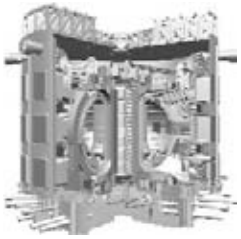

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EIGHTH MEETING OF THE ITPA TOPICAL GROUP ON DIAGNOSTICS

by Drs. A.J.H. Donné, FOM Institute for Plasma Physics Rijnhuizen, and A.E. Costley ITER International Team

The Eighth Meeting of the ITPA Topical Group (TG) on Diagnostics was held at the Culham Science Centre, UKAEA, from 14–18 March 2005. The meeting was opened by Professor Llewellyn Smith, Director of the Culham Science Centre. Professor Llewellyn Smith stressed the importance of diagnostics in operating and evaluating the performance of tokamak plasmas and highlighted that this will also be the case in ITER. The meeting was combined with a progress meeting on ITER-relevant diagnostic developments on-going in Europe, which was held on 14 March. More than 60 participants attended the meeting and all six ITPA partners were represented. Special sessions were devoted to alpha-particle diagnostics and to the ITER-relevance of present and future diagnostic upgrades of JET.

During the Progress Meeting on ITER-relevant diagnostic developments on-going in Europe, the European scientists presented their work on a large range of ITER diagnostics. In the year 2004 the EFDA-funded work in Europe has largely concentrated on those diagnostic systems that have been provisionally assigned to Europe through the ITER cost-sharing discussions.

The progress in the working tasks of the ITPA Diagnostic TG designated as high priority was reviewed. Generally good progress has been made.

1. One of the outstanding topics in ITER diagnostics is the determination of the best way to measure the spatial dependence of the emission of alpha particles and neutrons. Results of a detailed study undertaken by the Russian Federation (RF) were reported at this meeting. The work has shown that, in principle, measurements of the neutron emission can be made from a collimator array installed in a divertor port and that, when combined with measurements from the Radial Neutron Camera in an equatorial port, it should be possible to determine the neutron source profile as required. There are several difficult interface issues associated with installing a neutron camera at the divertor level and these are currently being worked on within the ITER International Team (IT) in collaboration with the RF.

2. In the special session on alpha particle diagnostics, several presentations were devoted to the measurement of confined alpha particles. Fast ion collective Thomson scattering at 60 GHz can meet most of the measurement requirements, and a thorough study undertaken in Europe, in collaboration with the ITER IT, has developed feasible concepts for the installation of the necessary launch and receive hardware. Work in Japan has shown that, in principle, a co-tangential neutron emission spectrometer can be used to study the alpha knock-on tail in neutral beam injector (NBI) heated ITER discharges. Gamma spectroscopy is yielding detailed information on the alpha particle distribution at JET and work is underway to develop radiation-hard filters and detectors that would be suitable for ITER. A quantitative assessment (feasibility study) for ITER of this technique is recommended. A novel diagnostic technique has been proposed based on measuring extreme ultra-violet (XUV) spectral line intensity ratios. This technique will measure the product of the alpha particle concentration and its collisional excitation rate.

   The measurement of the escaping alpha particles is difficult because the detectors/sensors will have to be installed close to the first wall where the heat and radiation loads are very high. Dedicated developments are in progress on several candidate diagnostics and the latest results, especially on radiation-hard ceramic scintillators and on the use of activation foils were reported. A potential new technique that utilizes

imaging bolometers with absorber foils of varying thickness to measure the intensity and energy distribution of the escaping alpha particles was presented by Japan.

3. Detailed reports were presented on the effects of erosion and deposition on mirrors in Tore Supra, TEXTOR and T-10. The experiments have shown that erosion does not have a significant effect on the reflectivity of the mirrors over a wide wavelength range. Deposition, on the other hand, generally causes the reflectivity as well as the polarization characteristics of the reflected radiation to deteriorate. For a full understanding of the processes involved, and particularly the development of models that have a predictive capability, improved experiments are needed. The magnitudes are required of a number of important parameters, such as the fluxes of main impurities and hydrogenic species, and charge exchange fluxes, and the mirror samples need to be protected from potentially damaging events such as disruptions. Experiments in plasma simulators should also be considered. The Specialist Working Group on First Mirrors is currently reviewing the experimental work done thus far and developing a proposal for the next steps in this work.

4. Progress was reported in the development of techniques and components for the measurement of magnetic fields in long pulse/near steady state operation. Radiation-hard Hall probes have been tested under irradiation and prospects for their application ex-vessel in ITER are promising.

   The phenomena of Radiation-Induced Electro-Motive Force (RIEMF), Radiation-Induced Thermo-Electric Sensitivity (RITES), and Thermally Induced Electro-Motive Force (TIEMF) can occur and can induce voltages that obscure and compete with the required signal. The understanding of the relative importance of these effects is increasing: it appears that the thermal effects are the most dominant. There are still considerable uncertainties and more experiments are needed with prototype coils in reactors.

5. The final high priority topic is the development of requirements for the measurement of dust, and assessment of techniques for the measurement of dust and erosion. The topic of dust is being considered in a study within the IT and thus far has not concluded on the specific measurement requirements. However, the requirements for erosion measurements have been specified and work is progressing on possible measurement techniques. At this meeting the latest work on a novel proposal for an optical laser radar system was presented. In principle, the proposed system meets the ITER target requirements for erosion measurement.

   It was reported that in DIII-D dust is observed as a parasitic signal in many of the Thomson scattering data. The basic particle/radiation interaction is Mie scattering. It is possible to determine the number density of dust particles. In dusty disruptions in C-Mod a large amount of dust is observed. A new dust diagnostic based on Mie scattering is being developed for C-Mod.

In the session on the present and future JET programme and its diagnostics, the emphasis of the presentations and discussion was put on the relevance of the future diagnostic additions for ITER. The TG was in general of the opinion that many of the diagnostics that are presently on the list for the long term JET programme, and to be installed in 2008, have a high relevance for ITER and could still affect the designs of ITER diagnostic systems.

An initiative launched by the TG at its 7th meeting was to try to identify the diagnostic techniques and components which are thought to be well suited for an ITER/BPX environment and could be tested in present-day devices. A summary of the initial responses was presented at the meeting. Suggestions that have been made include the use of various types of new optical fibres, such as holey fibres that allow for hydrogen hardening during their functional period, transmittive diffractive optics and metallic multilayer reflectors, various methods for mirror and window cleaning, and optical Rogowski coils. It was further suggested, by A Malaquias of the IAEA, that parts of the diagnostic work could benefit from establishing a Co-ordinated Research Program under the wings of the IAEA. This possibility will be further investigated.

The ITPA Parties reported steady progress for many diagnostic techniques that are relevant to ITER/BPX. Some examples of recent work are: Quartz Micro Balance for dust detection (CN), mirror erosion/deposition studies and prototype radiation-hard bolometers (EU), water activation system with Cerenkov detector (JA), VUV spectroscopy (KO), dispersion interferometer (RF), and Mie scattering on dust (US).

Participants at the Eigth Meeting of the ITPA Topical Group on Diagnostics, held at Culham, United Kingdom, 14 – 18 March 2005

Since the previous meeting, the Chinese HT-7 and HL-2A groups have joined the International Diagnostic Database (IDD) and have added information about their systems. Detailed information is now recorded for 266 diagnostics on 20 machines (tokamaks and stellarators).

The possible location and date of the 9th Meeting of the ITPA TG on Diagnostics was discussed. It is provisionally proposed to hold the meeting at KBSI, Daejon, Republic of Korea from 10–14 Oct. 2005. A special session on feedback on measurement requirements from the other TGs, and a thorough review of mirror work will be organized. The meeting will be combined with a one-day Meeting on Diagnostics Developments on-going in Korea.

The meeting ran smoothly due to the excellent organisation of the host, UKAEA, and the all the participants were grateful to the UKAEA for its hospitality and expressed their explicit gratitude to Dr. N Hawkes, and Mrs. K Bell for their care and attention to all the meeting arrangements. Special thanks also are due to Dr. C Ingesson for organising a very informative EU Progress meeting.

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THIRD IAEA TECHNICAL MEETING ON ECRH IN ITER

by Dr. S.Cirant, CNR Institute for Plasma Physics, Milano

The third International Atomic Energy Agency – Technical Meeting (TM) on Electron Cyclotron Resonance Heating (ECRH) in ITER, following those in Oharai, Japan in 1999, and in Kloster Seeon, Germany in 2003, was held in Como, Italy, from May 2 to May 5, 2005, in a two-and-half day intense workshop. The hosting Institution this time was the CNR Institute for Plasma Physics in Milano, which benefited from the support of the Centre for Scientific Culture “Alessandro Volta” for taking the meeting in the luxurious halls of the town’s civic theatre. Sixty-four delegates representing sixteen countries/organizations were present at the meeting.

The open and direct discussion between the different competences necessary for the successful application of Electron Cyclotron Waves (ECW) to fusion plasmas, which was a key and unique feature of the previous meetings, was encouraged also in this meeting by having oral presentations in plenary sessions. Experts in millimetre wave sources, systems and wave-plasma interaction had the opportunity to directly highlight respective features, and to address limits and expectations. In addition, summary sessions were organized after presentations, in an effort to get the best synthesis of the state of the art.

The International Advisory Committee, chaired by S. Cirant, identified the need for the integration of the work performed worldwide in a self-consistent picture of the mission of Electron Cyclotron Heating (ECH) and Current Drive (ECCD) in ITER as the focal point of the meeting, and highlighted this need in the call for papers. Very positively, all the 42 contributions clearly identified their specific relevance to ITER use and applications.

Talks on gyrotron development confirmed that very long pulses (minutes) at MW level in the frequency range 80-140 GHz are becoming familiar, and this is good news for the future availability of a 1 MW, CW source at 170 GHz, an issue which has been for a long time the main concern related to ECH/ECCD use in ITER. The

problems still arising from long pulse operation, mostly related to the extraction and removal of even the smallest fraction of power trapped inside the tube, seem not to prejudice the achievement of the final goal.

Not surprisingly, the discussion on gyrotron development was mostly animated by the interplay between sources, system and applications, rather than by the mere question of power availability. As a matter of fact, ECH/ECCD is ITER-relevant because of the precision with which it can be applied, both in space (localized absorption and directivity) and in time. Indeed Neoclassical Tearing Mode (NTM) control is a relevant example of this basic point. As shown in many talks, the scan of the deposition layer across the plasma radius is achieved in the present design by steerable beams, which could be moved either by a movable arrangement positioned outside the port (remote steering option), or inside the port close to the burning plasma (front steering). While the main point of view of the meeting on these two approaches will be addressed shortly afterwards, many talks pointed out that the problem could be solved by frequency tunability of the source, thereby indicating an alternative path for gyrotron development. Indeed the point of balance between new performance and timely availability of the systems has still to be found. A stimulating question was put on the table with respect to the question of “first day availability”: since the sources will have to be replaced a few times during ITER’s history, is there any reason of thinking at the first day option as the very final one?

It is in this type of discussion involving different expertise that the real motivation of an interdisciplinary meeting like this can be found.

Concerning systems, a point came out clearly with the progressive extension of the pulse length: when dealing with high power, long pulse operation, absolute values rather than percentages are important. Every per-mil at one MW is one kW, which can be deleterious if not properly removed.

According to the talks presented, one might assume that, apart from this point, the mm-wave transmission system is not the main concern for designers, who concentrate their main effort on the launcher steerability. Both front and remote steering options were thoroughly discussed, and a comparison between the relative merits and limits was outlined: remote steering allows safe positioning of movable parts, but suffers from a limited steering range, mirror heat loading close to unbearable conditions, and poor localization of the ECCD layer. On the contrary, front steering allows the achievement of satisfactory focusing and a wide steering range (in a word, better compliance with physics requirements), but the reliable and safe operation of moving equipment in a thermonuclear environment needs a convincing demonstration.

An important issue, directly connected to the actual realization of an ideal application, and linking launcher design to physics predictions, is related to the effect of a real multibeam launch on NTM stabilization and, in general, on disruption prevention and safe operation. The talks showed that on one hand the error in the launching angle will degrade the stabilization capability as calculated by using realistic beams ideally aligned, on the other that the optimum beam alignment should rely on automatic and feedback controlled actuators, which in a sense are to be considered an integral part of the launcher itself.

Several beam control strategies were discussed. Luckily enough, the development of this crucial matter can be almost completely performed and tested on present machines, which is actually the method pursued by many groups and Institutions.

Other ECH/ECCD applications (core heating and current drive, edge control, density and impurity control, breakdown and start-up assist) were briefly mentioned in the presentations, which possibly means that the field is only marginally explored.

All the main open issues related to the ITER-ECRH mission have been addressed in the meeting. Although most of them, if not all, still remain open, the intense discussion indeed has allowed a step forward towards system integration. This is a matter for the next meeting, which the IAEA has offered to host in Vienna by 2007.

Presentations and papers will soon be available in the conference web site, and publication in the Journal of Physics/Conference Series will follow.

In the meantime, the participants enjoyed the warm hospitality of the city of Como, and of the wonderful spring weather on Lario Lake and surroundings.

Items to be considered for inclusion in the ITER ITA Newsletter should be submitted to C. Basaldella, ITER Office, IAEA, Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, Austria, or Facsimile: +43 1 2633832, or e-mail: c.basaldella@iaea.org (phone +43 1 260026392).

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