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Institutsbeitrag / institute's contribution	22205 Institut für Plasmaphysik / Institute for Plasma Physics (IPP)
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Detailergebnisse / Details

Contributions to W7-X

The stellarator concept is the most promising alternative to the tokamak because of its inherent stationary plasma operation. The prospect of stationarity opens new possibilities to investigate reactor-relevant physics issues. However, it also requires additional solutions for the accompanying technical problems which are for instance related to the superconducting field coils, the durability and cooling issues of wall elements as well as the control and data analysis of diagnostics. FZJ participates in the design and construction of diagnostics for the stellarator **Wendelstein 7-X** which is presently being built at Greifswald by taking over a large work package. In the future, FZJ will also participate in the scientific exploitation of the project.

Within a co-operation between the Max-Planck-Institute for plasma physics (IPP) and the Forschungszentrum Jülich (FZJ) the task for the **superconducting bus system** (the superconducting current connections between the solenoid coils and to the current supplies) was adopted. The technical specifications (1-AAH-S0002.1) are the basis for the construction, manufacturing and assembly of the superconductors and the appropriate holders and supports. For the performance of these tasks an appropriate hall space was rented and prepared according to the requirements.

An overall concept of the project was prepared with the goal, to optimize the working steps and simplify the assembly. For a checking of the bending results as well as the examination of assembly a 1:1 model was developed. The individual parts are presently manufactured.

For an optimum compensation of the magnetic fields due to the current flow as well as for simplification of assembly a new topology was developed. A partition of the bus systems results in avoiding collisions with other parts, reduced space requirements for integration and facilitates transport. For the qualification of different working steps test setups were manufactured and first examinations were accomplished. These are setups for

- insulation checks including measurements in the Paschen minimum,
- thermal tests of the behaviour under cryo-temperatures at 77 K,
- mechanical bending loads as well as high helium pressure tests to check quench situations, and
- vacuum compatibilities of the materials and methods used.

The detailed design work for a set of new **VUV/XUV spectrometers** has been performed, which shall be used for impurity monitoring and impurity transport studies at the stellarator Wendelstein 7-X. The optical design for numerically optimised toroidal holographic diffraction gratings is finalised and the mechanical design for the spectrometers is developed in great detail. Many peripheral components of the spectrometers such as vacuum systems, detectors and calibration light sources are specified and procurement is ongoing. Delivery of many components is expected during 2004, while the construction and laboratory testing of the spectrometers is scheduled to be finalised in 2005.

A **high energetic hydrogen beam for diagnostic** is foreseen on Wendelstein 7-X for the measurement of ion temperature profiles. A diagnostic injector will be developed, the beam of which provides an equivalent current of more than 5 A at 60 keV. During the whole duration of injection (10 s) the beam properties (divergence < 0.5º, particles with full energy > 70 %) should be maintained. The pulse duration shall also cover the phases with additional neutral particle heating and will – with a pulse frequency of at least 0.5/min – also allow measurements during very long discharges. An additional beam modulation of 100 Hz will help to discriminate active and passive signal intensities and to improve the quality of the data.

The European tender action for the high voltage power supply has been finished. The contract, together with the fabrication of the neutralizer chamber will be given to the Budker Institute of Nuclear Physics (BINP) in Novosibirsk, Russia. Additionally, the grid structure for higher current densities and lower beam divergence of the ion optics has been optimised. The divergence of 0.35^o for a beamlet was verified in experimental tests at BINP.

In 2003 the disposition of the **available budget for Wendelstein 7-X diagnostics** was again discussed and updated. A main part of the scientists and technicians have been moved to the construction department so that – as a result – the reduced resources led to another concentration on the most necessary parts, which are either necessary for the start-up, time critical or already in contract form. In particular there was a reduction of the *present* efforts in the edge and divertor diagnostics. Shifted to a low level, however not cancelled, were the high-resolution X-ray imaging spectrometer and the Target Tile Manipulator. It was agreed that the devices can be fitted later to the vessel without too much additional effort and that for the latter, the necessary preparations would be made in the divertor modules.

A **thermo-stress analysis of various materials proposed as a window** for spectroscopic observation systems from the hot plasma for the stellarator W7-X has been performed (IWV). Window materials studied include fused silica, crystal quartz, magnesium fluoride, calcium fluoride, zinc selenide and sapphire. The calculations have shown that even for a large window (about 13 cm of diameter) sapphire appears to be the appropriate choice for visible/infrared optical systems which can successfully survive under a maximum radiation power load of 50 kW/m^2 during about 20 minutes discharge length which is expected for W7-X. Other materials such as fused silica, MgF_2, and ZnSe can only be used for small diameters such as 5 cm because of their high temperature radiation which may disturb the measurements. CaF_2 is unacceptable for such windows because of a strong in-plane distortion during the long heat load. However, the investigated optical materials may be usable for a short pulse duration or low power load.

The **plasma facing components** in thermonuclear fusion devices are subjected to intense fluxes of charged and neutral plasma particles and radiation. Resulting from these plasma-wall-interaction processes the materials will be degraded with respect to their thermal and mechanical properties. A major aim of the activities is to develop and fabricate new materials for Wendelstein 7-X and to characterise and to test them under simulated operation conditions, i.e. at thermal loads up to 20

MWm^{-2}. To evaluate the component behaviour and the resulting material damage under Wendelstein 7-X relevant conditions high heat flux simulation tests are continuously being performed with a powerful electron beam (JUDITH, hot cells at FZJ) and with ion beam test facilities (MARION, IPP at FZJ). These experiments are focussed on different design options of high heat flux components with carbon, pure B_4C, Si-doped B_4C and tungsten armour.