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India and ITER

"This week, India expressed formal interest in joining the effort to build an energy- producing fusion reactor. The six current partners--China, the European Union, Japan, Korea, Russia, and the United States--have just agreed on Cadarache, France, as the site of the International Thermonuclear Experimental Reactor (ITER). Now India's Atomic Energy Commission says in a letter to the E.U. that his country is considering "full partner" status.".

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The 'Plasma Physics India' Group

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About a year ago the 'Plasma Physics India', an internet (Yahoo!) group, was started as an attempt to bring together the people to discuss issues of common interest in an informal and conducive manner. The purpose of the group is to allows us, who are scattered in India and all around the world, to educate and express ourselves on many issues including, but certainly not limited to,

- Role of development of plasma physics in India.
- Requirement of fusion power for the developed India and India's role in international fusion program and collaborations.
- India's potential to develop and commercialize the Industrial Plasma Technology for domestic and international requirements.
- How plasma physics can contribute and benefit from the currently booming Space, Pharmaceutical, Nanotechnology, Information & Telecommunication, Defense and other technologies in India?
- Further improvement in standards of Indian education and research to make stronger impact in the Basic, Astrophysical, Fusion and Industrial Plasma physics.

URGENT

Members may please send in their active E-mail addresses to the Editor so that a mailing list can be generated to inform members of the latest news regarding conference/workshops conducted by PSSI.

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The group, with around fifty present members residing across the globe, is already serving as a forum to discuss scientific and technical ideas/problems, to share news of common interest, to exchange the hard-to-find articles, and to post and get unadvertised or invisible job/postdoc/ studentship positions. The group also desires to establish an open access Indian Plasma Physics Preprint Server, an archive for scientific & technical articles as well as PhD/Master theses, and currently arranging volunteers and other resources.

All members of PSSI are welcome to join the 'Plasma Physics India' group. Please visit the following web link to join up and actively participate in this group.

http://groups.yahoo.com/group/plasma_physics_india/join

SST Update : Fabrication of First Wall components

N. Ravi Pragash, Sameer.S.Khirwadkar and the SST First Wall Group, IPR

First Wall Components (also called as Plasma Facing Components PFC) of SST-1 tokamak comprises of Divertors, Limiters, Passive Stabilizers, Baffles and Auxiliary Baffles.

Fabrication process of each PFC system typically comprises of cutting and forming of copper alloy modules to required conical or cylindrical shape, grooving for cooling tube layouts on modules, brazing of stainless steel cooling tubes to copper alloy modules and final machining & drilling of tile bolt holes and diagnostic holes/slots as per specified requirements. About 4000 tiles of ultra high purity (ash content < 20ppm) fine grain graphite with complex 3-D shapes were machined to specified dimensions by CNC profile machining from 3D models of tiles. A typical graphite tile will have two curved surfaces to match the copper module and plasma profiles with a nut-bar slot and a drilled hole to hold the tile against copper modules by using mechanical bolting mechanism.

The major breakthrough in the PFC fabrication is in the process of brazing copper alloy modules to SS cooling tubes. The chosen high strength copper alloy materials are the CuCrZr (Copper-Chromium-Zirconium alloy) for divertors & baffles, and CuZr (Copper-Zirconium alloy) for passive stabilizers. The brazing cycle normally deteriorates the electrical, mechanical and thermal properties of copper alloy material. Hence a suitable heat treatment needs to be applied in order to retrieve the deteriorated properties. Exploring a number of brazing and heat treatment cycles, a new method of brazing combined with heat treatment cycle is selected and thereby, strength of 310 MPa is regained for CuCrZr alloy after brazing process. The critical requirement of electrical conductivity for CuZr alloy is also regained to 83% IACS after brazing process.

All the above mentioned process utilized a high precision, least distortion fabrication processes like CNC machining, forming, jig boring, etc., in order to meet the stringent requirements of Plasma Facing Components.

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Graphite tile assembly of the outer passive stabilizer.

Module Assembly of the outer divertor.

Forty Years of Plasma Physics at ICTP

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During 4-5 October 2004, ICTP (Abdus Salam International Centre for Theoretical Physics, in Trieste, Italy) celebrated its 40th anniversary with a conference, *Legacy of the Future*. The conference attracted more than three hundred scientists and policy makers from all around the world. Significantly, the conference held a roundtable discussion on the future of science in the developing world. Abdus Salam, (co-winner of the 1979 Nobel Prize in Physics, the founder and long-time director of ICTP) spearheaded the efforts to create an international centre dedicated to theoretical physics, that would pay special attention to the needs of scientists from the developing world. ICTP was formally inaugurated in 1964 under the auspices of IAEA (International Atomic Energy Agency) with a generous support from the Italian government. UNESCO (United Nations Educational, Scientific and Cultural Organization) joined in extending support to the new centre in 1970. ICTP has hence been encouraging science in developing countries through its various visiting programmes; and has held over two-thousand meetings attracting over a hundred-thousand visitors. India has a strong presence at the ICTP from the very beginning. Several Indians have served on the ICTP Scientific Council and directed many of the meetings. During 1970-2003, there have been about 6000 visitors from India totaling to about 10,000 person-months. Katepalli Raju Sreenivasan, a distinguished professor of physics and mechanical engineering, is the third director of the ICTP since 03 March 2003. He is the first experimentalist to hold this position. Sreenivasan, now a citizen of the USA, received his PhD in aerospace engineering from the Indian Institute of Science, Bangalore, in 1975. Several scientific bodies have since spawned with headquarters in and around ICTP. Collectively, they are known as the “Trieste Science System”, which include SISSA (International School of Advanced Study); TWAS (Third World Academy of Sciences). Professor C. N. R. Rao is the currrent President of TWAS.

Plasma Physics has been part of the ICTP activities from the very beginning. It is to be recalled that a meeting in plasma physics had served as a platform for the official launch of ICTP. Plasma Physics was also the theme of the ICTP Commemorative Meeting in 1984. A series of meetings by the name, “Plasma Physics College” have been around since 1977; four of these were jointly directed by Professor R. K. Varma during 1979-1985. In 1987 he became the director of Physical Research Laboratory, Ahmedabad and could not continue with the Colleges. A Plasma Physics Group was established in 1990 and was headed by Prof. S. Mahajan (based in the USA). Meetings with Plasma Physics as the main theme have been held every alternate year and as a sub-theme in numerous other meetings (Computational Physics, Energy Research and Solar Physics, to name a few). Many of the meeting have resulted in the publications of the proceedings. Plasma Physics is also part of the TRIL (Training in Italian Laboratories) and STEP (Sandwich Training Educational Programme) schemes of ICTP. This year there were three meeting related to plasma physics at ICTP.

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From the Editor

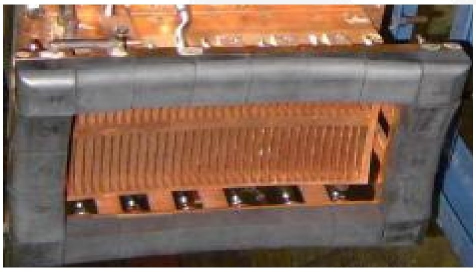
Dear members, From the good response and feedback that we have received from you, PSSI has decided to look in to the possibility of bringing out a yearly society journal, peer reviewed and containing review articles, contributed papers and short communications in the field of Plasma Science & Technology . This idea is still in the formation stages and the members will be intimated regarding the progress of this in due course. Ideas and suggestions from the esteemed members regarding this matter are welcome.

SST - Update : LHCD Drive System

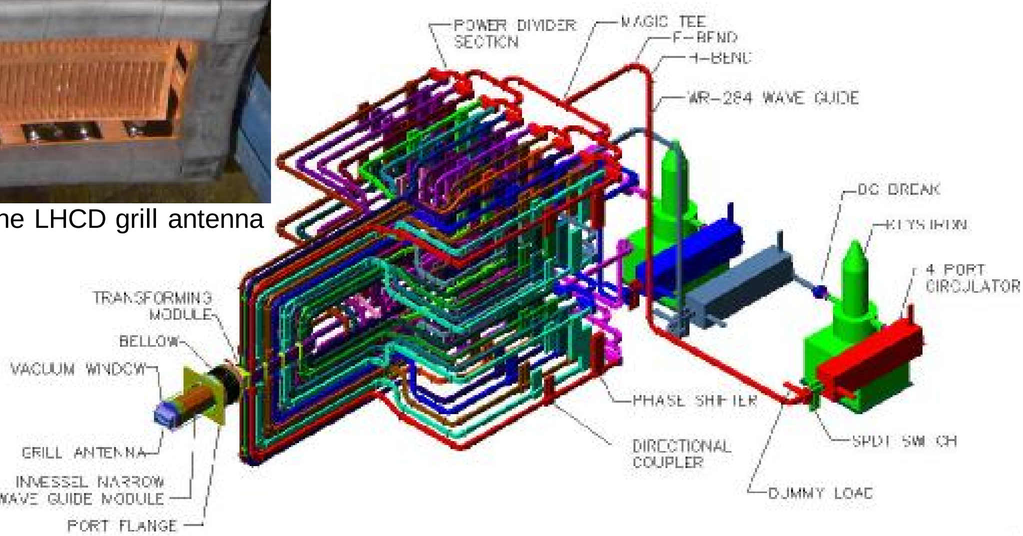
P. K. Sharma, Scientist, RF Group, IPR

A Lower Hybrid Current Drive (LHCD) system for Steady State Tokamak-1 (SST-1) is designed to launch 1 MW of rf power at a frequency of 3.7 GHz for CW operation to sustain plasma current non-inductively for 1000 seconds. The LHCD system is designed to sustain and maintain plasma current of 220 kA with the available rf power in SST-1 machine, which is designed to form an average plasma density of 2 x 10^{19} m^{-3}, with electron temperature of 1 keV, at a toroidal magnetic field of 3 T. The plasma would be formed and sustained in double null divertor configuration, with significant triangularity (d ~ 0.4 – 0.8) and elongation (k ~ 1.7 – 1.9). The RF source for the LHCD system consists of two klystrons, each delivering 500 kW CW rf power at 3.7 GHz. Phased locked oscillator, followed by low power solid-state based amplifier feeds ~10 W of input rf power to the klystron. The two klystrons yield four-output arms, which provides input to the four power-dividing layer of the LHCD system. Each layer divides the input power (250kW) into sixteen channels and comprises of seven high-power magic tees, eight high-power folded magic tees, sixteen high-power dual directional couplers and sixteen high-power phase shifters. The dual directional couplers monitors the forward and the reflected power whereas phase shifter, in each arm provides flexibility to launch desired spectrum into the plasma by setting phase in individual channel. To transform the standard waveguide transmission line to the non-standard waveguide transmission line, a three-step transformer is used in each channel.

Conventional grill type antenna is used, to couple rf power to the plasma and its design is developed using a code, based on the Brambilla theory. The design of grill antenna also supports the launching of composite spectra. The concept involves phasing of adjacent channels of the grill antenna, which steers the electromagnetic waves in preferred direction. The design of grill antenna also supports the launching of composite spectra. The concept involves phasing of adjacent channels of the grill antenna, which steers the electromagnetic waves in preferred direction. A vacuum window is placed between the antenna and the non-standard waveguide transmission line, to isolate the vacuum of SST1 machine and keeps the transmission line under pressure upto 3 bar. The entire transmission line is pressurized with dry nitrogen gas upto 3 bars. To operate the system in CW mode the entire system is water-cooled to actively remove dissipated energy.



Photograph of the LHCD grill antenna



The schematic of the LHCD drive system for SST-1

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