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Verantwortlich / in charge	Dr. W. Biel w.biel@fz-juelich.de
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Detailergebnisse / Details

Contributions to ITER

Within the TEC collaboration, IPP Jülich is working on several scientific tasks which are directly related to the development of ITER diagnostics. Furthermore, IPP Jülich is preparing to take over significant contributions to the detailed design of ITER heating systems and work is going on for the development and qualification of materials for plasma facing components (see also the report of the Institute for Materials and Processes in Energy Systems, IWV).

Diagnostics

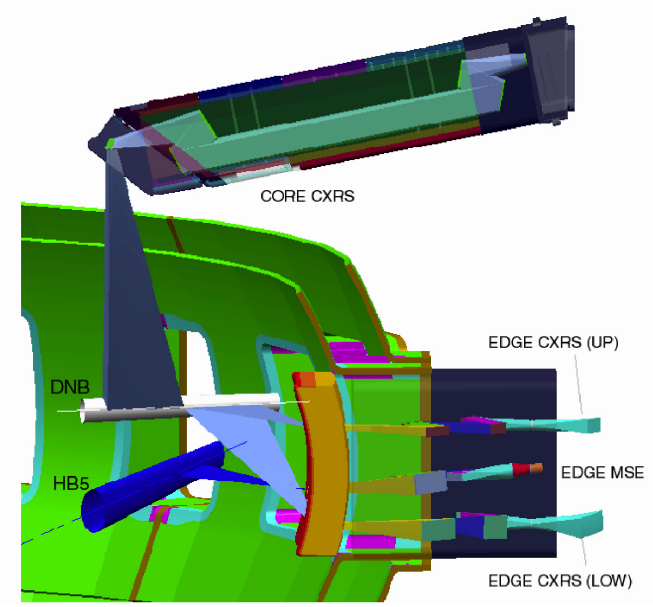
In the course of 2003, the available expertise and resources for the planned ITER diagnostic contributions have been reviewed within the TEC, and the ongoing ITER diagnostic planning as performed by the international diagnostic working group (DWG) has been supported. TEC has confirmed its continued interest to take over the responsibility for the construction of several ITER diagnostic systems or to participate therein, including the possibility to take over the assembly of an ITER diagnostic port plug. The actual selection of diagnostic packages systems to be worked on by TEC will depend on the results of the DWG negotiations among the ITER partners.

In 2003 a number of tasks have been devoted to the ITER diagnostic design. One of them was a design study of the poloidal polarimetry system for ITER, while another required the evaluation of the potential performance of active (CXRS) spectroscopy using the Diagnostic Neutral Beam (DNB) in combination with upper port viewing in ITER. A third task addressed the Motional Stark Effect measurements using the DNB for current density profile determination in ITER. Within the frame of the fourth task, work has been performed on the optical design of the VUV and X-Ray spectroscopy for ITER. Finally, tests for a new technique for alpha-particle measurements at ITER were performed at JET.

The polarimeter task was aimed at resolving remaining design issues associated with the conceptual design developed during studies performed under earlier EFDA contracts, in particular assessing the compatibility of the in-vessel optics with the ITER port plug. Apart from the retro-reflector, the issues that have been considered were the possibility to have a transmission line with only two focussing components per line, of which one (the second mirror) is placed inside the port plug. It has been investigated whether or not it is possible to have an automatic alignment procedure to direct the laser beam onto the retro-reflector by a mirror that is positioned as far as possible from the

plasma. More particularly, it was studied which mirrors would be the most ideal to be used for scanning. A design study was done concerning the alignment and calibration methodologies for initial installation and during subsequent operation. Specifically, the tolerable angular and lateral misalignments of the various optical components were studied to see whether the methodologies foreseen are realistic. Furthermore, a conceptual design of a double vacuum barrier was made. Finally, in cooperation with V. Voitsenya (Kharkov, Ukraine) specific laboratory tests have been done to check the reflective properties of retro-reflectors at micrometer wavelengths (in particular at 118 µm, which is the envisaged wavelength for the polarimeter) after having been exposed to deuterium ions from a plasma source.

The work done in the field of active CXRS using the Diagnostic Neutral Beam included an optimisation of the upper port viewing system based on physics arguments, a demonstration of the feasibility to implement such a viewing system, a motivation for an equatorial viewing port system for poloidal and toroidal velocity measurements, an assessment of the physics merits of a negative ion source based DNB compared to a positive ion source system, a study of the physics merits for a tilted DNB reaching the ITER magnetic axis, and a description of pilot experiments and drawing-up of a plan for further development work.



Layout of top and equatorial CXRS and MSE periscopes (courtesy IT Garching)

In the field of MSE for ITER an initial feasibility study and assessment was made of its implementation in ITER. In collaboration with a number of other Associations an assessment was made of the relative merits and limitations of MSE on the DNB and on the heating neutral beam.

Within the VUV-/X-ray spectrometer task, the optical design of 6 VUV spectrometers for ITER has been finished, which in total cover the wavelength range from 2.3 nm to 160 nm, divided into 6 different wavelength ranges with some overlapping. The use of MCP detectors in the ITER VUV spectrometers has been analysed based on experience from spectrometers at JET and TEXTOR and this detector type is found to be appropriate, provided that the detector location is behind the radiation shielding. The wavelength ranges chosen for the VUV instruments allow to monitor many different ionization stages of all relevant impurities in ITER with sufficiently high wavelength resolution and to identify all impurities in the plasma which have significant concentrations. The physics measurement possibilities for the X-ray diagnostic have been analyzed in detail. It has been found that the design for the x-ray spectroscopy at ITER can be made such as to allow for a simultaneous determination of the ion temperature profile, the ion rotation profile, the profile of the relative abun-

dance of different ionization stages and the profile of the electron temperature. Considerations about the optimization of mirror/crystal materials and reflection angles have been started.

A new technique was proposed in 2002 to measure alpha particle losses on ITER, based on charged particle induced activation. To document this technique, a probe shield cap was exposed to D-D plasmas using the vertical manipulator on JET. The results are very promising as the preliminary signal analysis of the radiation emitted by the exposed sample agrees in magnitude with that calculated assuming classical losses of fusion protons.

Heating

For the ITER Ion Cyclotron Heating and Current Drive system, in line with the continued activity of LPP-ERM/KMS in this field, an original antenna and matching system has been proposed and studied. Contrary to the reference system, which requires the installation of tuneable vacuum capacitors inside the vacuum vessel, the system proposed here is tuned externally, therefore requiring no movable parts inside the vessel. This matching option, based on the same resonant double loop – also called conjugated T – tuning concept as the reference ITER system, is shown to perform better and to have a number of substantial advantages when compared to it. The design group of IPP Jülich provided the 3D-CAD models for the conceptual design of this new ICRF antenna. The task also included adaptation of the new system in the ITER environment.

Closely related to the previous topic, LPP-ERM/KMS is also leading the ITER-like ICRF Antenna project on JET. The design phase of the antenna system is now complete and the procurement phase is under way. The new antenna is planned to be installed in JET and operated in 2005. Still related to the ITER antenna activity, a new antenna system has been designed and constructed for TEXTOR to be compatible with the inlet of a diagnostic beam. This antenna is conceived such as to allow testing the ”conjugated-T” mode of operation. The new antenna was tested electrically and will be installed on TEXTOR early in 2004.

For the development of the ECRH system for ITER, a team of 6 full-time professionals of the Dutch TEC partner FOM is involved in the design of the upper-port launcher. Contrary to the conventional front-steering system, where mirrors rotate very close to the plasma, FOM is developing the remote-steering launcher. Here, the scan in the vertical plane is achieved by means of rotating a mirror far away from the plasma, launching the mm-wave beam into a square waveguide, resulting at the end of the waveguide in the same scanning angles. The scan range is now of ± 12 degrees at the input and output of the square waveguide resulting in a scan range of ± 6 degrees to ± 8 degrees in the ITER plasma, depending on the focusing strength of the end mirror.

Modelling

As an ongoing long term support of the ITER team the B2-EIRENE plasma edge and divertor modelling code is permanently supported by IPP Jülich. In 2003 in particular the implementation of radiation transport in the EIRENE code was further developed. It must be expected that due to its size the dynamics of the ITER divertor will be significantly affected by opacity effects of the Lyman line radiation (distinct from present experiments). Implementation of these extensions into the ITER-team version of B2-EIRENE is currently underway. Due to its strong B-field also the effects of Zeeman line splitting on resonance line opacity has to be investigated, rendering emission and absorption highly anisotropic. The related code extensions have been started.

Several edge modelling studies in the last years have pointed out several rather critical divertor design aspects related to a rich chemistry of the hydrogen private flux plasma (e.g. in-out asymmetries in the divertor flow, pumping, etc.) This has led to a major revision of related databases for H, H^-,

H^+, H_2, H_2^+ and H_3^+ in 2003, involving now a large number individual reaction channels and their energetics. The new database has been established and published (FZJ-report Jül-4105, Dec. 2003). It will shortly be made available to the ITER team in electronic from through the EIRENE code database formats (www.eirene.de).

Plasma surface interaction (PSI)

Besides the ongoing physics programme special ITER related PSI topics are under evaluation in the framework of EFDA technology tasks. One task is the development of ITER relevant diagnostics to measure material deposition and fuel retention, in particular in the non-activated phase, to assess the fuel retention that gives the basis for the material choice in the later T-phase. The possibilities of laser desorption/ablation combined with in-situ spectroscopy detection of desorbed fuel and ablated material is tested in laboratory experiments and TEXTOR test limiter experiments. Special PSI effects associated with the use of castellated surfaces as foreseen in ITER to reduce the mechanical stress (10 x 10 mm with 0.5 mm gaps) are the subject of investigations in TEXTOR using macro brush ITER like wall structures. The analysis concentrates on edge effects with respect to power loading, arcing, material deposition and fuel retention in gaps, both in erosion and deposition dominated regions. The ERO code has been applied to ITER divertor conditions and geometry to model and predict erosion, deposition and T retention. In addition in a special task the change of optical properties of mirrors by plasma erosion and material deposition is investigated. Molybdenum and tungsten mirrors have been used in the SOL of TEXTOR in erosion and deposition dominated zones and the change of their optical properties was measured by means of reflectometry.