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**ITER News**

On Thursday 13th July 2006, the 9th ITER Preparatory Committee, currently managing the project for the ITER Parties, took place in Cadarache, France. New senior staff were designated for the future ITER Organisation, thus completing the top management structure.

**Professor Dhiraj Bora** of the Institute For Plasma Research, Gandhinagar (IPR) was designated as one of the **Deputy Director Generals of the ITER programme**. His



responsibilities would include CODAC, Heating and Current Drive Systems, and Diagnostics. Born in 1951 in Guwahati, Professor Bora received his Masters Degree from the Peoples' Friendship University of Moscow in 1974, and his Doctorate in Physics from the Physical Research Laboratory in Ahmedabad. For almost 25 years since then, he has been active in plasma physics research at IPR.

His primary interest has been radio Frequency heating and current drive in tokamaks. He has been the project leader of the RF group in IPR since its inception. In the past 15 years the group

has developed CW heating and current drive systems based on high power commercial tubes at MW levels and different frequencies. In his earlier days he was involved in microwave diagnostics and bolometers in tokamak plasmas. He is a member of the C-16 Commission on Plasma Physics of IUPAP for the next three years and a member of the advisory committee of the IAEA Technical meeting on ECH/ECCD in ITER. He is also the Deputy Project Director of ITER-India. Prof. Bora has been a past President and a very active member of PSSI. We take this opportunity to congratulate him on this achievement.

Some excerpts from a chat with Prof. Dhiraj Bora ;

PSSI : *On behalf of PSSI, let me first congratulate you on this occasion !*

DB : *Thank you very much !*

PSSI : *How do you look at this posting from an Indian perspective ? and when do you propose to take up this assignment ?*

DB : *I consider this position as an honour to all of us. This reflects on the fact that our work and abilities are being recognized in the ITER community. I have started preliminary preparations to start my duties in the central team. I plan to move to Cadarach sometime in the middle of September.*

*Continued on page ii....*

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<http://www.pssi.in>

**Plasma Science Society Of India**

(Regn. No. F-828, Ahmedabad)

**Institute For Plasma Research, Bhat, Near Indira Bridge  
Gandhinagar 382 428, Gujarat**

**Tel : 91-79-23969031-35**

**Fax: 91-79-23969017**

*PSSI : What new role do you think you can now play as a PSSI member?*

**DB :** As a PSSI member, I have always tried my best to popularize Plasma science and technology among various workers in the Institutes, Universities and Industries. Now that I will have closer contact with international experts, I will try to make their expertise more accessible to our researchers.

*PSSI : What role do you now see PSSI playing in context of Indian participation in the ITER program?*

**DB :** PSSI should be able to give a platform to all those interested in plasma science and technology to come closer to interact. In this front, PSSI is holding a workshop in near future to discuss the physics areas in which Indians would like to contribute once ITER is built. During the meeting one should be able to nucleate groups on different topics around experts available in the country to give an impetus to the National Fusion Programme and start work in the field of science and technology for future fusion reactors. PSSI should also try to form a field team to popularize and spread the message of how important it is for us Indians to push the frontiers of fusion research with Fusion reactors in mind for the middle of the century.

*PSSI : Can we now expect more foreign participation in PSSI activities?*

**DB :** I will try to make PSSI more visible abroad among interested workers in our field.

*PSSI : What message, (as a very active PSSI member) do you have to the plasma community in India?*

**DB :** With increased resources, PSSI should once again try to chalk out a working plan to bring more researchers into the main stream of fusion research. They can act as the link between major institutes and smaller establishments and may be also industries !

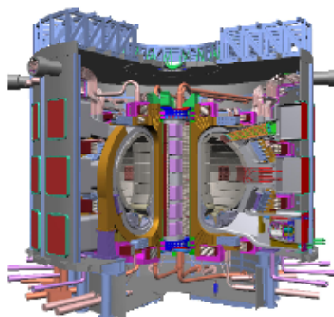
## **The National Fusion Program - ITER & Beyond**

**8-10 November 2006**

Ahmedabad Management Association Premises,  
Ahmedabad, Gujarat

### **A workshop jointly organized by the Institute For Plasma Research & PSSI**

This workshop is intended to build up a strong scientific community, drawn from National Institutes, Universities and Industry within India to work towards the portantly, towards a long term plan for the workshop will comprise of introductory as and India's commitments to the program also identify and highlight the areas under started with participating institutions/Univer- of long-term core working groups during the ideas and the final day of the workshop will ing groups, thereby laying down a roadmap carried out in the identified areas.



ITER goals of India and further, more im- Indian National Fusion Program. The well as detailed talks regarding the ITER during the first two days. The talks will which collaborative programs could be sites. It is expected that the formation course of the workshop will generate comprise of presentations by these work- for future collaborative work to be car-

PSSI members will shortly receive the announcement for this workshop. Please visit the PSSI website for more details regarding this workshop.



*View of the podium during the inauguration of the Plasma Processing -Industry Interaction Meet that was organized by PSSI & FCIPT during 27-28th July 2006 at IPR Gandhinagar. (L-R) Dr. Ganesh Prasad, Dr. S. Mukherjee, Prof. P I John, Mr. Suryakant Gupta, Dr. Amita Das and Dr. N. Venkatramani.*

## Report on the Plasma Processing - Industry Interaction Meet

Ms. Alphonsa Joseph

Facilitation Centre for Industrial Plasma Technologies (FCIPT)

Sector 25, GIDC Electronics Estate, Gandhinagar 382 044

Plasma Processing Interaction Meet PPIIM-2006 was organized on 27-28<sup>th</sup> July, 2006 at Institute for Plasma Research, Gandhinagar, Gujarat. The 50<sup>th</sup> issue of the "PLASMA PROCESSING UPDATE" was released by Shri. R. J. Shah, the Principal Industrial Advisor to Govt. of India in midst of other distinguished guest like Mrs. Paru Jaykrishna, Senior Vice President of Gujarat Chamber of Commerce and Industries, Professor P.K. Kaw and Professor P.I. John during this occasion.



Release of the 50<sup>th</sup> issue of the "Plasma Processing Update".

The main objective of this meet was to bridge the gap between the institute and industries and thereby to exploit the potential of plasma technology for industries. Further, this meet brought all the three i.e. the funding agencies (Govt./Non-Govt.), the user industry and the technology provider (FCIPT/IPR) to one platform to facilitate faster implementation of the newly developed technologies. Eminent speakers from different fields shared their expertise and views during the deliberations of the meet.

The meet was well attended by more than 30 participants from different industries. The meet included presentations by eminent scientist and industrialist along with interactive discussions and live demonstration of plasma based technologies. Application of plasma processing in plastic die industry, textiles, space applications, etc were hot topics of discussion during this meet. During the panel discussion it has been brought out by most

of the participants that such types of meet should be frequently organized to promote awareness of plasma processing to the industries. It was also pointed out that in addition to such meet, efforts can be taken to organize seminars by subgroups in different application areas.



Prof. P I John inaugurating the programme

The participants were invited for a grand banquet at Hotel Cambay Resorts and Spa on the 27<sup>th</sup> evening. Prof. John was also honored for his outstanding contributions to experimental plasma science and technology development in India in this function. The meet ended with the visit to tokamak built at Institute Plasma Research namely Aditya and Steady State Tokamak I.



Professor John being felicitated for his outstanding contributions to Plasma Science & Technology developments.

### Newsletter Content : Contributions From Members

Eesteemed members are requested to generously contribute towards the contents of this Newsletter. I would also request you to use this forum and media to highlight the plasma related research work being carried out by your Institution. Please see the PSSI webpage on how to submit articles for the Newsletter ..... Editor

## A New And Novel Regime In Plasma Based Acceleration Schemes

Sudip Sengupta

Institute For Plasma Research  
Bhat, Near Indira Bridge, Gandhinagar 382 428

The idea of accelerating electrons using the longitudinal field of large amplitude plasma waves, excited in a plasma either using a short laser pulse ( laser wake field acceleration, LWFA) or an electron beam pulse ( plasma wake field acceleration, PWFA ), has been around for almost three decades. ( For a comprehensive review see ref. [1a], and for a popular account of both LWFA & PWFA see ref. 1.b). It is now common knowledge, that a plasma being an electrically broken down medium, can sustain almost three orders of magnitude larger acceleration gradients (  $\sim 1$  GV/cm for  $n_e \sim 10^{18}$  cm<sup>-3</sup> ) than that obtainable using conventional RF based technology ( which is limited by the breakdown electric field  $\sim 1$  MV/cm ). One of the distinct advantages of plasma based acceleration schemes is that for a desired energy gain, the size of the accelerator goes down drastically, thus reducing the complexity and cost of the machine. This has fueled the dream of making tabletop accelerators for a variety of applications, ranging from the frontiers of high energy physics to biology and medicine.

For most practical applications, one requires a high quality beam with low divergence and low energy spread, besides having sufficient amount of charge. Till recently, one of the main hindrances in the practical realization of a tabletop accelerator had been the production of a monoenergetic beam. Most of the plasma based acceleration experiments could produce highly energetic electrons with low divergences but with very large energy spread ( For example, in the experiment performed by Malka et. al. [2] about  $10^8$  electrons were accelerated, the highest energy being  $\sim 200$  MeV, but the energy spread was almost 100% ). A brilliant experimental breakthrough, which has profound implications for the future of this field, has been made recently in a series of experiments [3]. These experiments have accessed a new and novel regime called the “bubble regime” in laser/electron beam plasma interaction physics. The principal novelty of these experiments is, that these experiments have been able to place self-injected electrons in a small region of the accelerating phase of the excited wake field ( wake field here is a bubble shaped nonlinear structure ), resulting in all the electrons gaining nearly identical energy as they go down the potential well. Under actual experimental conditions [3] electrons with energy as high as 80-170 MeV were observed with energy spread in the range of 2-24%. This is in stark contrast to the earlier experiments, where the self-injected ( or externally injected ) electrons covered a broad region of the wake field, resulting in a large energy spread.

The “bubble regime” was first discovered numerically in 3-D PIC simulation by Pukhov *et.al.* [4]. It consisted of an electron free cavity (  $\sim 5-10 \lambda_p$  wide ) bounded by a thin electron sheath, moving with group velocity of the laser pulse. A “neat” bubble gets excited when the length of the exciting laser pulse matches the plasma wavelength. As the relativistically intense laser pulse propagates through the plasma, it excites a wake field with a curved wave front. The curvature arises due to transverse variation in plasma frequency induced by the transverse profile of the laser pulse. Further, relativistic lengthening of the plasma wavelength creates an electron free cavity ( bubble ) propagating at the group velocity of the laser pulse. The rear end of the bubble, eventually breaks transversely [5] and injects electrons into a small region of the cavity. Due to injection of electrons, the curvature at the rear end changes, stopping further injection. The self-injected electrons, which are now moving in phase with the bubble, get accelerated to high energies with a very small energy spread. This, in a nutshell, is the physics of the bubble.

At present the theoretical challenge is to analytically describe the bubble structure in a self-consistent fashion. Experimentally the challenge remains to “see” the bubble. The intense ongoing activities in this field will certainly uncover the uncertain features of the “bubble” regime and also produce enough material for the laser-plasma physicists to chew upon, in the years to come.

[1a] Esarey *et.al.*, IEEE Trans. Plasma Sci. **24**, 252 (1996).

[1b] C Joshi, *Scientific American*, Feb 2006, p.41

[2] Malka *et.al.* Science **298**, 1596 (2002).

[3] Mangles *et.al.*, Nature **431**, 535 (2004), Geddes *et.al.*, Nature **431**, 538 (2004), Faure *et.al.*, Nature **431**, 541 (2004).

[4] Pukhov *et.al.*, Appl. Phys. B **74**, 355 (2002).

[5] Bulanov *et.al.*, Phys. Rev. Lett. **78**, 4205 (1997).

Sudip Sengupta did his Masters in Physics from IIT Mumbai and his PhD from IPR on “*Particle Simulation of Quark-Gluon Plasma*”. His current interests are in laser/electron beam plasma interaction physics, both theory and simulation, as applicable to particle acceleration, harmonic generation, self-generated magnetic fields etc. He is a life Member of PSSI. E-mail : [sudip@ipr.res.in](mailto:sudip@ipr.res.in)



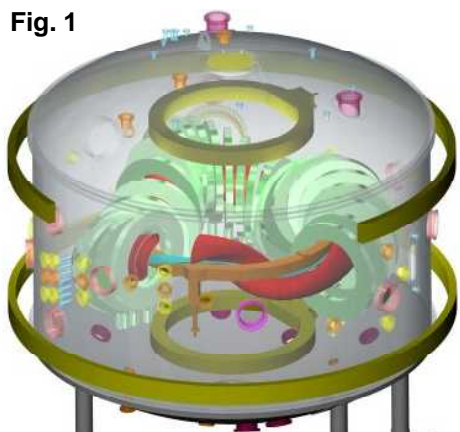
## CT Scan Of A Stellarator Magnetic Flux Surface

**Santhosh T. A. Kumar and Boyd D. Blackwell**

Plasma Research Laboratory, Research School of Physical Sciences & Engineering,  
The Australian National University, Canberra, Australia.

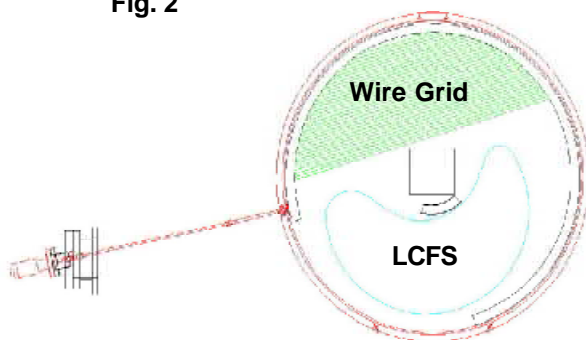
In stellarators, unlike tokamaks, magnetic flux surfaces also exist in vacuum. This gives an unique opportunity to experimentally study the magnetic properties, by carrying out vacuum flux surface mapping. Many different techniques have been used to map flux surfaces on different stellarators world wide, each has its own advantages and disadvantages. H-1NF heliac, situated in The Australian National University, is equipped with

**Fig. 1**



a rotating multi-wire system which gives high resolution images of magnetic flux surfaces, in a way conceptually similar to a X-ray CT scan.

**Fig. 2**

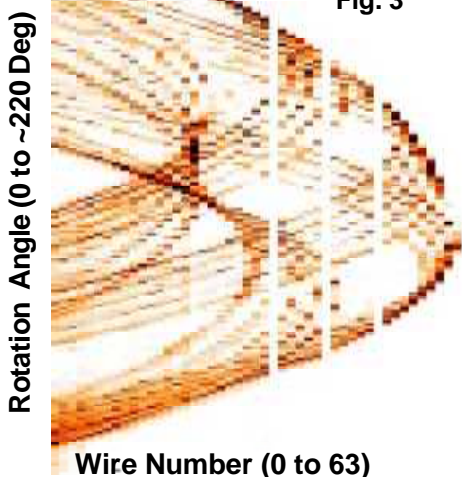


H-1NF is a medium sized 'flexible' heliac (helical axis stellarator) with major radius  $\sim 1$  m and average plasma minor radius  $\sim 0.2$  m [Fig.1]. A wide range of magnetic configurations is available on H-1NF (rotational transform ranging from  $\sim 0.6$  to  $\sim 2.0$ ) by selectively varying the coil currents.

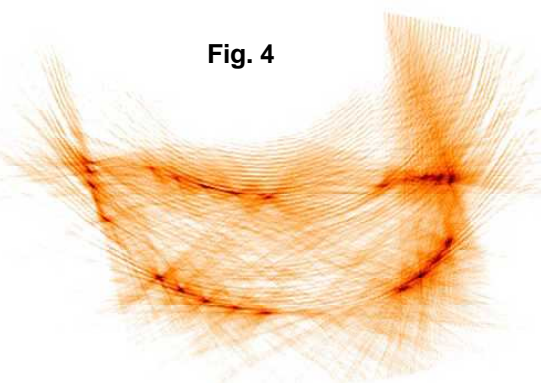
The multi-wire assembly consists of 64 fine Molybdenum wires, each 0.15mm diameter, stretched on a circular rotating frame [Fig.2]. This is permanently installed in the H-1NF vacuum chamber. During plasma operations, this can be rotated away from the main confinement volume to a 'park' position, without a vacuum break. Rotation of this assembly with minimum wire vibrations and required angular resolution is achieved by a computer controlled micro-stepped stepper motor. Working principle is as follows: Electrons are injected along a field line of a magnetic flux surface from an electron gun. The multi-wire system

is rotated in steps (inwards or outwards) to intercept the electron beam transits. Current collected by each wire is recorded at each rotation angle using a 64 channel multiplexer. The data is then subjected to tomographic

**Fig. 3**



**Fig. 4**



inversion techniques to reconstruct the magnetic flux surface. A sinogram is first formed, which is a plot of collected current as a function of rotation angle and wire number [Fig.3]. Sinograms can give a fairly good amount of information, viz the number of toroidal beam transits, signature of magnetic islands/rational surfaces etc. A simple back projection is used for a quick analysis [Fig.4]. This is a summation method, which involves distribution of the projections (wire current) over an array of two dimensional pixels. In order to compare the mapped surface with computer tracing, we need to separate the 'puncture' points from the background 'noise'. Algebraic Reconstruction Technique (ART) is used for this purpose, which is an iterative back-projection algorithm with corrections applied in each iteration to remove unwanted pixels and enhance the image.

....Continued on page viii

## PSSI ELECTION NOTICE

To: All Life, Institutional, Donor and Student Members of PSSI,

This is to bring to your notice that the elections to the **Executive Council** for the term **2007-2009** as allowed for in the Memorandum of Association of Plasma Science Society of India (PSSI), is to be held.

1. As per the Rules and Regulations of the Society, nominations are requested for the following positions of the Executive Council:

President	:	One Post	Vice President	:	One Post
Secretary	:	One Post	Treasurer	:	One Post
Councilors	:	Six Posts			

The relevant rules for nomination are reproduced here [Article II, sub clause 2, 3(b) & 3 (c)]:

2. The President, the Vice President and the Secretary shall not be eligible for immediate re-election for the same post. The Treasurer shall not be eligible for immediate re-election to the same post after serving for two consecutive terms.

3(b) Nominations for the office bearers shall be made over the signatures of at least two members with voting right.

3(c) Written consent of the members being nominated shall be obtained for all nominations.

The following schedule shall be observed for nominations:

<b>Last date for filing nomination</b>	:	<b>October 16, 2006</b>
<b>Last date for withdrawing nomination</b>	:	<b>October 23, 2006</b>

We request you to send (mail or fax) nominations for the office bearers so as to reach us positively by October 16, 2006 You may use the attached nomination form or reproduce the format.

**Dr. C. V. S. Rao**  
Email : [cvsrao@ipr.res.in](mailto:cvsrao@ipr.res.in)

**Mr. C. J. Hansalia**  
E-mail : [hansalia@ipr.res.in](mailto:hansalia@ipr.res.in)

Returning Officers, PSSI  
Election 2006

### Members Please Note :

Members elected/nominated to the Executive council are expected to play a proactive role in the activities of PSSI. Here are a few suggestions :

- n** Make an active effort to enroll more PSSI members from your area / Institution.
- n** Active contributions to the contents of the PSSI quarterly newsletter/website in the form of activity/research reports from their respective regions/Institutions, popular articles related to plasma science & technology, information regarding plasma related courses, workshops and conferences being conducted in their regions.
- n** To disseminate information regarding students' fellowship schemes awards offered by PSSI and encourage them to apply for the same.
- n** Encourage active participation for PSSI organized conferences/workshops from your region.

**Plasma Science Society Of India  
NOMINATION FORM**

I propose Prof/Dr/Mr/Ms/ \_\_\_\_\_ (name of the nominee),

\_\_\_\_\_ (address of the nominee)

for the position of \_\_\_\_\_ on the Executive Council of the PSSI for the term 2007-2009.

Name : \_\_\_\_\_ PSSI Membership No. \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_ Signature \_\_\_\_\_

E-mail: \_\_\_\_\_ Date: \_\_\_\_\_

I second the nomination of Prof/Dr/Mr/Ms/ \_\_\_\_\_ (name of the nominee),

\_\_\_\_\_ (address of the nominee)

for the position of \_\_\_\_\_ on the Executive Council of the PSSI for the term 2007-2009.

Name : \_\_\_\_\_ PSS Membership No. \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_ Signature \_\_\_\_\_

E-mail: \_\_\_\_\_ Date: \_\_\_\_\_

I agree to accept the office of \_\_\_\_\_ if elected and to work on the Executive Council for the term 2007-2009.

Name : \_\_\_\_\_ PSS Membership No. \_\_\_\_\_

Address: \_\_\_\_\_

\_\_\_\_\_ Signature \_\_\_\_\_

E-mail: \_\_\_\_\_ Date: \_\_\_\_\_

This nomination form should be mailed or faxed to the Returning Officers ;:

Dr. C V S Rao and Mr. C J Hansalia

Institute For Plasma Research

Bhat, Near Indira Bridge, Gandhinagar 382428, Gujarat

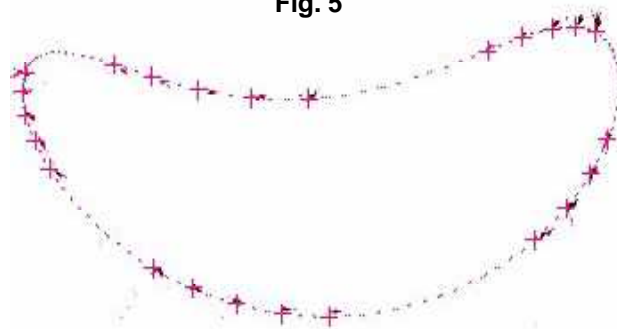
E-mail : C V S RAO <cvsrao@ipr.res.in> C J Hansalia <hansalia@ipr.res.in>

Fax : 079-23969017

**Last date for filing nomination: October 16, 2006**

Shown in **Figure 5** is an ART image overlaid on a computer trace result. This technique has many advantages over the conventional mapping methods (for example, fluorescent screen). As low electron energies are used ( $< 20$  eV, compared to 200 - 300 eV in other techniques), drift effects can be ignored. Position of the electron transit can be determined with an accuracy of  $< 1$  mm and the rotational transform of a flux surface can be obtained, accurate to three decimal places. Mapped surfaces are in machine coordinates, which allows point-to-point matching with computer trace. These properties have recently been exploited to study magnetic islands in detail and to develop an accurate magnetic model of the H-1NF heliac.

**Fig. 5**



Mr. Santhosh Kumar hails from Kannur in Kerala. He obtained his masters degree in plasma physics from Pune University for his research thesis entitled "*Plasma diffusion across multipole magnetic fields*", conducted at the Institute for Plasma Research, Gandhinagar. He is presently undertaking PhD research on "*Magnetic Islands, Configurations and Plasma Confinement in the H-1NF Heliac*" at ANU, Canberra. He is a life member of PSSI.



Email : [santhosh.kumar@anu.edu.au](mailto:santhosh.kumar@anu.edu.au)

The Australian National University is the site of the H-1 National Plasma Fusion Research Facility, and offers post-graduate research degrees in plasma physics (Ph. D. and M. Phil.), and an expanding range of Masters degrees, both by research and coursework. URL : <http://prl.anu.edu.au/studentinfo> Email : [prl@rsphysse.anu.edu.au](mailto:prl@rsphysse.anu.edu.au)


### From the Editor's Desk

As you might be aware, this is election year for the PSSI Executive Council. Please find enclosed, the details regarding the election process. I request one and all to actively participate in the PSSI elections.

The PLASMA-06 will be organized at Malaviya National Institute of Technology, (MNIT), Jaipur from 19 to 21 December. Members will soon be receiving the first announcement from the local organizing committee. Members are requested to look up the conference link on the PSSI website for latest information regarding PLASMA-06.

Student members whose membership ends in July 2006 are requested to either upgrade to life membership or the new student-membership scheme (announced in previous issue of the newsletter), failing which they will not be sent any further PSSI communications.

For advertisements on this newsletter, kindly contact editor at [info@pssi.in](mailto:info@pssi.in)

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