PSSI ESTD 1978

Newsletter Of The Plasma Science Society Of India

Plasma INDIA

Volume 21, No.3, (2006)

The National Fusion Programme

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Fusion research in India started in the early eighties with the construction of Aditya. Aditya became operational in 1989 and has pursued a broad research programme aimed at understanding fusion plasmas and assimilating fusion technologies. Its outstanding contributions include a better understanding of energy transport in magnetically confined plasmas due to edge turbulence. The second generation experiment, the Superconducting Steady State Tokamak, SST-1 is now ready for commissioning. When operational, it will be the first experiment in the world holding hot tokamak plasma for 1000 seconds.

The Fusion Roadmap

The broad concept of a roadmap for fusion was that beyond SST-1, there will be a SST-2, which will be a machine resembling JET. This concept was essentially inward looking in the sense that external events like ITER had no significant impact on the programme. A qualitative change happened to our outlook with India's transition at the end of 2005 to becoming an ITER partner. ITER participation has three aspects, all of which will make a significant impact on our own future programme.

One aspect of immediate relevance is the fulfillment of the commitment for ITER procurement package. This means building and supplying advanced tokamak components to international specifications. When ITER becomes operational, we will also have the opportunity for participation in burning plasma experiments. Both of these aspects will help us to learn a host of advanced fusion-relevant technologies. Indian industry also would be upgraded through its contractual role in actually engineering and assembling these parts in the ITER machine. Another important input to fusion reactor technology is what we learn by building the Tokamak Blanket Module, where the fusion neutrons will be exploited both for heat recovery and tritium breeding. All of these would substantially influence our programme options and will enable us to shorten the time frame of our programme. Participation in ITER brings the possibility of building a demo reactor closer to reality.

Building a demo reactor implies development of indigenous competence in understanding the physics of burning plasmas and acquiring technologies essential to produce and control such plasmas. In terms of specific targets we must achieve, these are generating a community of fusion physicists, setting up programmes for 'Balance of ITER' technologies, developing industries as fusion technology contributors and human resource development.

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The Action Plan

The potential members of the fusion physics community come from two target groups. The first is the group of plasma physicists who are working in other institutions and in other areas of plasma physics like space plasmas etc. A less obvious, but very desirable target is the number of good physicists or mathematicians already active in other fields of theory or modeling. They can be attracted into doing fusion theory or modeling through demonstrating that there is complentarity between their areas of expertise and emerging areas of physics of burning plasmas. State of the arts reports prepared by experts can be very useful in initiating both these groups into topical plasma physics. Presentation and discussions of these in focused workshops may be the best way to expose them to these topics and help them to generate research proposals, which can then be funded.

The target groups for technology development can be science and engineering faculty from IITs, NITs and major universities. In the past they have made excellent contributions to strategic programmes in Space and Nuclear Energy programmes. Small and medium scale industries, especially those run by scientists and technical personnel would also be an ideal target group in the process of development of fusion technologies. Considerable skills exist in areas such as software development, electronic instrumentation, engineering process development, and metallurgy and materials development.

It is sobering to realize that even a major programme like ITER-India would be doing only 10% of ITER. The other 90% will have to be done through the National Fusion Programme, which is in the process of being defined. These involve fusion materials, fusion Neutronics, RF and microwave power systems, power engineering, data acquisition and control systems, plasma diagnostics, robotics, superconducting magnets and cryogenic technology etc. The research and development capability that will be nucleated in academic institutions and industries can be an important contributor to the future development of these technologies.

PSSI Workshops on The National Fusion Programme

The first PSSI workshop held in IPR on 8-10th November 2006 was the first step in the roadmap. The major objective of the workshop was to bring experts from many areas of physics and technology to a common platform, expose them to the challenges involved in the fusion programme mentioned above and to discuss the strategies for realizing the programme.

The workshop consisted of theme presentations on various topics as well as complementary talks by invited specialists. Working groups were formed for identifying and discussing specific areas of collaborative research. A number of definite ideas on collaborative, multi-disciplinary research projects were nucleated, which will now be taken up for funding.

The response to the invitation to the workshop was very encouraging. 105 participants from major universities and IITs participated in the three day workshop. Close to 90 proposals were nucleated, which are now being fine tuned and made ready for formal reviews prior to being approved for funding. We hope to release funds by April 2007.

The future PSSI workshops would be in the form of focused workshops on specific areas and with specific target groups. Tentatively, the next workshop will involve small and medium industries with the objective of tapping their expertise in contributing to specific manufacturing, material and instrumentation problems. The workshop for SMEs will have to be qualitatively different from the fist one we have conducted. This will be aimed at generating focused R&D activities in instrumentation, manufacturing techniques etc.

Prof. P. I. John addressing the participants of the PSSI-NFP workshop.

One of the observations made during the first workshop was that while there was no dearth of enthusiasm, there was a discernable lack of skills required to pursue the research objectives. For example, people who want to work on codes had no prior exposure to codes. To impart the required skills, we plan to start short-term orientation programmes. The topics and the schedule for these are now being developed.

Line Integrated Electron Density Profile In A Spark-Gap Using Michelson Interferometer

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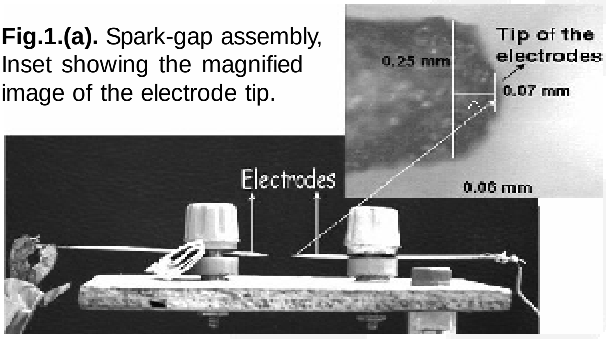
We report the measurement of line integrated electron density profile in a spark plasma by using Michelson interferometer in a single shot. The pulsed plasma was produced by applying the pulsed high voltage across needle shaped electrodes kept around 7mm apart in air, as shown in Fig.1.(a). The schematic of the experimental set-up used for recording the line integrated electron density profile is shown in Fig.1.(b). The electrodes were placed in one of the arm of the Michelson interferometer as shown in the figure. The interferometer was illuminated with a collimated He- Ne laser beam and adjusted for the straight parallel fringes. Whenever, a pulsed high voltage is applied across the spark gap, the pulsed plasma formation results into introducing an additional path difference in the interfering beams. This additional path difference modifies the interference pattern in the region of the plasma. The modified interferogram was recorded directly on to CCD (PCO-pixelfly,). From the measurement of the fringe shift, electron density of plasma was estimated. The plasma width, required for the calculation of line-integrated density, was measured by imaging the plasma in the right perspective with one is to one correspondence on to the CCD.

Fig.1.(a). Spark-gap assembly, Inset showing the magnified image of the electrode tip.



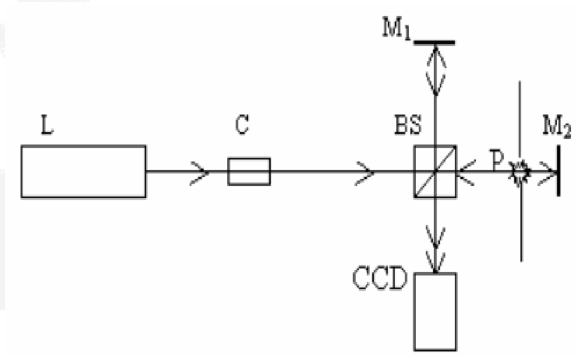


Fig.1.(b). Interferometric set-up to measure the electron density profile, **L**: He-Ne laser, **C**: collimator, **BS:** Beam splitter, **M_1, M_2** : Mirrors, **P**: Pulsed plasma.

Interferogram recorded in presence of spark for vertical fringes (fringes perpendicular to the electrodes axis) is shown in Fig 2.(a). Distortion into the fringes in the region of the plasma is very obvious from the interferograms.

Wherever the electron density is maximum the deviation of the fringes are also maximum. The line integrated electron density profile is estimated by measuring the deviation of the fringes and is shown in Fig 2b. The electron density measured in the spark gap of the present set-up is in the range of around 10^{17} cm^{-3}.

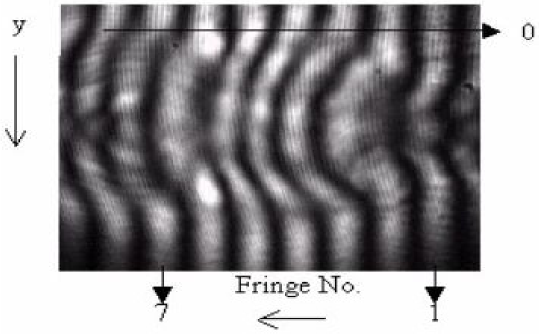


Fig 2.(a). Interferogram in the presence of plasma.

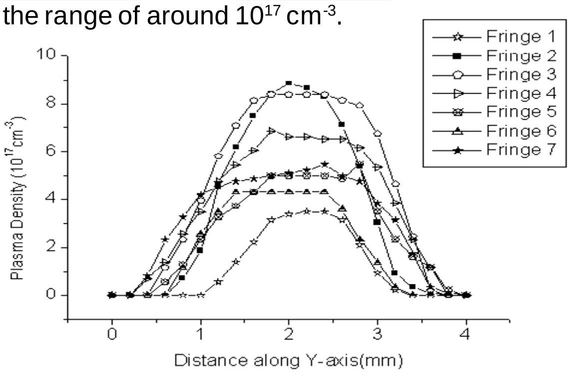


Fig.2.(b). Line integrated electron density profile.

With the gated CCD, the spatio-temporal profile of the air breakdown can be recorded which can be used to study the complete dynamics of the plasma formation. It will be helpful in designing the high-speed spark gap and similar devices with improved efficiency.

Professor Alika Khare is with the Department of Physics, Indian Institute of Technology Guwahati. Her research interest includes Laser-matter interaction, laser interferometry and atom lithography. Email: alika@iitg.ernet.in

PLASMA - 2007 will be held at the Institute For Plasma Research, Gandhinagar and PLASMA - 2008 is proposed to be held at BARC, Mumbai.

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A report entitled Research Opportunities in National Fusion Science and Technology Programme (Report NFP – 01 Sep 2006) has been prepared. The NFP document and future versions will serve as the master database for all research and development activities proposed and performed under this programme. The content will get modified with each version The document will be distributed to potential PIs as printed reports and shall be put on an appropriate website.

Conclusion

The NFP initiative should be viewed as a mass conversion of scientists, engineers and technocrats into the fusion faith. This is a formidable task. We aim to achieve in the next 5 years, what China achieved in 20 years. The NFP initiative offers a great challenge as well as opportunity. This is relevant, especially to the younger colleagues, who will have to carry the burden of executing this programme.

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ITER Agreement Signed

On the 21st of November 2006, ministers from the seven parties of the international nuclear fusion project ITER (China, European Union, India, Japan, the Republic of Korea, the Russian Federation and the United States of America) came together to sign the agreement to establish the international Organization that will implement the ITER fusion energy project. The signature took place at a ceremony at the Elysée Palace in Paris and was hosted by the President of the French Republic M. Jacques Chirac and by the President of the European Commission, M. José Manuel Durão Barroso. The signed documents were formally handed over to the representative of the International Atomic Energy Agency, to be Signatories to this milestone agreement are Vladimir Travin (Russian Federation), Kim Woo Sik (Korea), Takeshi Iwaya (Japan), José Manuel Barroso (European Commission), Jacques Chirac (President, French Republic), Xu Guanhua (Republic of China), Anil Kakodkar (Department of Atomic Energy, India), Raymond Orbach (US Department of Energy), and Janez Potonik (European Commissioner for Science and Research). The signatories along with President Chirac are shown in the picture.

Source : www.iter.org

IMPORTANT NOTE TO MEMBERS

Many members have still not updated their postal as well as e-mail addresses and a large number of newsletters are being returned due to the member having changed their address/email without informing PSSI of their address change. In order to ensure that you continue to receive all PSSI communicatiuons without fail, we request esteemed members to kindly send us their current postal address as well as their active e-mail address(s). One may either go to the PSSI website and use the memebr data update facility or send us the following details by post to : Secretary, PSSI, Institute For Plasma Research, Bhat, Gandhinagar 382 428.

(1) Full Name (2) PSSI Membership No. (3) Postal address with PIN code (4) Active email address (alternative email address, if any)

Dr. Shashank Chaturvedi, Life Member of PSSI, has been awarded the Homi Bhabha Science and Technology Award for the year 2005 by the Department of Atomic Energy for his contributions to Pulsed Power and modelling of high strain rate phenomena.

PSSI extends its hearty congratulations to Dr. Chaturvedi for this acheivement.............. Editor

Editing, layout & composing : Ravi A.V. Kumar