at the next Workshop of the group and reported to the Physics Committee by the end of 1995.

3. Threshold database

It is essential to be able to estimate the power necessary to achieve the H-mode in ITER. An approach to this question using global parameters is currently performed with the ITER threshold database. This database includes relevant data from 9 divertor tokamaks: Alcator C-Mod, ASDEX, ASDEX Upgrade, COMPASS-D, DIII-D, JET, JFT-2M, JT-60U and PBX-M. Each of these devices exhibits a more or less clear linear increase of the threshold power with n_eB_T (n_e being the line averaged density and B_T the toroidal magnetic field). The analysis of the database with the nine tokamaks is guided by the dependence observed in single devices and by dimensional constraints imposed by plasma physics. If one assumes either the B_tS or the n_eB_t dependence is correct, the dimensional constraints give the following expressions for the threshold power: $P_{thres} = 0.025\ n_e^{0.75}B_TS$ and $P^{thres} = 0.4\ n_eB_TR^{2.5}$, the units being MW, $10^{20}m^{-3}$, T, m; S is the plasma surface area and R the major radius. The extrapolation to ITER yields a threshold power of about 100 MW and 200 MW, respectively, at $n_e = 0.5x10^{20}m^{-3}$. The present experimental data do not allow one to choose between these two expressions. These results were reported and discussed during the meeting of the Expert Group on Confinement Database and Modelling. A report on the present status of this work is being written, and this version of the database will be released by mid-May.

An extension of the database is necessary, and a large effort is at present being undertaken by the contributing devices with dedicated experimental parameter scans to improve the knowledge of the dependences on n_e and B_T over a larger range. In addition, being aware of the importance of the crucial role played by local edge parameters for the determination of the threshold, the teams are intensifying their effort to provide the database with edge measurements. The wall conditioning is also known to influence the threshold. The neutral density is therefore also being documented, and preliminary results were presented at the meeting. Finally, the question of the H-L threshold is also being addressed with specific experiments. The next version of the database will include the data relevant to these different points.

4. L-Mode Database

Most of the action items developed at the last workshop were carried out, resulting in a database whose characteristics are good enough to develop thermal energy confinement time scalings. The present database, ITERLDB1.1, consists of 2719 OH and L-mode observations, and of these 1613 are L-mode, no He discharges. Out of the latter subset, 1037 observations contained thermal confinement times. The scalings based on total energy confinement times revealed trends similar to those contained in ITER89-P. The thermal energy confinement time scaling showed a stronger density dependence, as well as a stronger power degradation, than did the total confinement time scaling. Comparisons of these scalings to H-mode data indicated that the parametric scalings of the two sets of data were different, and that the H-mode data could not simply be described by some enhancement factor times the newly developed scalings.

5. H-Mode Database

The group responded to questions put forward by the JCT concerning the use of recommended global scaling laws for ITER predictions. They noted that the scaling: 0.85 ITER93H(Elm-Free) does fit the ELMy H-mode database and is in agreement with the latest ITER demonstration discharges and can, therefore, be used to predict ITER global energy confinement time. It can also be used for q_{95} values above 3. However, the isotope effect -- present in the scaling law with a 0.4 exponent -- is more uncertain as an interaction between input power per particle and mass dependence has been shown to be statistically significant. This interaction predicts that the mass dependence of ITER is very weak, which suggests that in an extrapolation to ITER the database mean of the mass should be used rather than a mass of 2.5. New data from recent TFTR tritium experiments might help resolve this issue. Towards the end of 1995 the H-mode database will be extended with more ELMy data from JET (high current) and ASDEX Upgrade. The group has also agreed to assemble a new database containing hot ion H-mode data from JT-60U, DIII-D, JET and other tokamaks.

6. Closing Sessions

The meeting concluded with brief presentations on status and plans for the high-priority R&D Physics tasks. A more extensive presentation of the present status of H-mode transport modelling as covered by task 4.9 was also given. A workplan and an allocation of tasks covering all previous sessions which are to be performed within the next six months were agreed on by the group.

Finally, the Japanese members of the expert group offered to organize the next Workshop of the group in Japan, since the previous workshops of the group have been held in Europe and the USA, respectively. The experts from the other Parties accepted this invitation and went on to propose the tentative dates of October 16-19,1995, for this next meeting in Japan.

Goeff Cordey, Expert Group Chairman, closed the Workshop by thanking all experts present for their participation and the ITER San Diego JWS for hosting this meeting.

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Printed by the IAEA in Austria
May 1995

95-01684