stellarator news

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HSX Update

The Helically Symmetric Experiment (HSX) is rapidly approaching operational status. HSX (R = 1.2 m, a_p = 0.15 m, B = 1.0 T) is designed to investigate improvements in neoclassical confinement predicted through a near symmetry in $|B|$. All symmetry-breaking terms in the magnetic field spectrum at the plasma edge are well below the 1% level, with the toroidal curvature term less than 0.25%. With four field periods, and a rotational transform slightly above unity, HSX will explore the benefits of high effective transform, $| N - m \iota | \sim 3$, in a quasi-helically symmetric configuration. Electron cyclotron heating (ECH) at 28 GHz (< 200 kW) will be used to produce a low-collisionality plasma with central electron temperatures ~ 1 keV at moderate densities (< 10^{13} cm^{-3}). Figure 1 is a drawing of HSX.

The magnetic field is produced by a set of 48 modular coils (12 per field period) which are assembled into modules including a planar but noncircular auxiliary coil and

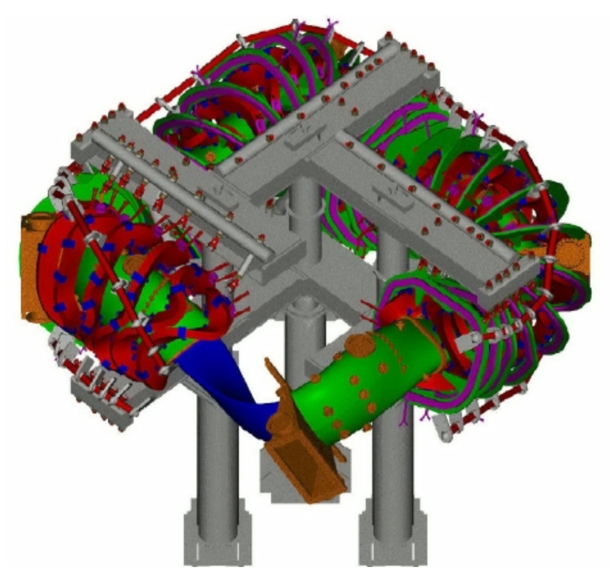

Fig. 1. A cutaway rendering of the HSX device, showing the plasma and all of the major components.

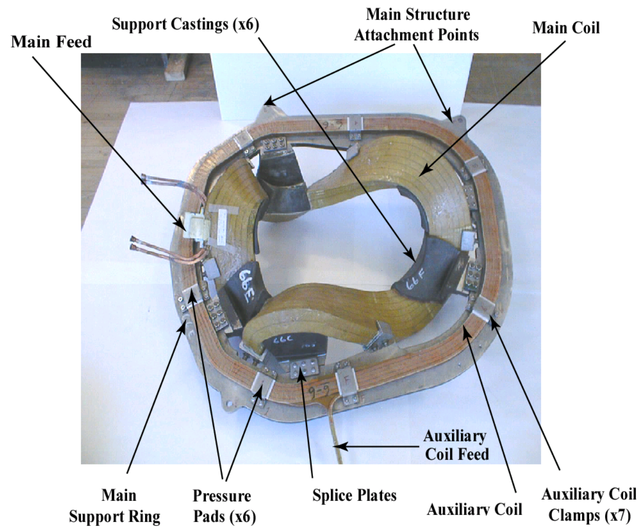

Fig. 2. Assembled coil module showing the main modular coil, the auxiliary coil and supporting rings, and castings.

In this issue . . .

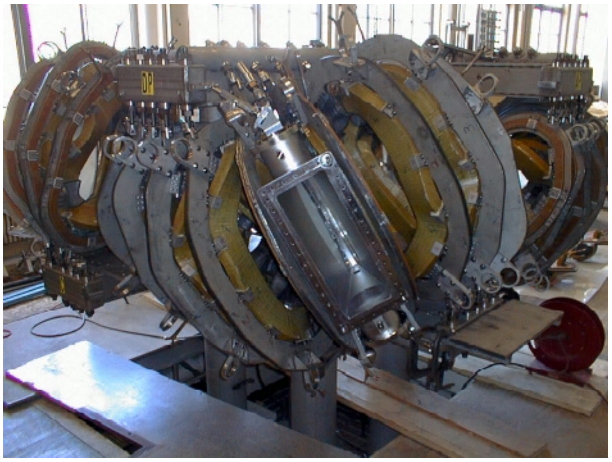

Fig. 3. Coil modules being mounted and aligned to the main support structure.

supporting elements, as shown in Fig. 2. The auxiliary coils provide flexibility in the magnetic configuration, allowing for breaking of the symmetry through introduction of a toroidal mirror mode for transport studies or deepening of the magnetic well for stability studies. These coils also permit small variations of the rotational transform about the design point without significant compromises to the field symmetry. All 48 coil modules have been assembled.

The coil modules are now being installed on the main support frame as shown in Fig. 3. Alignment is accomplished with a portable coordinate measuring machine (CMM). Adjustments are made at the three main structure attachment points so that reference marks placed on the coil from the original winding/potting forms can be positioned with respect to the global machine coordinate system. At present, 32 of the 48 modular units have been mounted and aligned. Variations in the reference points used for alignment from their ideal values range up to 0.5 mm, well below the 2.0-mm limit indicated by field error studies. Pipe elements, which form a toroidal ring-to-ring truss on the outboard side of the torus, are being installed as the coils are mounted and aligned. The remaining 16 modules will be installed as soon as the vacuum vessel is installed.

Explosive forming was used to fabricate the vacuum vessel sections with their strong three-dimensional shaping, which is shown in Fig. 4. The complete torus is made from 16 sections of two distinct types, exploiting the usual stellarator symmetry. Each section is formed to within ~3 mm of its desired shape. Two sections and a field-period joining flange form a complete half-period of the HSX vessel. This assembly is not independent from half-period to half-period in that the joint flanges must mate precisely. This couples the two half-periods that will be adjacent in the final assembly. The "float" in the system is at the boxport locations at the ends of each full field period. Figure 3

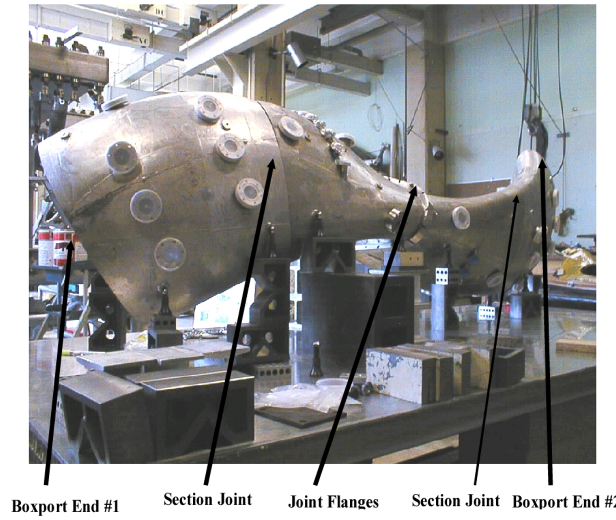

Fig. 4. One field period of the vacuum vessel being measured for final machining.

shows a full field period of the HSX vacuum vessel set up for measurement (also with the CMM) of the actual locations of the ends of the field period for machining. We have also used this setup to determine the location and shape of the holes in the boxports that mate with the vacuum vessel sections. The position and orientation of each section were optimized to minimize the variation from ideal for the assembled system as a whole.

The ends of each section have been machined, the joint flanges installed, and the boxport holes machined to accept the ends of the vessel sections. All of the diagnostic ports have been installed, with the exception of the large 6-in port in each period where there was concern over assembly clearance to the coils. Figure 5 shows the test assembly of a field period of the vacuum vessel. The boxports (at the ends of the vessel) were aligned to their

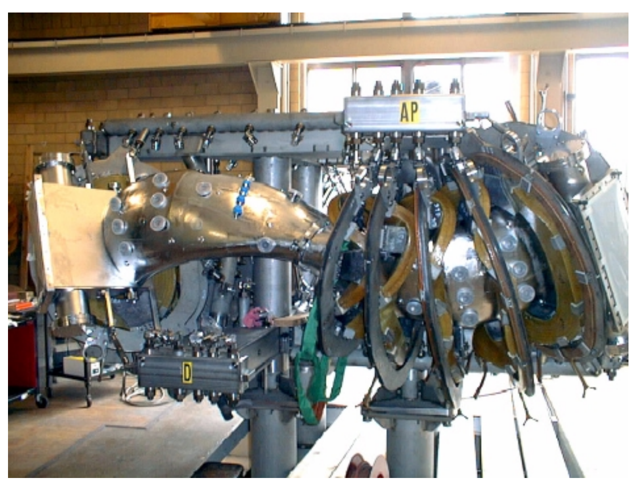

Fig. 5. A completed field period of the vacuum vessel spanning from boxport to boxport. The sections can be installed through the mounted and aligned field coils.

proper position relative to the machine global coordinates. The test assembly showed that the full field period fit together for final assembly with the joint flange properly aligned, pinned and bolted. It was also determined that the large port could be installed before insertion of the vacuum vessel into the coil modules. This step is in progress and the vacuum vessel will be installed upon its completion. Only eight welds are needed to complete the torus, and these weld joints have been designed for minimum pulling. The remaining 16 coil modules will be installed after the torus sections are in place. Insertion and alignment of each module takes about a half-day.

First field-mapping results should be available for the next issue of *Stellarator News*. The mapping system, a conventional electron gun, fluorescent mesh, and CCD camera, has been mostly completed and is under test. The buswork and coaxial coil feeds have all been fabricated and tested, both electrically and for fitup to the coils and main support structure. Vacuum pumps are running on test stands and await hookup to the vessel upon its completion. HSX can run steady state at 1 kG, and will use a 2-kW, 2.45-GHz ECH discharge cleaning system to condition the vessel. This system is in assembly. The main magnet power supply has been fully tested into a dummy load for the B = 0.5 T operations required in the first experimental campaign.

The main 28-GHz ECH system is nearing completion. Beam, magnet, and gun power supplies have all been tested. The socket controls have been checked out and are now undergoing final testing in oil at high voltage. The gyrotron has been power conditioned at ORNL and is on site. The tube will be installed in the socket after the final testing of control electronics using a “dummy” gyrotron is completed. All transmission line components have been fabricated and tested for operation at low power. Final installation of the transmission line needs to be accomplished after all of the coil modules are installed. Operations with the main ECH are scheduled to begin in July.

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Meetings

12th International Stellarator Workshop

September 27– October 1, 1999

The International Stellarator Workshop is held every two years to focus on new results and ongoing activities in theory and experimental research in helical systems. With a number of new operating devices and world-wide interest in stellarator configurations for plasma containment, this should prove to be an exciting Workshop.

Topics

Transport and confinement improvement
MHD equilibrium and stability
Plasma edge and turbulence
Particle and power handling
Divertors and impurity control/transport
Plasma heating
Diagnostics
Configuration optimization
New devices
Reactor studies

Date and Place

The Workshop will be held September 27–October 1, 1999 at the Monona Terrace Convention Center in Madison, Wisconsin. Monona Terrace is a newly constructed Frank Lloyd Wright-designed structure first proposed in 1938. The Center brings to life one of Wright’s final creative visions in a spectacular lakeside setting. For information on Madison, tour the Web site: http://www.visitmadison.com

Language

The working language for the Workshop is English.

Registration

If you are planning to submit a paper or attend the Workshop, please fill out and return the registration form on the Web page by August 26 (fax or mail). Please note that to encourage advance registration for planning purposes, there is a substantial discount on the fees for registration by this date. Web-based registration is available for those wishing to pay by credit card or purchase order. The address is:

http://hsxa.ece.wisc.edu/Stell_Workshop.

Additional conference information will be posted to the site, as it becomes available. Registration fees include banquet, book of abstracts, proceedings on CD-ROM, and conference materials.

Deadlines and Contacts

Receipt of one-page abstracts- - - - - - -	-July 30, 1999
Lodging Reservations - - - - - - - - - -	August 26,1999
Advance (discounted) registration - - -	August 26, 1999
Receipt of final papers - - - - - - - -	September 27, 1999

Workshop Web site:
http://hsxa.ece.wisc.edu/Stell_Workshop
Program:
J.F. Lyon (lyonjf@fed.ornl.gov)
Local arrangements:
D.T. Anderson (dtanders@facstaff.wisc.edu)

People

Prof. Atsuo Iiyoshi resigning the post of Director General of NIFS

(Article reproduced from the March 1999 issue of *NIFS News*.)

At the end of March 1999, Prof. Atsuo Iiyoshi resigned his position as Director General of the National Institute of Fusion Science (NIFS) to become the president of Chubu University. This concludes a very successful period of his professional life.

Prof. Iiyoshi was the first Director General of NIFS, which was established 10 years ago, on 29 May 1989, and could be viewed as the institution succeeding the famous Institute of Plasma Physics of the University of Nagoya and its early Director, Prof. Husimi. The foundation of NIFS was the result of intense and deeply rooted discussions during the later 1980s. Successful work on heliotrons, developed under Prof. K. Uo at the Plasma Physics Laboratory of the University of Kyoto, led to a strong concentration of the NIFS's activities on "helical systems" (stellarators) with the Large Helical Device (LHD) as the central experiment. Prof. Iiyoshi, at that time still a member of the Heliotron Team, was a leading figure during these discussions, and it was quite natural that he became the first Director General of NIFS.

At about the same time there were discussions also in Europe, particularly at IPP Garching together with CIEMAT in Madrid. The net result was a revival of stellarators, because these devices were found to be particularly suited for use as fusion power stations if their expected properties could be demonstrated. As a consequence of these discussions, Europe has embarked on the construction of Wendelstein 7-X as leading experimental facility. Thanks to Prof. Iiyoshi's engaged activities on the Japanese side, an IEA Implementing Agreement could be concluded which joins together all the world activities on stellarators. This is particularly important because the two leading experiments, LHD and later Wendelstein 7-X, will be fully complementary in their detailed properties, as follows from the jointly established theory. Prof. Iiyoshi has recently become the Chairman of the related Executive Committee.

Under Prof. Iiyoshi's strong and far-sighted leadership, the new institute facilities were created at Toki, the scientific divisions were formed and started their work, and the LHD experiment was built according to schedule. Just one year ago, it started operation without difficulties and with very promising first results. Thus, the foundations are laid and the phase of exploitation has begun. It is a rule for Japanese National Laboratories that their Director's term of office should be strictly limited. Thus, Prof. Iiyoshi is leaving the institute now and will take a new position as President of Chubu University. He can look back to a very successful period of his life!

We wish him the same for his new position. Prof. Fujiwara will be his successor at NIFS. We also wish Prof. Fujiwara all possible success for the duration of his term!

Günter Grieger
Member of the NIFS Advisory Council,
Director Emeritus of the Max-Planck-Institut für Plasmaphysik, Garching, Germany