ANNUAL REPORT
2016-2017

प्लाज़्मा अनुसंधान संस्थान

Institute for **Plasma Research**

Bhat, Gandhinagar 382428

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EXECUTIVE SUMMARY

During the year (2016-17), the Institute continued its activities in Fusion research, Technology development, Industrial and Societal applications and Experimental & theoretical investigations of fundamental plasma physics, apart from deliveries to the ITER project.
Some achievements and key developments are enumerated below:

1. Recommissioning of the Aditya tokamak with a set of external coils and internal graphite tiles for shaped plasma experiments is one key achievement. Operation on the device was resumed in December 2016 and plasma current of 80-95 kilo Amperes extending up to 180 milliseconds has been achieved.
2. Renewed efforts have been put on resolving the issues with SST-1 Magnet systems. A series of diagnostics experiments have been carried out and revision of the liquid Helium distribution and feeder systems is being considered.
3. Several other smaller experiments too produced significant research results. The LVPD system experimented with energetic electron loss process in atmospheric plasma with a new rectangular cathode. The Microwave Plasma experiment (SYMPLE) integrated a 3MW, 3GHz, 5 micro-Seconds pulsed modulator and conducted long term confinement experiments. Plasma Torch experiment demonstrated a high of 85kW power, a new probe capable of withstanding the high temperature was also developed.
4. An Inertial Electrostatic Confinement Fusion device produced neutron dose rate of 13-27 μSv/hr in an input voltage range of 40-60kV. Further characterization is in progress. In an Magnetised Plasma Experiment for Plasma Surface Interaction experiment 200kW operation at axial field of 0.45Tesla achieved $10^{20}m^{-3}$ density.
5. Coating with 500 micron pure Tungsten material on Steel was achieved for 50mm x 30mm surface area (collaborator - ARCI (Hyderabad) and tested for integrity over 1000 - 5000 Cycles range.
6. While the TBM activity is entering Engineering Design Phase and neutron estimation database is being generated, mock-up of a TBM first wall module was complete to qualify the fabrication processes (HIP) and materials (Indian RAFM), etc.
7. Development of a helium gas purifier and cryogenic plate-fin heat exchanger for operation with He are underway as a part of large cryo plant development.
8. A 25kg Payload articulated arm has been manufactured and undergoing tests as a part of the development of reactor remote handling equipment. A gripper assembly of 1kg capacity is also in progress. A low cost Virtual Reality Integrated Development laboratory has been commissioned; this is going to help review of design of complex machines.

9. Beam extraction of 27mA/cm^2 with low (<1) electron to ion ratio has been achieved in the negative ion based Neutral Beam experiment, the source uses RF plasma with Caesium injection to produce negative ions of Hydrogen.
10. A 3-D molecular dynamics code has been developed for studies of ionised cluster with electrons relevant in laser plasma interactions. Design studies relevant to structural and nuclear design of future tokamaks.

In Industrial and Societal applications, the FCIPT division have initiated trials on several innovative areas of applications:

- Trials in biological applications of plasma
- Plasma jet based fungal treatment experiments are ongoing in collaboration with PG medical college, Kolkata.
- Use of another type of plasm jet for treatment of Lung Cancer Cell is being explored in collaboration with BARC.
- Hip implant balls have been plasma coated with Titanium Nitride in collaboration with CGCRI, Kolkata.
- Microbial properties of Plasma Activated Water are being studied in collaboration with Gujarat Environment Management Institute and initial results are promising.
- Oxygen barrier coating of plastics for food packaging
- Application of a 2.5m wide atmospheric plasma column to treat man-made Textile in collaboration with MANTRA, Gandhinagar.
- Study of growth of nodular corrosion in pressure tubes of NPCIL's PHWRs using an atmospheric pressure CO2 plasma.
- Plasma based Nano-material production with excellent control on size may have potential application in pharmaceutical industry.
- A Plasma Pyrolysis based waste disposal system of 150kg/day has been installed by an industrial collaborator at the GIFT city, Gandhinagar.

The Institute has as also initiated use of another core competence area, viz., computer software development in application areas. Two initiatives are showing good potential in their initial trials.

Development of a deep learning software for automatic detection of lung nodules in chest X-Rays in collaboration with TMC, Mumbai. An image processing tool to identify regions of protein collocation in biological cells for Molecular Biology Division of BARC.

ITER India made substantial progress in deliveries and R&D in preparation to ITER supplies.

- Indian In-wall Shield blocks were delivered for 2 sectors of the vacuum vessel.
- The Cryostat base section and lower tier cylinder, involving fabrication of some 1500 tons

of steel reached the site workshop at ITER and final site assembly has begun.

- Large part of the Cooling Water System comprising of various pipe works, large heat exchangers, pressurisers, etc, have been shipped to ITER site.
- After successful test of prototype cryolines at the laboratory in campus, production has started at different places in India and abroad.
- The R&D for ICRF system achieved the full 1.5MW, 2000 Seconds operation (with matched and mismatched loads) in the campus laboratory.
- A cryopump module for use by the DNB system was developed and is undergoing tests.
- A 100kV HV Power Supply was delivered to the Neutral beam Test facility in Italy apart from commissioning and characterization of similar unit in the campus laboratory.
- A Fast Scanning Fourier Transform Spectrometer has been received and final assembly in progress at laboratory.

Academic programs like Summer School (46 students), Technical Training and Doctoral programs (42 students) of the institute were continued as usual. The institute had 217 publications in peer reviewed journals apart from 88 Research Reports and 48 Technical Reports published during the year.

DIRECTOR,
IPR.

ANNUAL REPORT

APRIL 2016 TO MARCH 2017

Since 1986 the institute has been involved in plasma physics research with fast growing facilities, trained man power and many fruitful national and international collaborations. Starting with small tokamak experiments and basic plasma experiments, the institute has been acquiring expertise in most of the relevant scientific and technological requirements for controlled thermonuclear fusion. Through the participation of the country in the ITER project, technologies related to fusion are being developed in the institute which are also being tested in the international arena. Also the technologies thus developed are being made available and being applied to many other societal problems benefiting the country.

CHAPTERS

CHAPTER A

SUMMARY OF SCIENTIFIC & TECHNOLOGICAL PROGRAMMES

A.1 Fundamental Plasma Physics

The fourth state of matter, Plasma, after solid, liquid and gas is being studied in various conditions so as to explore applications for the humankind. Here it is being studied in very small scale laboratory experiments as well as in slightly bigger scale in tokamak configurations.

A.1.1 Basic Experiments

A.1.1 Basic Experiments

Basic Experiments in Toroidal Assembly (BETA)

In a simple toroidal device such as BETA, the plasma profiles and properties depend on toroidal magnetic field topology. For example, the toroidal connection length crucially controls the adiabatic or the non-adiabatic nature of electron dynamics, which in turn governs the nature of instabilities, fluctuations, and transport, the latter of which governs the plasma mean profiles. Recently, extensive experiments were performed in BETA by controlling the mean parallel connection length Lc , by application of external vertical component of magnetic field Bv , where Bv is of the order of 2% of toroidal magnetic field BT. Interestingly, for nearly closed field lines, which are characterized by large values of Lc , it is found that flute like coherent modes are observed to be dominant and is accompanied by large poloidal flows. For small values of Lc , the mean density on the high field side is seen to increase and the net poloidal flow reduces while a turbulent broad band in fluctuation spectrum is observed. Upon a gradual variation of Lc from large to small values, continuous changes in mean plasma potential and density profiles, fluctuation, and poloidal flows demonstrate that in BETA there exists a strong relationship between Lc , flows, and fluctuations. The net flow measured is found independent of the direction of Bv , but an asymmetry in the magnitude of the flow is found. The observed imbalance between the mean flow, fluctuation driven flow and net flow is still unexplained. Lastly, extensive experiments varying both BT and Bv but keeping certain ratio values to be constant, has been performed. A manuscript is under preparation. Presently work is underway to measure particle confinement time experimentally as well mass scaling studies.

Large Volume Plasma Device (LVPD)

LVPD has progressed primarily on three major fronts, namely, i) experimental investigations for a) understanding plasma transport due to Electron Temperature Gradient (ETG) turbulence, having relevance to plasma loss in fusion devices and b) understanding physical mechanism involved for the loss of energetic electrons present in LVPD plasma, ii) continuing

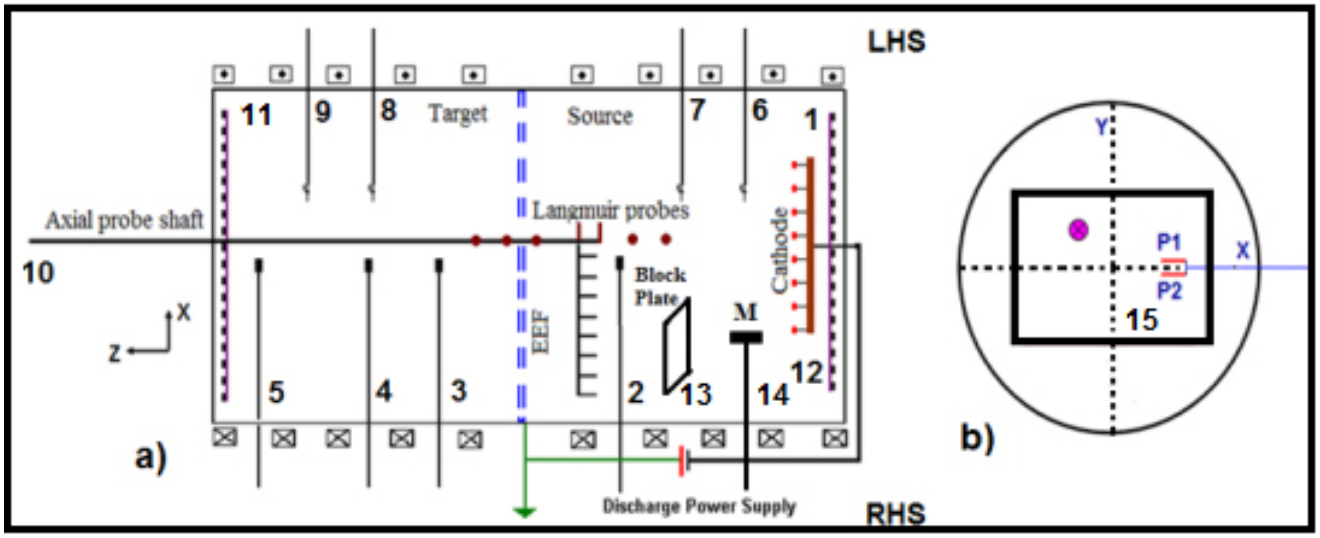


Figure A.1.1 Schematic a) LVPD experimental system and b) cross-section view of rectangular source function.

efforts to complete automation of the device and iii) development of diagnostics.

(i) Experimental Investigations

(a) Turbulent Particle transport in Electron Temperature Gradient (ETG) Turbulence Background: Turbulent transport is a ubiquitous phenomenon prevalent in laboratory, space and astrophysical systems. Figure A.1.1: Schematic showing a) LVPD experimental system and b) cross-section view showing rectangular source function. ETG turbulence has

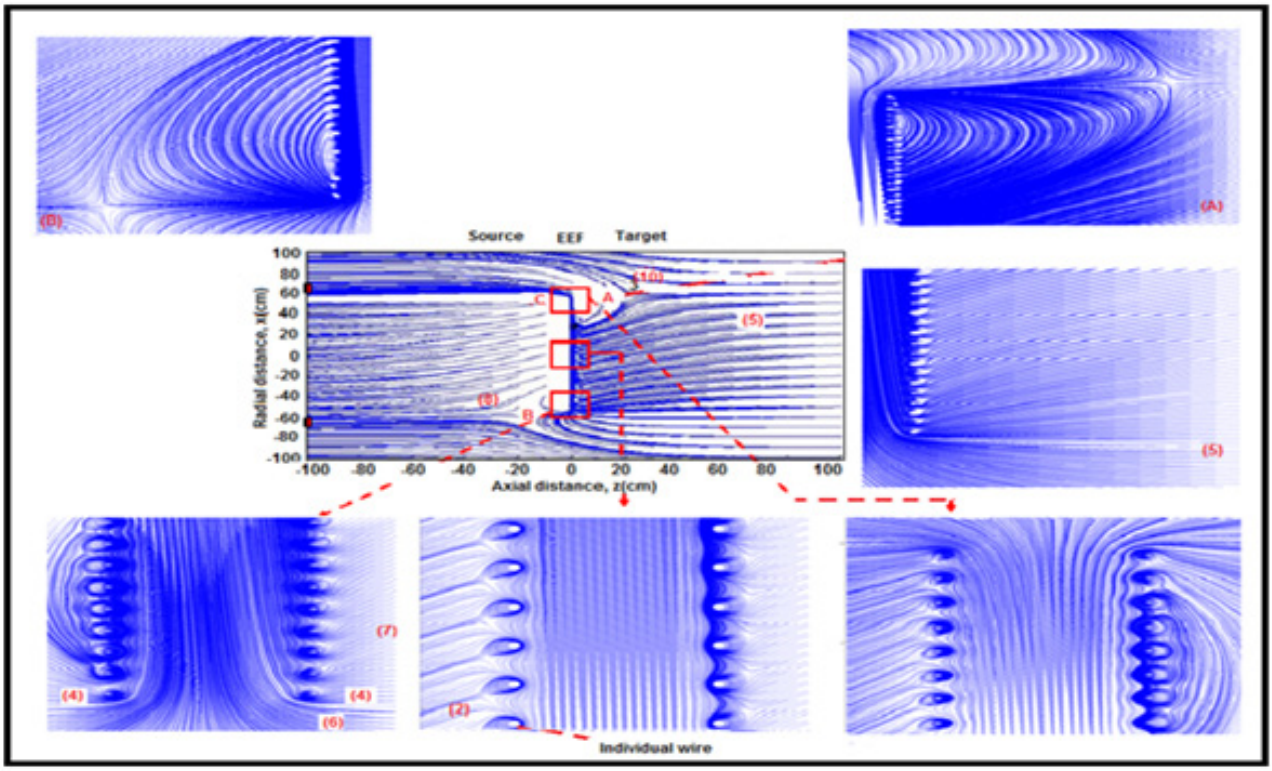


Figure A.1.2 Shows simulated coupled magnetic field of the EEF solenoid with uniform ambient magnetic field

been successfully established turbulence in target plasma of LVPD and brought its scales in measurement limits of conventional diagnostic tools. The source of the underlying turbulence has been established as electron temperature gradient driven modes in the core of the target region of the device. This is ensured by making the target region free of energetic electrons by using a transverse magnetic field with the help of an Electron Energy Filter [see figure A.1.1]. The phase velocity, correlation between density and potential fluctuations and turbulence power spectra confirms that the observed turbulence in LVPD is driven by ETG.

(b) Understanding Physical Processes Involved in Energetic Electron Loss: Energetic electrons are produced in large numbers in LVPD because of direct acceleration of emitted electrons from the filamentary source. The transverse magnetic field of EEF (Bx = 150G) modifies the ambient magnetic field (Bz = 6.2G) in the near vicinity of EEF. Figure A.1.2 shows the simulated coupled magnetic field of EEF. Magnetic field of EEF has led to formation of the magnetic mirrors. In the source plasma region, we have measured excess floating potential (mimics presence of energetic electrons) values in the plane at different axial locations in source plasma side. It seems then most energetic electrons emitted from the filaments are lost in the EEF while causing ionization in the source region and excitation of neutrals. It is found that only energetic electrons in the left half side are reflected back from the magnetic mirror to the source plasma and these electrons should have velocity distribution with loss cone features. It is found that the polarization angle obtained from the phase difference at various frequencies of the fluctuating signals is not circularly polarized. It is inferred here that the polarization might be elliptical. According to the cold plasma approximations, this could be due to the whistler waves of frequency 10kHz-70kHz propagate at highly oblique angles (theta= 89 degrees) for LVPD device and plasma parameters. Such Whistler waves can be described by Quasi Longitudinal (QL) approximation. These observations in LVPD source plasma can have similarities to QL excited when the interplanetary magnetic field near the magneto pause turns southwards, it triggers reconnection events which release the energetic electrons emanating out from solar flares and travelling with the solar wind into the earth's magnetosphere. The pole bound electron flux gets trapped in the earth's magnetic field and suffers loss cone instability generating the observed QL whistlers.

(ii) *Complete Machine Automation:* In continuation to augmentation of 40 channels PXI based data acquisition system

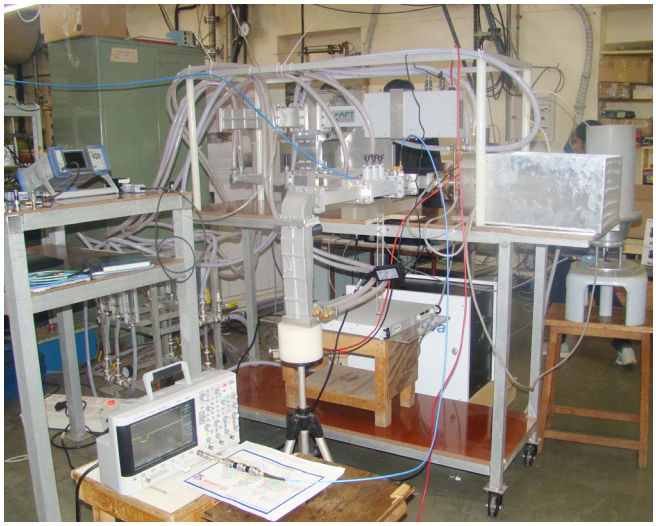


Figure A.1.3 Magnetron system, integrated with the pulsed modulator and the HPM coupling components.

on LabVIEW graphical development platform, the software has been enhanced to adapt object - oriented software engineering principle and architecture. The process automation software of MCS has been enhanced for advanced capabilities. The process automation software presently covers high current filament power supply (10 kA/ 20V) and 12 numbers of probe positioning systems (stepper motor and drive based linear positioning system (travel length ~ 100 cm)) connected on 4-wire RS485 and interfaced using standard Modbus communication protocol. The software has been enhanced to cov-

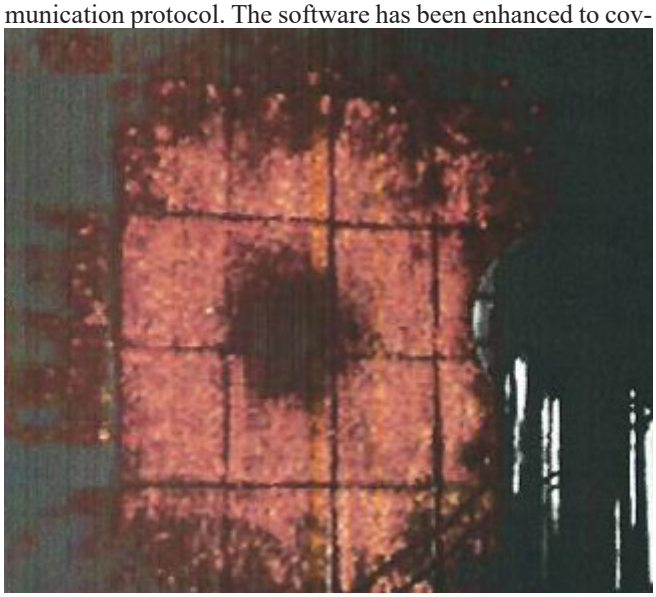


Figure A.1.4 The Neon bulb glow pattern establishing the HPM output from BWO in the TM mode.

er the simultaneous positioning of 12 probes from sequential positioning in the horizontal plane of the machine.

(iii) *Diagnostics Development:* This development work for turbulent energy flux measurements has been undertaken. This requires real time sampling of temperature and poloidal velocity fluctuations. The triple probe developed for pulsed plasma investigations is calibrated for temperature measurements using single and double probe diagnostics. Final work on delivering it as a diagnostic tool for energy flux measurements is in progress and soon real time measurements of energy flux will be undertaken using this diagnostics.

SYstem for Microwave PLasma Experiments (SYMPLE)

A pulsed modulator with 3 MW, 3GHz, pulsed (5 microsecond) Magnetron has been integrated with the driver and the coupling components (circulator, variable attenuator, directional coupler, dummy load, tuner etc.). The system, as shown in the figure A.1.3, has been tested successfully for the desired pulsed modulator output (50 kV, 100 kA) and the High Power Microwave output. The Backward Wave Oscillator being developed at BARC as a combined effort by IPR and BARC, has been tested for the HPM output characteristics. The BWO tube, when integrated with the KALI – pulsed power driver, delivered about 500 MW HPM power. Figure A.1.4 shows the neon bulb glow pattern that ensured attainment of HPM power in the TM mode.

Non-Neutral Plasma Experiments

Design and Developmental tasks: Trap components and inner bore have been redesigned, fabricated and installed to probe the plasma better and accommodate thick conductors for TF. Inner surface of the vessel has been polished thoroughly for better, free from outgassing and sustainable vacuum. The pumping line has been placed on a newly designed and fabricated support structure for stability and ruggedness. TF coil has been upgraded to cause a toroidal magnetic induction of 1.2 kilogauss for the time duration of about 3 seconds. Protection circuits for data acquisition and control system have been developed and tested. A query based database management system has been developed for the detailed analysis of experimental data and currently going through rigorous tests. A test plasma has been made and diocotron oscillations have been observed post vessel conditioning and installation of improved trap components.

Experiments: Long-time confinement experiments have been performed. The electron plasma in the system approaches

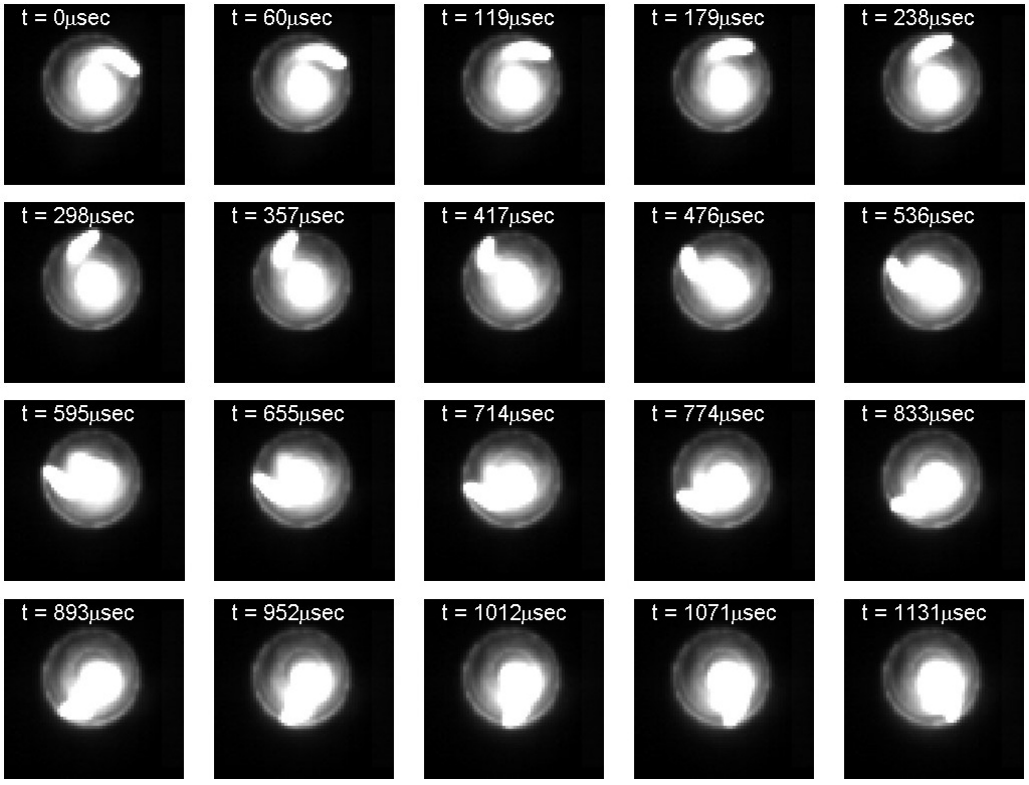


Figure A.1.5 End-on images showing rotation of the nitrogen plasma column in an atmospheric pressure dc non-transferred plasma torch captured using fast camera in the presence of external magnetic field

magnetic pumping transport. Attempts have been made to obtain radial shift of electron charge cloud from ratio of two capacitive probe signals based on shape identifying algorithm.

Plasma Torch Activities

Steady-state operation of plasma torch was demonstrated at 85 kW. A novel enthalpy probe was developed that eliminates the possibility of welding/brazing joints facing the plasma plume and can withstand higher plasma temperatures. Plasma torch computer model was successfully run on the high performance cluster machine. The model was upgraded to include more realistic boundary conditions and role of metallic vapour in the plasma. Results were shown to match with experiments to a great extent. Fundamental studies involved the investigation of dynamical behaviour of the plasma using fast imaging techniques [see Figure A.1.5] where the role of external magnetic field, discharge current and gas flow on the arc dynamics were de-lineated. In another experiment, the role of fluid dynamic configurations on the plasma torch efficiency was also investigated.

Interaction of Low Energy Ion and Neutral Beams with Surfaces

An experimental setup exists for studying interaction of low energy ions with metal surfaces which utilizes high density plasma beam (10^{13} cm^{-3}) of 26 mm diameter. The plasma is generated with the help of 800W pulsed microwaves (frequency = 100 Hz, duty cycle = 10%) and 800 Gauss magnetic field produced by a pair of electromagnets (Helmholtz coils). This above plasma source was built with the dual purpose of studying not only interaction of high density plasma but also neutral beam with metal surfaces. To generate a neutral beam a reflection plate is placed in the path of the plasma beam at 45^{o} to its axis. To image the neutral beam a micro channel plate (MCP) / phosphor screen based low energy (1-100eV) neutral beam observation system has been procured. This observation system can only function in the pressure domain which is lower than $5x10^{-6}$ mbar. Hence differential pumping mechanism is needed to keep the pressure in this domain while the pressure in the main plasma source is about 400 times higher. The ultra-high vacuum (UHV) chamber which will house the neutral beam observation system and which utilizes turbo and dry scroll pumps has already been fabricated and tested for ultimate pressure ($6x10^{-8}$ mbar) and also for the differential pumping mechanism. Presently we are in the process of assembling the neutral beam observation system in the UHV chamber. In the near future we will not only image the neutral beam but also detect it with the help of an ionizer cum mass spectrometer as well as determine flux by adding an energy analyser.

Multi-Cusp Plasma Device

A new design for the ionizer plate is being explored while the design for the caesium oven is being revisited through the various experiences gained through the caesium material used in the negative ion source experiments. The Argon plasma produced by filamentary sources have established a very quiescent nature for about a radial distance of 6 cm from the axis, while different fluctuations have been recorded beyond 6 cm. Though the gradient is there in the axial direction, it is found to be very small compared to the gradient length in the radial direction, at the midplane perpendicular to the axis of the main chamber. The fluctuations are being studied in detail with the variations with respect to the magnetic field gradients and different field values. Reports are being generated for publications from these works.

Inertial Electrostatic Confinement Fusion (IECF) Device

A cylindrical IECF chamber has been installed at CPP-IPR. By making use of hot or cold cathode discharges the deuterium plasma is being produced in it (Figure A.1.6). Fusion neutrons are emanated from the device on applying voltage of above 20 kV to the deuterium plasma. The high voltage is applied to the central grid of IECF device using the HVPS (200 kV, 80 mA). The experiments are conducted to check

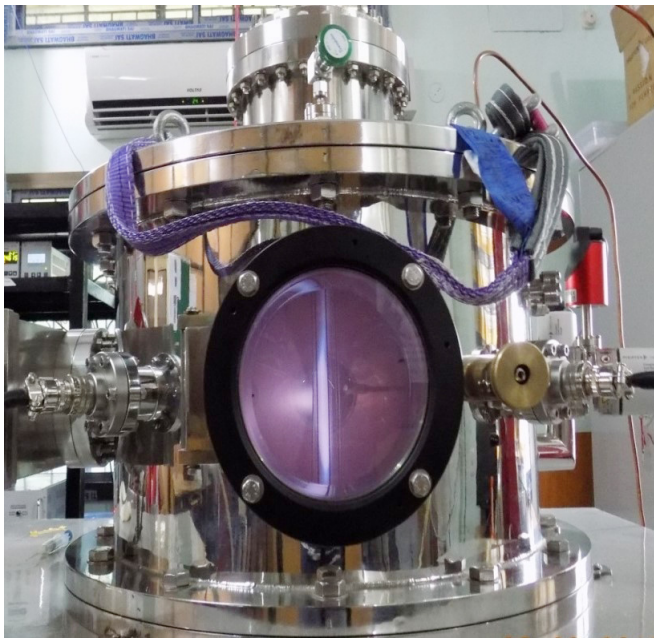


Figure A.1.6 Inertial Electrostatic Confinement Fusion (IECF) device showing glow discharge plasma

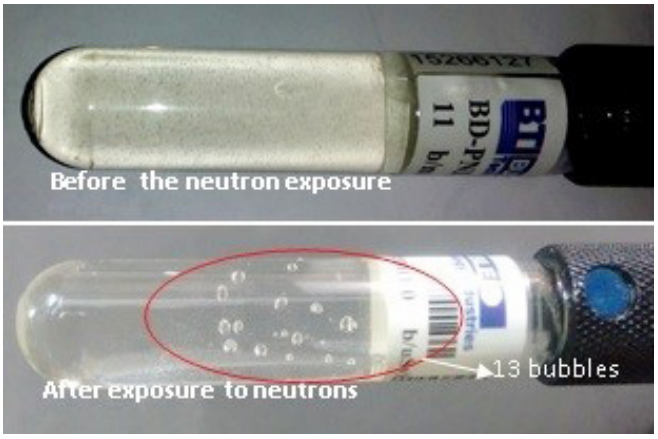


Figure A.1.7 Detection of neutrons from IECF device using bubble detector

the neutron emission from IECF device using neutron area monitor. The detector in area monitor is basically a He-3 proportional embedded with polyethylene and boron plastic as moderator. The neutron area monitor was kept at a distance of 1.5 m from the IECF chamber. A dose rate of about 8.861 μSv/hr have been observed. This was also confirmed by using a bubble detector (BD-PND) which recorded 13 bubbles corresponding to neutron dose of 13μSv for a volatge of 40 kV for about 10 s. On further increasing the voltage to 60 kV, a maximum neutron dose rate of 27 μSv/hr was also obtained.

Studies on Negative Ion Source

In a typical voluminous negative ion source, one needs a plasma with very low temperature around 1 eV without any other energetic electrons. It is because the negative ions are produced by attachment of low energy electrons to a neutral hydrogen atom. This type of low temperature plasma is typically made by using magnetic filtering from the plasma produced using filaments where the high energetic electrons are stopped by the filter. The filtering process is influenced by many processes which need to be understood. An experimental device has been built to study these influential phenomena.

Influence on cross-field diffusion by effecting the diamagnetic drift of the charged particles: The experimental setup consists of two identical multi-cusp magnetic cages of 0.32 m in length and 0.25 m in diameter each for source and target regions. Magnet channels (N-S) are kept separated from each other to form a transverse magnetic field (TMF). Five tungsten filaments are used in the source region to produce Hydrogen plasma at a working pressure of ~ 5 x 10^{-4} mbar,

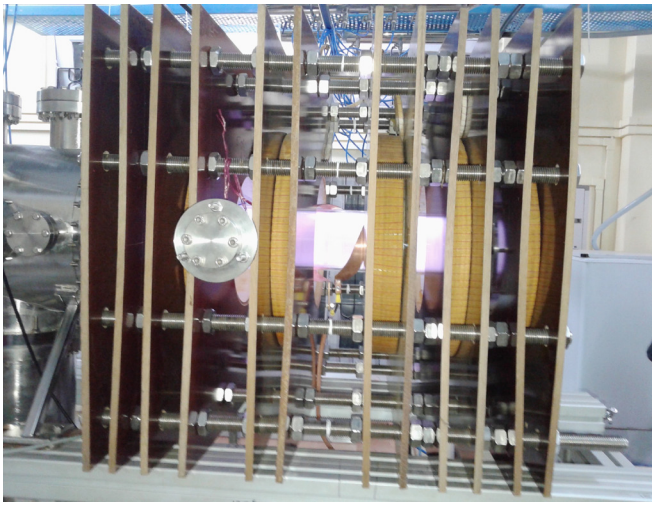


Figure A.1.8 Argon plasma produced in the HeliPS system

at a discharge voltage = 80 V. Two stainless steel plates (P1 and P2) are biased up to 80 V. The electric field between the plates, in one configuration, restricts whereas, in the opposite configuration, facilitates charged particle movement from source to target region. It is found that diffusion of plasma across a magnetic filter can be varied by influencing the diamagnetic drift.

Measurement of negative ion density using laser photo-detachment signal: The negative ion density is measured using the laser (Nd YAG, 1064 nm ~ 70 mJ) photo-detachment setup. The laser beam is reflected by multiple mirrors to make it incident inside the target region just opposite the Langmuir probe tip which is kept biased. The photo detachment signal is then collected in an oscilloscope. Initial experiments and analysis of oscilloscope signals show negative ion density of ~ $3x10^{13}$ m^{-3} in the target region at a discharge current of 1 A (ne = 0.9 x 1015 m^{-3}).

Ion-Ion Plasma Experiments in a Helicon Source

A helicon plasma system has been designed and developed at CPP-IPR which will be used for production and experiment of ion-ion plasma using electronegative gases. The entire chamber system (stainless steel + glass) was pumped down by using Turbomolecular pump(1000 l/s) backed by rotary pump and a base pressure up to $8.5x10^{-6}$ mbar was obtained. The six solenoid magnets are made and installed along the axis of the chamber after testing. Radio Frequency Generator of 13.56 MHz and 3 kW RF power with matching network was installed in the Helicon plasma system. Figure A.1.8

shown the argon plasma produced with a working pressure of 10^{-3} mbar, RF power at 100 W and the B field at 300 Gauss.

CPP-IPR Magnetized Plasma Experiment for Plasma Surface Interaction (CIMPLE-PSI)

This is a linear magnetized tokamak divertor simulator system developed for ITER relevant Plasma Surface Interaction (PSI) studies. The system uses a segmented arc source for production of a plasma jet, which is confined into a collimated beam by an axial magnetic field (0.45 Tesla) produced with a water cooled electromagnet. Four roots vacuum pumps of total 14,000 m^3/h capacity ensures few pascal pressure near the plasma material interaction region through differential pumping geometry. At a 200 kW power operation with a plasma density of 1.4 $X10^{20}$ m^{-3} and temperature in the range of 1-2.7 eV , the ion and heat flux parameters were estimated to be 0.4$X10^{24}$ $m^{-2}s^{-1}$ and 6.9 MW/m^2 respectively. The diagnostics capability were enhanced with the introduction of a retractable Langmuir probe system and water calorimeters of different sizes. This device will be also augmented by integration of ELM like laser pulses, which will result in an unique system, that will help in understanding the synergy of the steady-state plasma and transient heat pulses.

A.1.2 Aditya Tokamak

Status of the Machine: The Aditya tokamak (R0 = 75 cm, a = 25 cm) having a limiter configuration has been upgraded to a tokamak with divertor configuration. It has been designed to produce a circular plasma with plasma current ~ 150 – 250 kA, plasma duration of ~ 250 – 300 ms with electron density and temperature in the range of 3 – 5 x 10^{19} m^{-3} and 500 eV – 1000 eV respectively. Further, it has also designed to obtain shaped plasmas with plasma current ~ 100 – 150 kA, elongation (k) ~ 1.1 - 1.2 and triangularity ~ 0.45. After successful commissioning and integrated power testing of machine, the installation of various sub-systems has been completed to obtain the first plasma discharge. Figure A.1.9 shows the Aditya U tokamak with pumps, diagnostic and other peripheral subsystems, ready for operation. Two turbo molecular pumps and two Cryo pumps are installed on vacuum vessel. The total gas load of the vessel and in-vessel components generated by global leak rate, total out gassing rate and per-

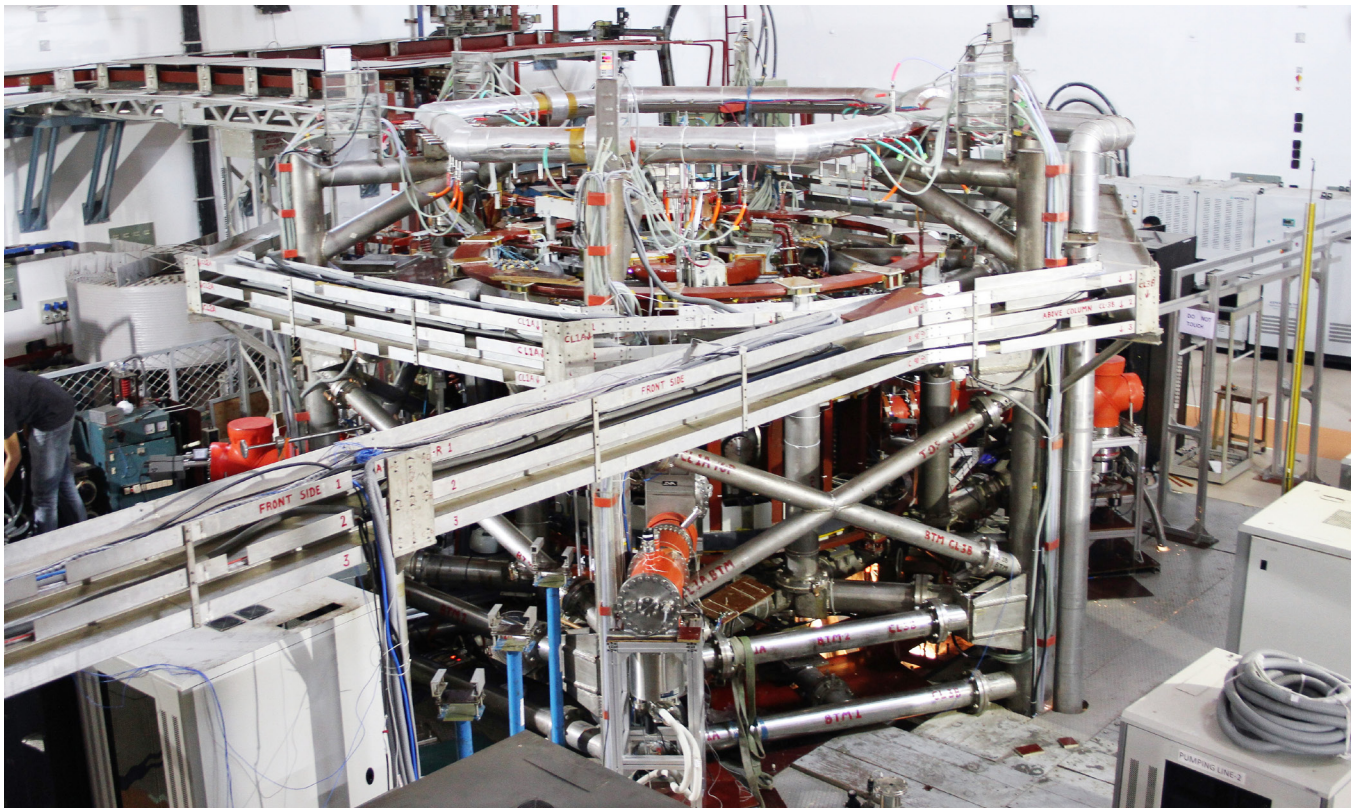
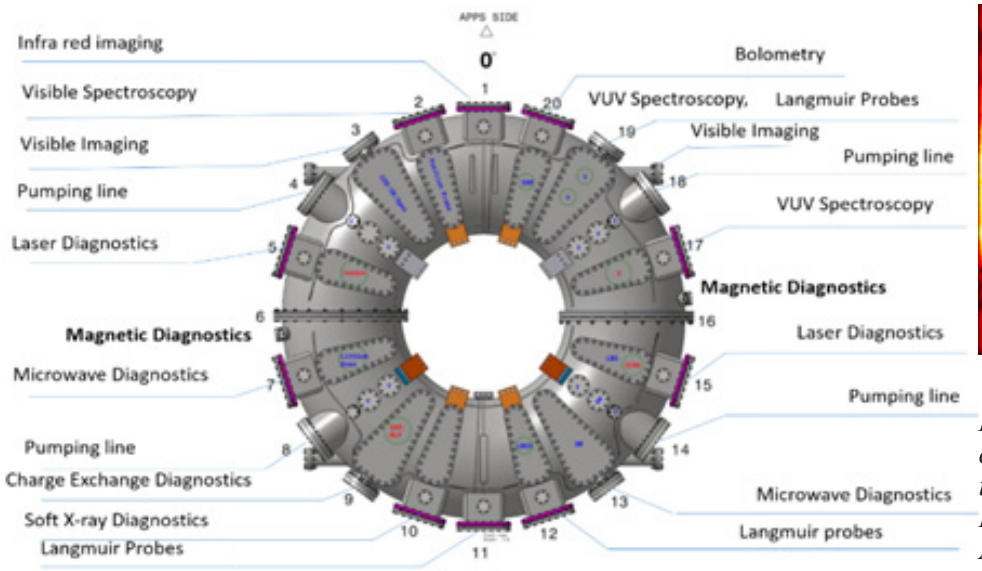


Figure A.1.9 Top view of Aditya – U tokamak with installation of pumping lines and various sub-systems



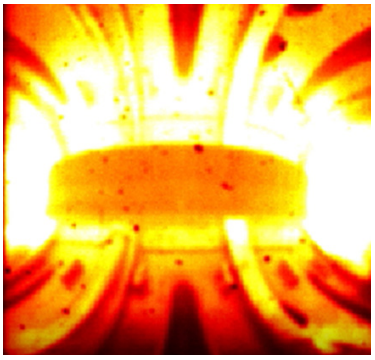


Figure A.1.10
Left : Top View of port allocation of different diagnostics along with pumping lines. Right : Image of typical Aditya-U discharge (# 30360)

meation has been maintained ~10^{-6} mbar.litre/s to achieve ultimate vacuum as ~10^{-9} mbar. The magnetic diagnostics such as flux loops, two poloidal arrays of magnetic probes (Mirnov coils), for plasma position measurement, diamagnetic loop, four internal Rogowski coils have been installed in Aditya-U. Apart from magnetic diagnostics, spectroscopic, microwave and other diagnostics such as soft and Hard X-ray detectors, bolometers, electric probes are installed for the first phase of plasma operation. The location of different diagnostic on vacuum vessel is shown in the Figure A.1.10 (left). For recording the data gathered by different diagnostic systems, PXI based data acquisition systems are used. To facilitate the smooth communication among systems lying in tokamak hall and the power supplies, an optical fibre based trigger transmitters and receivers system with programmable delay setting has been design, develop and installed. After data transferred to Server, it is available on IPR-intranet and can be retrieved and analysed using MATLAB / MDSplus/ Other analysis software.

Plasma facing Components: The plasma boundary is formed using inboard toroidal ring Limiter made up of Graphite in the first phase of operation. Apart from the toroidal ring limiter there exist one outer limiter assembly installed at one particular toroidal location with poloidal extent of 1/4 of poloidal periphery of vessel in first phase of operation. In addition, one pair of the safety limiter which is a poloidal ring of graphite tiles placed inside vessel at toroidally symmetrical locations. The divertor plates will be installed in second phase of operations.

Error Field Measurements and Simulation Studies: Error magnetic field, the unwanted Br and Bz components of magnetic fields due to transformer (Ohmic) coils inside the vacuum vessel), have been measured at 2 different toroidal locations as a function of Radius R and height Z. It is observed that the error fields are reduced in magnitude as compared to previously estimated values.

First Plasma After Upgradation: The first discharge in Aditya-U has been obtained on 1st December 2016. Prior to the operation, the performance of Aditya-U vacuum pumping system had been tested successfully to achieve base vacuum in the range of 10^{-8} Torr. Then suitable discharge cleaning has been carried out using glow discharge cleaning mechanisms for several hours on several days. The pumping system is again tested successfully for high gas feed pressure in wall conditioning operations in the pressure range of 10^{-4} to 10^{-2} Torr for long hours (~ 12 hours). Initially repeatable plasma discharges of plasma current of ~ 80-95 kA with duration of 80–100 ms with toroidal magnetic field BT (maximum) ~ 1T and chord-averaged electron density ~ 2.5 x 10^{19} m^{-3} and temperature (estimated) > 150 eV has been obtained The disruptions during the plasma current-flattop due to sudden growth of MHD modes are steered through by properly adjusting the ramp rate of plasma current. The generation of runaway electrons are controlled using high fill in pressure during the breakdown phase and by suitable external hydrogen gas puffing during the plasma current flat-top. Later, the discharge duration has been enhanced up to 180 ms with the application of negative converter power supply. All the subsystem of the Aditya-U machine have been performed as desired and the

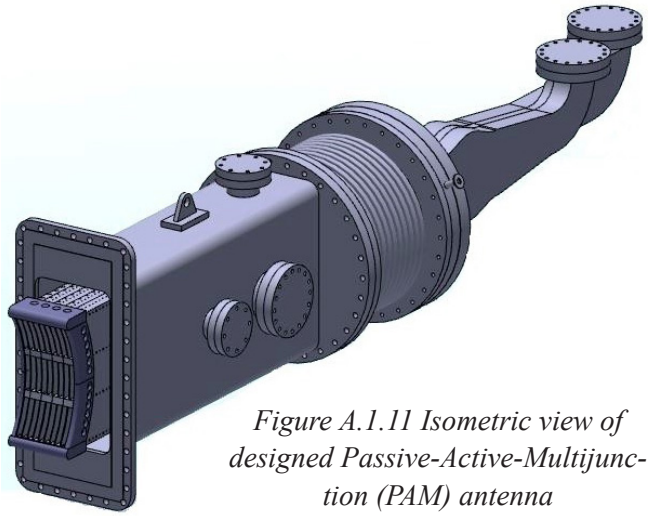


Figure A.1.11 Isometric view of designed Passive-Active-Multijunction (PAM) antenna

initial discharges are very satisfactory in terms of the functionality of the machine.

Heating and Current Drive Systems

Electron Cyclotron Resonance Heating (ECRH) System: the 42GHz ECRH system would be used to carry out experiments at 0.75T and 1.5T operation. This system has been used previously with Aditya. Now the layout has been modified to connect the system with Aditya-U. The necessary support structure has been procured to connect the transmission line. The system will be installed soon as per the clearance from Aditya-U.

Lower Hybrid Current Drive (LHCD) System: A new LHCD antenna, based on passive active multi-junction (PAM) is under development for Aditya-U machine and for which the design has been completed. Figure A.1.11 shows an isometric view of the designed PAM antenna, which would launch lower hybrid waves in to Aditya-U plasma. Fabrication drawings are completed. The purchase procedure for fabrication is initiated. Proposal is on reflectometry to measure the edge density profile in Aditya-U tokamak to understand the coupling of LH waves launched from PAM antenna. The specification is finalized for the reflectometry system for the Ka band frequency of 26 GHz – 36 GHz. Design for the horn antenna is carried out for transmission and receiving of signals. Optimization of horn antenna would be required for the available space and better directivity. Voltage Controlled Oscillator (VCO) prototype board is designed for generating the frequency according to tuning voltage which is generated through FPGA programming. The VCO section has been designed, fabricated and tested. I-Q demodulator card is designed, fabricated and is being tested.

Ion Cyclotron Resonance Heating (ICRH) System: For Aditya tokamak ICRH had a capability of introducing 200 kW RF power only and still many RF experiments like second harmonic heating, wall conditioning, preionization, current ramp up, discharge mitigation etc, were conducted successfully. During the next phase of Aditya up-gradation, it is planned to upgrade ICRH system for introducing RF power up to 5000 kW for doing experiments of second harmonic heating. The power will be introduced through two different ports with the help of two fast wave antennas. Single 9" transmission line will carry RF power from RF lab to Aditya hall and will be divided into two transmission lines with T junction and will deliver RF power to two antennas. Another transmission line will be used for ion Bernstein wave antenna for heating experiments and 100 kW, 45.6 MHz indigenously developed RF generator will be used. Complete layout has been finalized and all required components/equipment like RF switches, vacuum interface section, transmission line, support structure is in the final stages of procurement.

A.1.3 Superconducting Steady-state Tokamak (SST-1)

To improve the quality of discharges in the SST-1, various tasks are being carried out as suggested.

<u>*(a) Characterization study of Poloidal Field coils cooling and hydraulics:*</u> SST-1 consists of two types of superconducting coils, namely toroidal field (TF) and poloidal field (PF) coils required for plasma confinement and shaping.

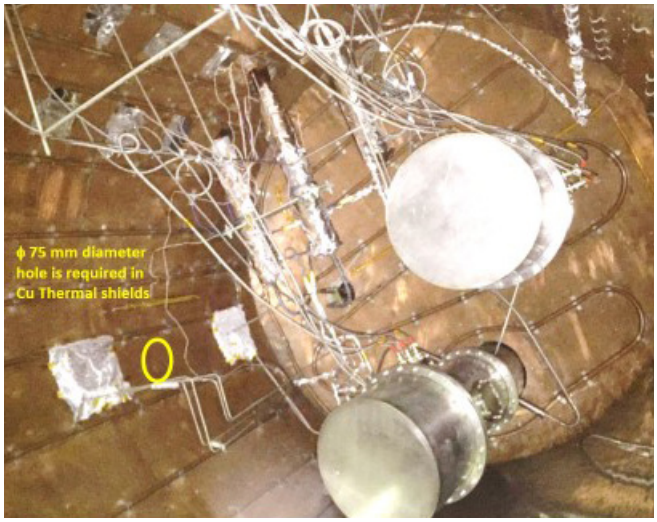


Figure A.1.12 Inside View of current Feeder System

Figure A.1.13 Water cooling Jacket on Electrical Motors of Helium Screw compressors

The NbTi superconductor based cable in conduit conductor (CICC) of critical temperature 9.4 K at zero magnetic field, have been used for both coils. These magnets are force flow cooled with helium. In the previous experimental campaigns, TF coils were cooled up to 5 K and charged up to 4.5 kA for more than seven hours for SST-1 plasma experiments. PF coils were also cooled up to 15 K, which is above the critical temperature of NbTi superconductor, hence, these coils were not charged with electrical current.

In order to cool PF coils below the critical current, hydraulic circuit has been changed from the current feeder chamber side and cooling characterization was done. As a part of this study, the following tasks were carried out : (a) Installation and commissioning of new additional cryo Valves for group wise regulation of flow within the existing Integrated Flow Distribution and Control (IFDC) system; (b) Isolation of return paths of PF Hydraulics at the current leads assembly chamber (CLAC); (c) Installation, commissioning of new modifications within the CLAC ; (d) Introduction of new 2R-Cryo line from CLAC to IFDC. The above-mentioned tasks undergone routine helium leak testing at Room Temperature under sniffer mode and the level of helium leaks are found to be acceptable.

(b) *Trouble-shooting of Automatic Closing/Opening hydraulic Assembly in the Current feeders system;* Maintenance of Gear-Box Assembly of the Current feeders system has been carried out and made the Gear-Box Assembly operational.

(c) *Performance Enhancement of Electrical Motors of Helium Screw Compressors*: In order to minimize wear and tear of Ball-Bearing of 315 kW rated Electrical motors due to very high ambient temperatures within the IPR helium compressors station for round the clock operation, an innovative and indigenous technical solution has been realized to keep the electrical motor currents in the acceptable range as well as enhance the life of Ball-bearings. This solution envisaged the introduction of water cooling jacket locally at the D-side of bearings as depicted in the figure A.1.13.

(d) *Upgradation of Magnet Data Acquisition System:* Magnet data acquisition system has been upgraded with (i) 64-bit Window and linux support, (ii) Live TF and PF Mass flow calculation; (iii) 100000 samples per CSV file; (iv) Implementation of new off line data plotting utility with origin 8.5; (v) PLC based DAQ software with existing VME software; (vi) Live screen indication of Minimum, Maximum and Average temperature.

Heating and Current Drive Systems

Electron Cyclotron Resonance Heating (ECRH) System: The 42GHz ECRH system has been used successfully for pre-ionization and start-up of SST-1 tokamak plasma. Approximately 150kW to 250kW ECRH power is launched in SST-1 for 100ms to 300ms duration and several experiments have been carried out at 1.5T operation in SST-1. The 82.6GHz-200kW ECRH system has been integrated on SST-1 for pre-ionization and start-up of SST-1 tokamak plasma at

Figure A.1.14 Indiginously developed Solid State Crowbar

3.0T operation.

Technology development related to ECRH: In order to operate the Gyrotron with reliability and for multi-pulse operation, the existing system has been modified and other technologies related to high voltage has been developed.

A Development of tail-bite system for Anode power supply: The existing anode power supply has limitation to operate for more than one pulse due to its slow fall time. A dynamic low impedance based tail-bite system has been developed and integrated successfully with the existing anode power supply. The integrated system has been tested successfully up to 20kV for multi-pulse operation.

B. Solid state crowbar development for Gyrotron: A remarkable development has been done by ECRH division to operate the Gyrotron safely. The technology for solid state crowbar has been developed successfully. It is an important indigenous technology development in the field of high voltage. The system has been tested successfully up to 20kV, this crowbar removes the high voltage within 10 micro-s. The 30kV solid state crowbar is under testing and 50kV is scheduled in next 2 years.

C. VME DAC system Upgradation: The VME based DAC system for ECRH has been upgraded for two pulse operation (Start-up as well as heating in plasma).

D. Real time feedback launcher: The advance launcher capable to steer the beam with proper feedback is under design stage. The conceptual design has been carried out and engineering design in progress.

E. The prototype calorimetric power measurement in pulse condition is developed using microcontroller.

Lower Hybrid Current Drive (LHCD) System: The LHCD system is made available for experiments on SST1 during campaign-X VI I to XIX. Prior to campaigns, the LHCD grill antenna and vacuum window are actively cooled throughout the baking cycle, during which SST1 machine and its PFC's inside the machine is baked up to 250 ^{o}C. Later, the standard procedure for high voltage and RF conditioning is followed to bring up LHCD high power sources for the said campaigns. The klystrons are operated, in parallel mode, with regulated high voltage power supply (RHVPS). The LHCD power has been successfully launched in to the SST1 machine during these campaigns and encouraging results have been obtained. Temporal elongation of plasma pulse is observed. Scintillating detector (CdTe) signal confirm generation of suprathermal electrons responsible for non-inductive current drive due to LHCD. Spikes are also seen in loop voltage with LH power, which are the characteristics of LH power in low density discharges. Gas puffing from near the grill antenna is also carried out for local ionization of gas with LH power to increase the edge density for improving the coupling of LH power with plasma. A marginal increase in edge density is observed with gas puffing from antenna side in presence of LH power and thus significant improvement in reflection coefficient is not observed.

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A.2 Technology Developments

Under the purview of continuous progress in Plasma Science and Technology, many technologies are being developed. A brief about the technologies developed under various heads are given here.

A.2.1 Magnet Technology

This programme caters to the development of different magnets which will be used for confining plasma in various configurations.

Nb3Sn based superconducting CICC: The manufacturing of ~ 1000 m of 14 kA Nb3Sn based CICC is under progress with Indian Industry. The manufacturing parameters for this CICC such as percentage of cold working, sizing and shaping dies, linear feed and hammering frequency has been optimized and demonstrated on 10 m dummy CICC. The heat treatment of Nb3Sn superconducting strands and cables from various twisting stages is carried out with respect to required heat treatment schedule. Successful heat treatment of bobbin samples, straight wires and sub-cables has been carried out. Further samples investigations for development of superconducting phases using EDAX and for its critical current capability at 5 K are going on.

Figure A.2.1 Integrated MCFLT at factory site

Winding Facilities: Special purpose winding machine for manufacturing of saddle shape coil has been installed and demonstrated by winding of dummy coil at IPR. Apart from this, lab scale solenoid as well toroidal winding machine has also been installed and currently used for the winding of small lab-scale solenoid magnet.

Material characterization facility at low temperature (MC-

Figure A.2.2. Special Purpose Winding Machine for saddle shape coil

FLT): The integration of MCFLT system has been completed successfully at factory sight as shown in figure A.2.1. The initial testing trials at room temperature and 77 K have been completed at factory site. The test plan for pre-dispatch inspection for MCFLT is under progress. MCFLT facility is expected to install in IPR by end of this year after its performance validation at factory site.

A.2.2 Divertor Technologies

This programme continued its efforts in developing materials & fabrication technologies for Plasma Facing Component (PFCs), nondestructive evaluation/testing and high heat flux testing of PFCs and establishing/improving new test facilities at IPR. A brief of the major works done are given here.

Tungsten Coating Technology Development for First wall Application: Additional test mock-ups made of Copper Alloy, Stainless Steel and IN-RAFMS steel substrate materials coated with 500micron thick Pure Tungsten material over 50mm x 30mm surface area are fabricated by collaborator - ARCI (Hyderabad). Integrity and uniformity of tungsten coating is checked using Ultrasonic Testing Technique. These tungsten coated test mock-ups are successfully tested for their thermal cyclic fatigue performance at 500°C surface temperature for 1000 thermal cycles. High Heat Flux Test Facility (HHFTF) has been used for these tests.

High Pressure High Temperature Water Circulation System (HPHT-WCS) for HHFTF: Installation & Commissioning of HPHT-WCS has been successfully completed. This can supply water up to 60bar pressure, 160C temperature and 300lpm flow rate. HPHT-WCS is also integrated with HHFTF for supplying coolant water to component for testing its performance under high heat flux conditions.

Figure A.2.3. High Pressure High Temperature Water Circulation System (HPHT-WCS) for HHFTF

Dome Fabrication and testing: ITER-like dome (scaled down version) is fabricated using tungsten macro-brush brazed to copper-alloy substrate having hyper-vapotron cooling channel. Ultrasonic testing is performed to know flaws in brazed joint between tungsten and copper interfaces. High heat flux testing of dome is performed using HHFTF at IPR. Dome could successfully withstand 1000 thermal cycles at incident heat flux of 3.3MW/m2 using 15.6kW e-beam power and 200 thermal cycles at 5.3MW/m^2 using 24.6kW e-beam power.

Tungsten Materials Development: GLEEBLE 3800 system is used for development of tungsten-copper functionally graded material by Direct Sintering of pure tungsten and pure copper powders stacked in layers to achieve desired density gradient of tungsten and copper materials.

Materials Studies: Material joining studies relevant to fabrication of plasma facing components are continued. Diffusion bonding and brazing of metallic materials are performed

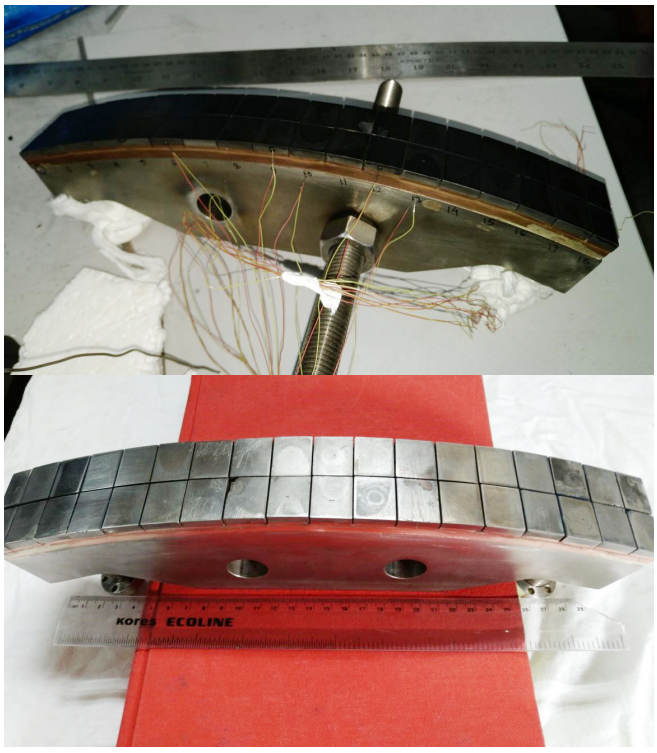

Figure A.2.4 Fabricated DOME successfully tested up to 5MW/m2 using HHFTF

at elevated temperatures and pressures using Gleeble 3800 System. Studies on welding of 10mm to 40mm thick sections of SS316LN and XM19 (dissimilar structural materials relevant to divertor cassette body fabrication technology development) are carried out as a BRFST project undertaken by PDPU, Gandhinagar. Development and characterization of Tungsten-Copper functionally graded materials for plasma facing component is initiated as a BRFST project undertaken by IMMT, Bhubaneswar.

Brazing Studies and Brazing Experiments: Brazing, casting, annealing experiments are performed to develop technologies relevant to fabrication of plasma facing components. Vacuum Brazing of BZT Ceramic with Titanium using TiCuNi (at 980°C) and CuSIL-ABA (at 850°C) is performed for RF Window development related work.

Ultrasonic Testing & Simulation: Mechanism to inspect tungsten monoblock divertor with curved copper-alloy tube is finalized. Purchase order is released for supply of ultrasonic probe mounted on flexible shaft. Studies on estimation of mechanical properties of materials (relevant to fabrication of plasma facing components) based on ultrasonic wave velocity measurements are initiated. Phased Array ultrasonic probe is used to study sensitivity criteria for inspection of defects in thick-section weld joints.

A.2.3 Cryo-Pump & Pellet Injector System

Concept and Design evolvement of twin screw cryogenic screw extruder for pellet injection: Technologies related to fuelling of plasma in form of frozen hydrogen cylindrical shaped solid pellets is under progress. The indigenously developed SPINS-IND, a single barrel pneumatic gun type pellet injector is successfully operating and is able to freeze cylindrical pellets of size ranging from 1.8 mm to 4 mm. Pellet velocities achieved is a function of pellet size and propellant pressure. SPINS-IND has the achieved velocity range of 700-1000 m/s for 4-2 mm size pellets respectively. Taking a step further development of twin screw cryogenic extruder system is undertaken. Extruder type pellet injector (ETPIS) pushes solid hydrogen forward with counter-rotating inter-meshing screws driven by servomotor capable of extruding sufficient solid hydrogen to extrude 3 mm (L) x 3 mm (D) size pellets at 10 Hz injection frequency. The concept of extruder incorporates four stage of cool down, independent support mechanism of twin screw assemblies and high frequency inline injection scheme. For validating the proof of an argon extruder operating at liquid nitrogen temperature was realized. Argon is liquefied within a heat exchanger dipped into a LN2 filled closed container with a specified mass flow rate. Liquefied argon is then feed into the extruder chamber where it gets solidified and extruded through the nozzle. Based on the studies carried out for argon extruder technical bottlenecks were with real-time implementation in experiments. Screw gear and motion concept, cryogenic sealing criticalities and the thermal mass and conductivity related problems were identified. During experimental exercise argon liquefaction and assembly cool-down to 86K was observed with a twin screw motion at around 5RPM.

A.2.4 Test Blanket Module (TBM)

Indian Lead Lithium Ceramic Breeder (LLCB) blanket concept will be tested in ITER through Test Blanket Module (TBM) program. The objective of the ITER TBM Program is to generate experimental data on the performance of tritium breeding blankets in integrated fusion nuclear environment. This programme is engaged in the Design and Development of LLCB TBM and its associated ancillary systems.

Test Blanket System (TBS) and Blanket Neutronics Activities

Development of IPR Interface Code for Shutdown dose rate estimation in Fusion system (IICSF): An interface code (IICSF) which couples the radiation transport tool and activation tool has been developed to simulate the shutdown dose rate. The code IICSF has been validated with a computational benchmark exercise which has been developed by ITER organization for shutdown dose rate calculation. This code (IICSF) is capable of simulating the dose rate in the fusion nuclear system at any area of the machine and at any time after shutdown in a single run.

Nuclear Analyses of Neutron Activation System for Indian TBM in ITER: Neutron Activation system has to be mounted in Indian Test Blanket Module for measurement of nuclear responses by sending the foils and capsules during neutron irradiation in ITER. The analyses have been performed to analyse the compatibility of systems with TBM and to assess the irradiation durations of foils & capsules which are required to plan the handling of irradiated foils & capsules. The outcome of the analyses has supported the NAS design.

Joint Benchmarking Exercise with China TBM team to establish the common shutdown dose rate (SDDR) estimation methodology: China TBM team to establish the common

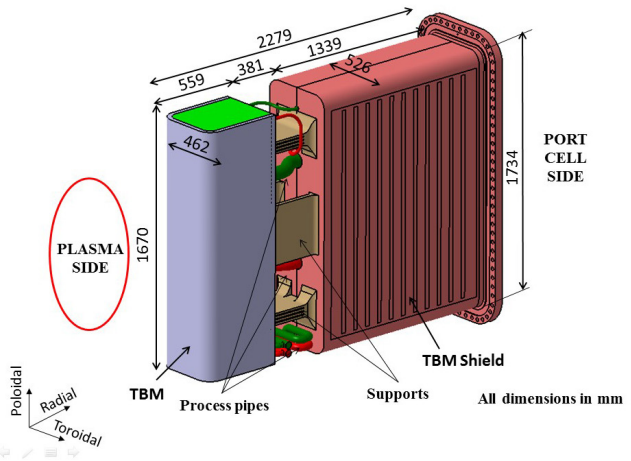

Figure A.2.5 Lead Lithium Ceramic Breeder (LLCB) Test Blanket Module (TBM) Set

shutdown dose rate (SDDR) estimation methodology: India is sharing the ITER port#2 with China for testing its breeding blanket module. Since the areas of maintenance are common for both, an exercise has been launched to establish a common methodology to estimate the SDDR in ITER. The Outcome of the exercise is showing the good agreement in SDDR results between both teams and also with Korean TBM team results.

Preliminary Estimation of Occupational Radiation Exposure during the Indian TBS maintenance activities in ITER: Indian Test Blanket Systems (TBS) will be placed in ITER for the performance testing. During the ITER operations and shutdown phase, maintenance activities are required in TBS for smooth functioning and to avoid the accidents. Since ITER is a nuclear machine, therefore radiation exposure for workers should be limited as per IAEA requirements. The preliminary estimation of occupational radiation exposures for Indian TBS maintenance activities has been carried out.

Neutronic mock-up experiments for TBM Shield module neutronic Design validation: A Shield module is associated with Indian test blanket module to provide the shield to human accessible zones from neutron radiations. A Preliminary neutronic design and analyses have been performed for shield module. To validate the neutronic design of shield module mock experiment will be performed in IPR 14 MeV neutron source lab. Design of the experiment has been completed and mock-up of TBM Shield has been fabricated. Neutron irradiation of mock-up will be conducted soon.

Engineering Design Activities: The conceptual design review activities for the Indian LLCB-TBS and associated IO-Activities have been completed. ITER Organization has given the approval to proceed to the next development (Preliminary Design) phase. Currently, the design of various components of TBM is being updated and further optimization in the design of LLCB TBM set including feasibility of the challenges in engineering design and fabrication methodologies will be addressed in PD phase. The First Wall (FW) of TBM has been modified and optimized considering the lower Helium mass flow requirement. The internals of TBM has been altered to make the design ease to fabricate as well as to improve the process parameters like higher temperature window of ceramic breeder zones for tritium release. The design of Neutron Activation System has also been considered in LLCB TBM design. The alternate design of back plate for FW helium manifolds to incorporate NAS is in progress. In the design of supports between TBM and shield, the cylindrical configurations as well as plate configuration with bolting mechanism is under study to avoid the dissimilar welding. All the design and analysis activities will to be qualified as per RCC-MR code used for the design, fabrication & testing of TBM set.

Indian TBM is using IN-RAFMS as first wall structural material, which will experience higher operating temperatures that would cause high thermal stress to the material. In this connection, an R & D experiment was setup to measure strain in ferritic steel (P91) plate of different thickness (6mm and 11mm) which is surrogate material for RAFMS. The experiment will be performed in next design phase.

Liquid Metal Process and MHD Activities: Lead Lithium Cooling System (LLCS), is the primary coolant system of LLCB TBS, which will extract the heat generated in the nuclear fusion reaction occurring inside ITER. Various R & D activities towards Pb-Li technology are in progress at IPR, to establish the efficient and safe operation of LLCS in ITER's harsh operational conditions of high temperature, magnetic field and radiation environment. A continuous operable highly sensitive rectangular Halbach flow meter was designed for lead lithium applications. Recently, a Pb-Li alloy production system, based on electromagnetic stirring technique, has been successfully commissioned at IPR and few batches of Pb-Li alloy of desired composition (Pb-16Li) have been produced. An indigenously developed cold trap unit was tested in a high temperature Pb-Li loop for in-situ Pb-Li purification. The experimental results show collection of PbO and Li_2O in the SS sieve of the cold trap unit. A Pb-Li experimental loop (refer Figure A.2.6) has been fabricated and is being operated

Figure A.2.6 Panoramic view of the Lead-Lithium (Pb-Li) heat transfer experimental loop

for heat transfer studies. The Pb-Li MHD experimental loop has attained the final design stage and procurement of major components is completed. The loop assembly will start very soon. Progress is also made in 3D thermo-fluid MHD analysis using numerical MHD codes. Several benchmark problems have been solved.

Structural Material Development Activities: These activities are under progress to develop India-specific Reduced Activation Ferritic Martensitic Steel (IN-RAFMS) and qualification for its use in LLCB TBM. IN-RAFMS is being developed in collaboration with IGCAR and M/S MIDHANI. The extensive data base is being generated in IPR and IGCAR. To qualify the material as required by ITER, large heats of IN-RAFMS has been produced to generate the physical and mechanical properties database as per the RCC-MRx guidelines. Tensile properties have been generated in as-received condition as well as simulated post weld heat treatment condition. Fatigue properties for IN-RAFMS have been completed and submitted to IO. Electron beam, TIG and HIP joints have been proposed for weld properties data generation and determination of weld strength reduction factor. Extensive testing and database generation from large heat is under progress.

Corrosion studies of Indian Reduced Activation Ferritic–Martensitic Steel (RAFMS) with Lead Lithium Eutectic: To carry out the corrosion studies, a pump driven loop has been set up in TBM lab at IPR. The test section is maintained at 465^{o}C and the liquid metal is flowing at 10 cm/sec velocity. Flat and tensile IN-RAFMS sample coupons are loaded in test section. The loop completed 2500 hours operation. Samples are taken out and characterized with SEM on surface and cross section. Hardness testing and tensile testing are also carried out. One more system is developed in which samples can be rotated at required velocity (from (10-100) cm/sec)) in Lead Lithium maintained at required temperature (350-500) ^{o}C.

Fabrication Technologies Development Activities: A 10 channels mock-up of TBM FW (U-shaped) has been fabricated indigenously at vendor site in Mumbai with technology support from BARC. The dimensions of this mock-up for bends & channels meet the requirements of LLCB TBM Design. Mock-up has been hydro tested & helium leak tested. As a next phase activity half size TBM first wall would be fabricated. Development of U-shaped FW 8 channel mock-up using IN-RAFM steel by HIP joining (High pressure and elevated temperature diffusion welding) process is being carried out. This is an alternate fabrication route being established as a part of enabling technologies R & D. The isometric representation of mock-up to be HIP bonded. The TBM back plate assembly mock-up using electron beam welding process has been taken up in order to demonstrate the manufacturing feasibility of the TBM Back plate design. Engineering drawings of components and assembly, technical specifications for fabrication, inspection and performance testing of mock- up assembly have been prepared and work is under progress.

Ceramic Pebble Development Activities: Lithium Titanate Ceramic Pebble production capacity has been upgraded to 5 kg of qualified pebble per month. At every stage of pebble fabrication (powder, pellet and pebble preparation) extensive characterizations are also being carried out to meet the desired properties. These fabricated pebbles have also been characterized in different international R & D laboratories (China, European Union, Korea & Japan) under the round

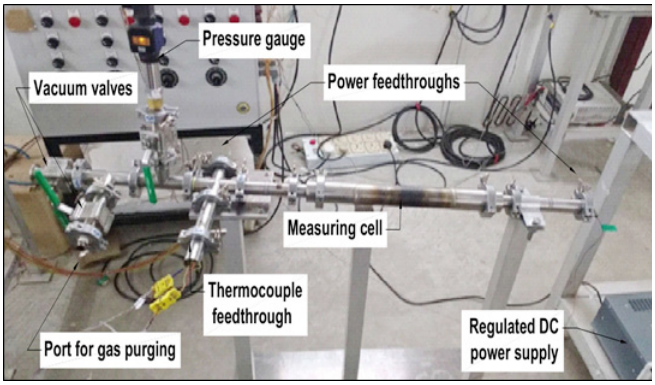

Figure A.2.7 Experimental set for thermal conductivity measurement using hot wire method

robin test as a part of IEA solid breeder subtask. An experimental set up for measuring the effective thermal conductivities by steady state and hot wire method (Figure A.2.7) have been indigenously built at IPR. Presently experiments with the pebbles are under progress. Effective thermal conductivity of Li_2TiO_3 pebble bed has also been estimated numerically using COMSOL for different packing arrangement

Helium Cooling Systems Development Activities: An Experimental Helium Cooling Loop (EHCL) facility (450 °C, 0.4 kg/s) is being set up to perform R & D experiments and to experience the operation and control requirements for FWHCS and LLHCS. The conceptual design of the EHCL was carried out in-house and the procurement of loop equipment such as circulators, heat exchangers, electrical heater, valves, and instrumentations are under progress. The helium circulators along with their test loop were installed and the performance tests of the circulators were conducted successfully. The circulator test loop is operational .

Instrumentation & Control Design and Development Activities: A compact and rigid sensor was conceptualized & customised using a K-type multilevel thermocouple and thermo-well assembly. This sensor was experimentally validated to measure bulk temperature profiles as well as to estimate liquid Pb-16Li level. Long duration test (over 1200 hours) was performed to estimate the reliability and longevity of the sensor assembly in liquid Pb-16Li environment. Automation was implemented in corrosion experiments for Indian RAFM steel in pump driven liquid Pb-16Li loop. A multi-channel data acquisition &monitoring application was developed using LabVIEW platform. • Preparation of Process Flow Diagram (PFD) and Process and Instrumentation Diagrams (P&IDs) for Neutron Activation System, First-Wall Helium Cooling System, Lead-Lithium Helium Cooling System, Lead-Lithium Cooling System, Coolant Purification System, Tritium Extraction System has been completed.

TBM Safety and Neutron Diagnostics Development Activities: During the report period several input data in specific to LLCB TBM systems, operational states, radiological data, tritium release and management data, Instrumentation and Control (I&C), Human factor integration plan (HFIP), maintenance operations and data for ESP and ESPN classification has been generated and submitted to ITER Organization. Neutron Activation System is a diagnostic for neutron energy and spectra measurement. Conceptual design of Neutron Activation System (NAS) is carried out including major parameters like capsule dimensions of activation foils, capsule size, transfer station, capsule transfer pipes, driving gas pressure etc. A test facility is developed to demonstrate functionality of this system.

A.2.5 Large Cryogenic Plants & Cryo-systems

This programme is mainly involved for the indigenous helium refrigerator/liquefier (HRL) plant development of cooling capacity 1 kW at 4.5 K.

Manufactured prototype indigenous components:
Manufactured prototype indigenous components: Main indigenous prototype (1/4th of full scale) cryogenic components of plant for phase-A are: 3 different (2-stream-He/He and He/boiling LN2 and 3-stream-He/He/He) kind of cryogenic plate-fin heat exchangers (PFHE) operating between 300 to 15 K with helium flow rate ~30 g/s for hot stream, a helium gas purifiers for test of purification at temperature 80 K and 20 K with flow rate ~30 g/s and a SS filter for helium gas to filtrate dust particles of size more than 20 micron. These have been designed indigenously and manufactured by Indian industries.

Cryogenic test facility being built-up: Fabrication and assembly of test facility and tests at low temperature have been started. A test bed was made with heat exchanger for leak tests of PHE2 at 80 K assembled and insulated in open atmosphere. Integral leak rates at 80K are found to be less than 10-5 mbar-ltr/s and satisfies design requirement. The thermo-hydraulic performance of this heat exchanger will be tested within a vacuum chamber which is under progress. It will include sufficient instrumentations for accurate performance measurements, like, absolute pressure and pressure drops of different streams within heat exchangers, temperatures at different locations, flow rates of different streams.

Instrumentations and controls development: Dynamic analysis of the helium turbine test facility operation has been tried using Aspen software. The control logic for the automatic operation sequence of turbines are worked out conceptually. These will be further worked out after which it will be used in the helium turbine test facility. A data acquisition system with display unit for cryogenic sensors has been developed. A monitor which show readings for different cryogenic sensors like temperature, pressure, differential pressure, etc, has been developed indigenously.

A.2.6 Remote Handling & Robotics Technology

The main focus was in expanding the expertise in the domain of Virtual Reality (VR) development by integrating various VR based applications in a single facility called Virtual and Augmented Reality Integrated Development (VARID) facility. A High payload (~25Kg) articulated arm has also been commissioned at the RHRTD Lab. This system is one-of-its-kind cantilevered system which has been completely designed in-house and fabricated by industrial partners. The system can traverse a toroidal geometry and can carry out inspection and maintenance activities. Further, the division has moved in to some new fields in robotic research and technology such as, Artificial Neural Networks, Visual Servoing, Hyper-redundant robotic systems, Gravity Compensation based robotic systems and advanced safety systems for RH equipment. These new fields of development, coupled to the core research areas of the division, can be used effectively to bring out solution to real-life problems with societal benefits. The major achievements this year are outlined below.

Virtual & Augmented Reality Integrated Development Laboratory (VARID-Lab): A low cost solution for Virtual Reality facility has been conceptualized and realized at the remote handling and robotics division. This facility – VARID-Lab will be utilized to develop various virtual and augmented reality applications that will have the flexibility to integrate with remote handling equipment and scale the developed applications to the planned major VR facility. The VARID-Lab facility will serve the following major roles: (a)Platform for rapid design reviews for RH equipment and schemes of existing and future tokamaks at IPR; (b) Facility for application development of specialized VR applications that are not commercially available; (c) Facility to integrate design and analysis tools (like finite element code, multi body dynamics, etc.) into VR; (d) Facility to develop and integrate applications from other domains like haptic feedback, image processing and real time physics into VR; (e) Facility for application development and testing for real-time robotic hardware linked virtual and augmented reality; (f)Centralized control facility with modular architecture for operator training and executing of RH operations.

Integration of Virtual Reality Applications for Remote handling with VARID-Lab: The VARID-Lab is being consistently used for various design and control activities for RH systems at IPR. Many VR based applications that were previously developed by the RHRTD Division have been integrated to VARID-Lab. The highlights of some of these applications are as follows: (a) VR control and monitoring application is created for all available RH equipment at IPR. A specialized control network and application is created to receive the joint data from the equipment and constantly update a VR model at ~8Hz.; (b) A comprehensive master-slave topology with active haptic and visual feedback to carry out remote handling operations in tokamak has been developed; (c) For routine applications like deployment and retrieval of RH equipment from tokamak systems, teach and play algorithms are used.

Development of Prototype Articulated Robotic System –II (PRAS-II): PRAS-II system, as shown in Figure A.2.8, has been designed and commissioned This system is a 5+1 DOF equipment exhibiting snake like articulation for traversing a toroidal workspace. The system is designed to carry a maximum payload of 25kg at 2m. The system will be integrated to haptic controlled virtual reality setup for online control, tracking and monitoring of operations. The following are the major achievements of the development: (i) The system can handle a payload of ~25kg at reach of 2m with positional accuracy of < 2mm ; (ii) The system proves the expertise to design and develop precise remote handling equipment with heavy payload capabilities, a major requirement for future tokamak devices; (iii) The unique real time VR based control and monitoring system makes it easy to use the system in

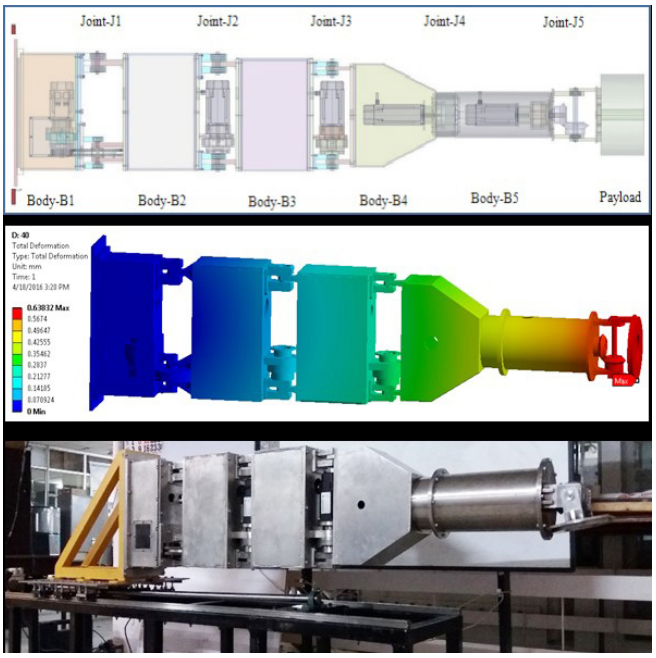

Figure A.2.8. PRASII CAD Model, Structural Analysis, Final System

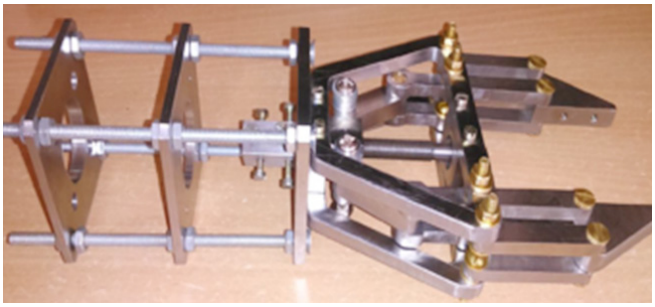

Figure A.2.9 Gripper Assembly developed

remote locations.

Development of Prototype Hyper-Redundant Inspection System (Hy-RIS): Prototype 3-Axis tendon controlled Hyper-redundant robot for inspection in constrained spaces has been developed at the RHRTD Lab. The complete system design and control system design for the robot has been done in house. Unlike conventional serial manipulator, where each joint has a motor mounted at its axis, the Hy-RIS has a universal joint. The motion of the universal joint is controlled using the plastic tendons which are connected to the motors mounted away from the robot body. Such a system has high dexterity and can be used within constrained spaces within the tokamak environment

Development of a Prototype Gripper Assembly: A Gripper Assembly has been designed and developed which can lift up to 1kg of payload. The fabrication was completed using the water-jet cutting machine at IPR. The gripper has been integrated to ABB-industrial robot to demonstrate various applications like tile manipulation and material handling.

Development of SST-1 Compatible In-Vessel Inspection System (IVIS): An ultra-high vacuum (UHV) compatible (~1e-7mbar) and high temperature (~150^{o}C) visual inspection system, IVIS, is under development. The IVIS can be deployed inside the SST-1 like vacuum vessel during plasma campaign without breaking the vacuum. Presently, the design and analysis of the IVIS has been completed. The system is around 4.2m long and has a payload capacity of 1kg. The system is accompanied by a vacuum enclosure chamber called the 'Vacuum Storage Cask' and a mock up chamber to evaluate its performance in various environmental condition. A vacuum compatible camera is being developed separately in-house.

A.2.7 Negative Ion Neutral Beam System

A. Twin Source

Source manufacturing: Manufacturing of "High Vacuum Compatible components" completed at Hind High Vacuum Company, Banglore with successful completion of Vacuum Brazing and Mo coating procedures. All the components passed the acceptance test successfully during Pre-dispatch Inspection, which basically includes MSLD leak testing, High pressure water test, visual examination and electrical isolation tests. Components passed the vacuum leak tightness to the requirement of 10-09 mbar-lit/sec. inside cooling lines of plasma facing components were tested with high pressurised water at 8 bar for 30minutes. High Vacuum components have been received at IPR and site acceptance test completed in DNB lab of ITER-India. Further Installation and commissioning activities of TWIN source initiated with integration with TS Vacuum vessel. CAD integration of TWIN source experimental plan completed for AIR mode of operation.

TS HV Bushing: FRP based twin source bushing is designed for 50 kV isolation. Insulator is being prepared by filament winding method.

Installation of RF shield for 180kW RFG: Installation of RF shield on the 180kW 1MHz in successfully completed at the TWIN Source experimental setup.

Twin Source DACS: Twin Source operations are scheduled

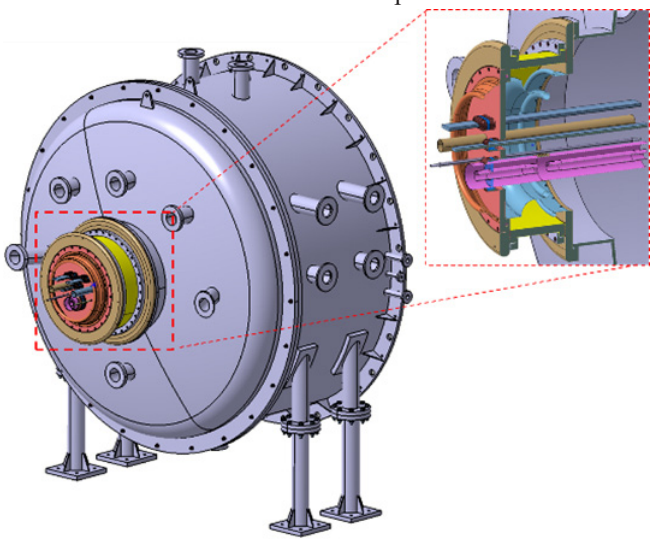

Figure A.2.10 Picture depicting Twin Source High Voltage bushing

in later part of 2017. To support the operations Data Acquisition and Control System (DACS) is presently in advanced stage of completion. The integrated tests of DACS are undergoing with dummy signals and commissioning has been initiated. The software development for data acquisition module has been completed. The GUI is developed on ITER CODAC platform. Various power supplies have been integrated with TS DACS and rest of subsystem of twin source is advance stage of completion. The signal conditioning modules have been fabricated in house for field integration.

B. ROBIN

Extraction experiments: ROBIN is a negative hydrogen ion source experimental facility at IPR. Presently, ROBIN experiments are being performed in the surface mode (with Cesium (Cs) injection) in which negative ions is produced on a low work function surface through surface conversion process of neutrals or positive ions. In the present set-up, negative hydrogen ion beam extraction is effected through an extraction area of ~ 73.38 cm2 (146 apertures of 8mm diameter). The three grid electrostatic accelerator system of ROBIN is fed by high voltage DC power supplies (Extraction power supply System: 11kV, 35A and Acceleration power supply System: 35kV, 15A). The plasma diagnostic i.e. Langmuir probes and Optical Emission Spectroscopy and Beam diagnostic i.e. Beam Emission Spectroscopy and Thermal Differential Calorimeter have been employed in ROBIN to study the source behavior. OES is used to monitor the source impurities as well moreover Residual Gas Analyzer (RGA) is also implemented in ROBIN for the same purpose. Cs is highly reactive and makes Cs compounds which are not desired for the source performance. Impurities were found in the initial phase of experiments in surface mode subsequently modifications have been done to improve upon it. Recently high negative ion current density (27 mA/cm2) and low electron to ion ratio <1 have been achieved. The beam divergence measured in the range of 2.5-7° for different combination of extraction and acceleration voltage. The diagnostic is being developed to find out the Cs distribution over the plasma grid.

ROBIN DACS: ROBIN Data acquisition and Control system was upgraded for surface mode operations. Various changes were done in ROBIN DACS components. Calorimeter was integrated with data acquisition system. HVPS was integrated with ROBIN control system. Advanced diagnostics such as Laser Photo Detachment were integrated with ROBIN DACS. New software modules were created for online trend visualization of important parameters. The main control GUI was modified as per system requirements. Image below shows the main ROBIN GUI. Other important interlocks were also integrated with control system such as PG bias based RF generator interlock and RF power supply interlock for protection of RF generator

Electrical System For Robin

VSWR Measurement system for RF generator : The installation, integration and acceptance testing of VSWR measurement system has been performed successfully over 100kW RF dummy load through DACS of ROBIN for a power level of 80kW (1MHz). The system comprises of 200kW directional coupler (Genex make), RF power sensors (R&S make) and optical communication system (S.I. Tech make). The activities related to the final integration of this system with ROBIN is underway.

Video monitoring system for ROBIN: For the close monitoring of the HVPS system of ROBIN during its operation and in order to incorporate additional safety in the HVPS facility, bullet camera based close circuit video monitoring system has been installed in the NNB HVPS facility. In addition to this, a PTZ camera based video monitoring system has been installed and integrated to monitor the traces of various signals available on the ROBIN DACS during experiments, in the HVPS facility.

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A.3 Societal Benefits of Technology

Time to time, many of the technologies developed in the institute is transferred to various vendors for commercialization. Also many technologies are developed for very special applications as and when it is required. A brief of the technologies being developed and which are under different status are given here.

Development Of Rigid Plasma Jet: Rigid plasma jet is developed for BARC-BSG group for studying the effect of plasma on Lung Cancer cells. This jet is made such that the live electrode is in the jet while the body on which the treatment to be given is ground. Helium is used as plasma producing gas. The output power of jet is approximately 2.5-3 watt. The cells are treated with plasma jet for various times such as 2 min, 4 min, 6 min 8 min and 10 min. Preliminary tests shows the cell death of 50 to 60%.

Development Of Flexible Plasma Jet: Flexible plasma jet is developed for studying the tumour cell interaction with plasma. The plasma is produced using butterfly catheter. This jet is having electrode less configuration. Helium gas is used as plasma producing gas at the flow rate of about 3 to 5 LPM. The tests are carried out for 5 min, 10 min and 30 min exposure time. The Preliminary experiments show the increase in the ROS concentration as shown in figure – 2, which is required for apoptosis (cell death) of tumour cells.

Treatment Of Skin Diseases Using Plasma Jet: An already developed atmospheric pressure plasma jet is being used to treat the skin infection at PG medical college Kolkata under the supervision of skin specialists. This plasma jet can be touched by bare hands and the technology has been successfully transferred to M/s Aditya High Vacuum Pvt. Ltd. This is for the first time after taking the ethical permission; plasma jet is directly put on human for the treatment of Tinea Cruris (Fungal disease) in India. The patient is treated with plasma jet for 20 minutes. The treatment will go on for one month once a week. After 1st and 2nd treatment, patient is in good state of heath and fungal infection is improving.

Development Of Atmospheric Pressure Co2 Plasma Source For Nodular Corrosion Studies With BARC & NPCIL: At NPCIL, nodular corrosion has been identified as one of the reason for pressure tube leak of nuclear reactor. Understanding the root cause phenomena of growth of corrosion is considered critical R&D area to assure long term health of pressure tubes in all PHWRs. In order to check the possibility of corrosion due to ionized carbon dioxide (i.e. radiation ionisation) a lab scale carbon dioxide plasma source was required. At FCIPT, IPR a carbon dioxide plasma source working at atmospheric pressure is developed. This has a potential use in simulation of reactor environment with respect to radiation ionisation for carrying out degradation study of Zr-2.5Nb pressure tube material. The following figure shows multiple plasma jets near the zirconium alloy tube operating in carbon dioxide atmosphere. The resultant nodular growth if observed can help in better understanding of the phenomena.

Development Of Novel Biomedical Implants With Enhanced Reliability: The Titanium (Ti)-Titanium Nitride

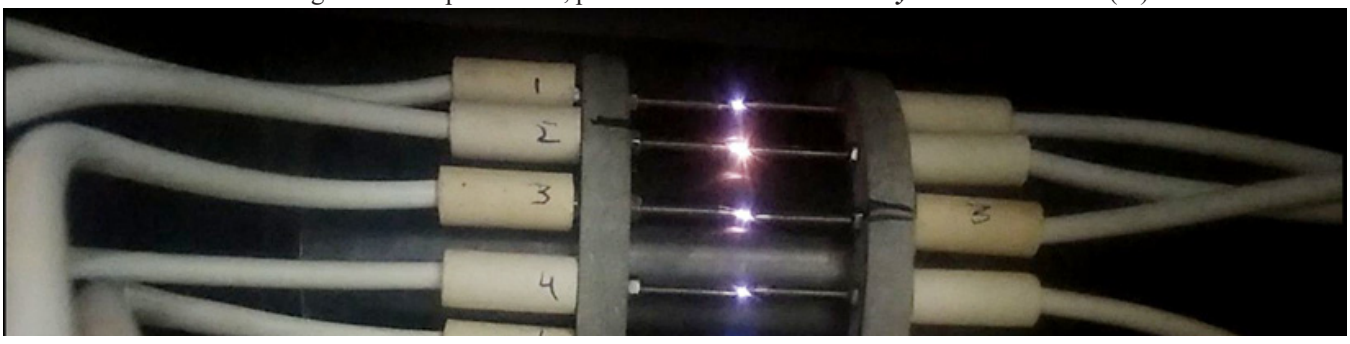


Figure A.3.1 Atmospheric pressure plasma jet is being used to treat the skin infection at PG medical college Kolkata under the supervision of skin specialists.

Figure A.3.2 CO_2 Plasma Generated for Nodular Corrosion Studies

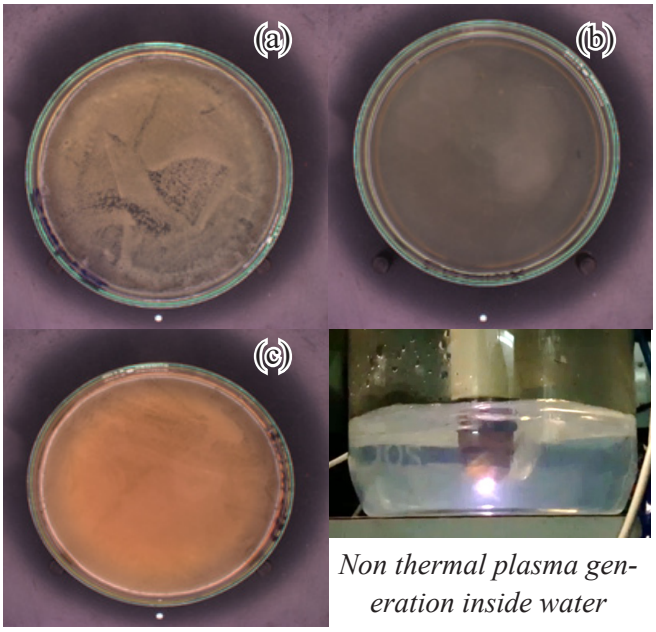
(TiN) multi-layer coating developed on flat stainless steel (SS 316L) and Ti alloy samples as well as on the prototype Hip implants balls for biomedical application. The testing for biocompatibility is going on at CGCRI, Kolkata.

Development Of Plasma Based Tin Coating System For Amrita University, Coimbatore: In this project plasma based TiN coating system was developed at FCIPT. The system was successfully installed at Amrita University, Coimbatore. The system is being used to study the deposition of TiN and copper on aluminum substrates used in Aerospace application. The plasma based TiN coating system shown in figure beside was developed and installed at Amrita University, Coimbatore.

IPR – GIFT CITY CONTRACT

A MOU has been signed with GIFT city (Smart city Gandhinagar) for installation and commissioning of plasma pyrolysis system of 150kg/day capacity. GIFT city has placed a work order to ipr's technology licensing partner M/s B.L. Engineering (BLE) for this project activity. BLE has installed and commissioned the system at gift city in march 2017 under the technical consultancy of ipr team. This system has a fully automated remote feeding system for paper, plastic and STP (sewage treatment plant) waste coming out from other waste treatment plant in gift city. The whole plant is run by various instrumentations and PLC and HMI based control system. This system has successfully been commissioned.

Microbial Inactivation Using Plasma Activated Water: Plasma-activated water (PAW) is defined as the water exposed to non-thermal or thermal plasma where chemical species



Non thermal plasma generation inside water

Figure A.3.3 : E-Coli bacterial growth at different interaction time duration between PAW and E-Coli Solution (a) 0 min, (b) 45 mins, (c) bacterial growth in untreated water

formed, interact with water during the exposure or after the plasma discharge is switched off. Plasma activated water is emerging field and has many applications in killing harmful micro-organism to cure various skin diseases and may eliminate the use of pesticides in agriculture. Studies suggest that plasma activated water possess reactive nitrogen species (RNS) which include nitrous (NO2 -) and nitric (NO3-) and reactive oxygen species (ROS) such as peroxy radicals (.OOH) and hydrogen peroxide dissolved in water. Electrons get attached with oxygen species and assist in scavenging oxidation reactions. Recent research has shown that microbial cells can be killed when they are exposed to plasma activated water. IPR has developed a novel apparatus and process to produce activated water using non-thermal plasmas. The initial chemical analysis and microbial analysis has been carried out with the help of Gujarat Environment Management Institute (GEMI), Gandhinagar. E.Coli bacteria growth study in untreated and plasma activated water (PAW) was carried out at GEMI, Gandhinagar. The growth of E.Coli bacteria at different experimental conditions is shown if figure A.3.3. It was also observed that plasma induced chemical change in water is able to enhance sprouting behaviour in vegetables such as potato. One potato washed using tap water and the other one using PAW, the potato washed with PAW shows en-

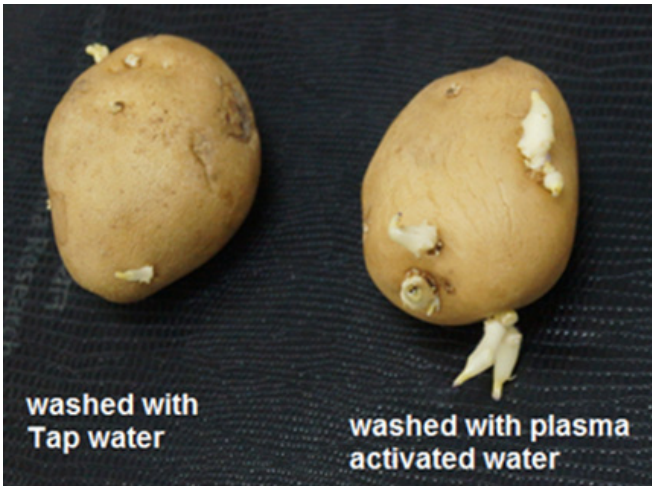


Figure A.3.4 Enhanced sprouting behaviour in potato washed using PAW compared to the one washed using normal tap water

hanced sprouting behaviour compared to the potato washed using normal tap water after 7 days of washing as shown in figure -A.3.4.

FCIPT-TEX project (Funded by DST): A MoU is signed between IPR Gandhinagar and Man Made Textile Research Association (MANTRA). In this project a power source has been developed capable to generate atmospheric pressure plasma across 2.5 meter wide electrode pairs. In this system textile material can be treated up to moderate line speed up to 60 meter per minute. Dielectric Barrier Discharge (DBD) plasma generation at atmospheric pressure across 2.5 meter wide electrode pair has been tested.

A Novel Process For Improving The Service Life Of Agricultural Cutting Blades In North East Region: Conventional plasma nitriding is a popular process for enhancing the life of the industrial components by improving the properties like surface hardness; wear resistance, fatigue strength and corrosion resistance. However, this process is not useful for sharp blades. This is because the sharp edges are brittle after plasma nitriding and break during cutting. In this study a novel process was developed to study the cutting performance of agricultural cutting tools using a hollow cage. A negative bias was applied to the hollow pipes and the blades were nitrided without applying any potential. These agricultural tools were sent for field trials to cut bamboo shoots in Nagaland. It was found that the cutting efficiency of the agricultural tools treated by this process was three times better than the untreated tools.

Oxygen Barrier Coating for Food Packaging Applications: This project is about enhancement of oxygen diffusion barrier properties of polyethylene packaging web. Polyethylene is very economic packaging polymer with good mechanical and heat seal properties but is a very poor oxygen barrier material. Due to this reason it is always used with other polymer material as a multi-layer package. Recycling of multi-layer packaging material is almost of no use and hence single layer packaging material is preferred. SiOx coating using PECVD method has been deposited on polyethylene packaging material with different process parameters to enhance its oxygen diffusion barrier properties.

Development Of CZTS Based Solar Cell Using Magnetron Sputtering: In this work CZTS (Cu2ZnSnS4) based solar cell is prepared using magnetron sputtering. First Molybdenum (Mo) layer is deposited on soda lime glass using DC magnetron sputtering followed by Cu, Zn, Sn layers by DC-Co-Sputtering. After this sulphurization is done in sulphur and Nitrogen mixture environment. After that a thin layer of CdS is deposited using Chemical Bath Deposition (CBD) method and then thin ZnO layer followed by ZnO: Al layer as Transparent Conducting Oxide (TCO) was prepared using RF-magnetron sputtering. 2% efficiency is achieved in solar cells prepared by this method.

Materials Characterized Using Transmission Electron Microscope (TEM): A 300 kV FETEM was procured and installed at FCIPT, IPR. The TEM is FEI make and the model is Tecnai G2 F30. The instrument is equipped with EDX, STEM, and EELS accessories. The instrument can be used basically for high resolution imaging, crystallographic studies, defect identification & analysis, and also to obtain chemical information from nano sized particles and features. The instrument is being used regularly

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A.4. Theoretical, modeling and Computational Plasma Physics

Plasma physics requires a very intense computational capability for its modelling and simulation program.The institute has developed a versatile computational facility in many years. At present work is being done in the the following heads:

A.4.1 Nonlinear Plasma Theory & Simulation

Effect of driving frequency on the electron energy distribution function and electron-sheath interaction in a low pressure capacitively coupled plasma: By using a self-consistent particle-in-cell simulation, investigation of the effect of driving frequency (27.12–70 MHz) on the electron energy distribution function (EEDF) and electron-sheath interaction in a low pressure (5 mTorr) capacitively coupled Ar discharge for a fixed discharge voltage, has been carried out. It is observed that a mode transition occurs with driving frequency, changing the shape of EEDF from a strongly bi-Maxwellian at a driving frequency of 27.12 MHz to a convex type distribution at an intermediate frequency, 50 MHz, and finally becomes a weak bi-Maxwellian at a higher driving frequency, i.e., above 50 MHz. The transition is caused by the electric field transients, which is of the order of electron plasma frequency caused by the energetic "beams" of electrons ejected from near the sheath edge. Below the transition frequency, 50 MHz, these high energy electrons redistribute their energy with low energy electrons, thereby increasing the effective electron temperature in the plasma, whereas the plasma density remains nearly constant. Above the transition frequency, high-energy electrons are confined between opposite sheaths, which increase the ionization probability and therefore the plasma density increases drastically.

Effect of weak static magnetic field on electron and ion dynamics in low pressure capacitive discharges: Single frequency capacitive discharge (CCP) with magnetic (B) field (parallel to electrode) is a more superior technique, to control ion energy and ion flux, compared to dual-frequency CCP. Later has limitation because either coupling in frequencies occurs (if lower and higher frequencies are too close) or electromagnetic effects appear (for >70MHz to rectify coupling effect). Electron and ion dynamics of helium plasma has been investigated by varying B with help of PIC simulation. The sheath width reduced ~ 80% (control ion energy) and bulk density increases ~7 times (increases ion flux) from . This asymmetry appears because of coupled diffusion of electrons/ions across magnetic field.

Relativistic wave-breaking limit of electrostatic waves in cold electron-positron-ion plasmas: A one-dimensional nonlinear propagation of relativistically strong electrostatic waves in cold electron-positron-ion (EPI) plasmas has been analyzed. The motion of all the three species, namely, electron, positron, and ion has been treated to be relativistic. The maximum permissible electric field amplitude − so called "wave- breaking limit" of such an electrostatic wave before wave-breaking has been derived, showing its dependence on the relativistic Lorentz factor associated with the phase velocity of the plasma wave, on the electron/positron to ion mass ratio, and on the ratio of equilibrium ion density to equilibrium electron/positron density. Such studies are relevant for some astrophysical scenarios.

Relativistic electron beam driven longitudinal wake-wave

breaking in a cold plasma: Space-time evolution of a relativistic electron beam driven wake-field in a cold, homogeneous plasma is studied using 1D-fluid simulation techniques. It is observed that the wake wave gradually evolves and eventually breaks, exhibiting sharp spikes in the density profile and sawtooth like features in the electric field profile. It is shown here that the excited wakefield is a longitudinal Akhiezer-Polovin mode and its steepening (breaking) can be understood in terms of phase mixing of this mode, which arises because of relativistic mass variation effects. Further, the phase mixing time (breaking time) is studied as a function of beam density and beam velocity.

Phase Mixing of relativistically intense longitudinal wave packets in a cold plasma: Phase mixing of relativistically intense longitudinal wave packets in a cold homogeneous unmagnetized plasma has been studied analytically and numerically using the Dawson Sheet Model. A general expression for phase mixing time as a function of amplitude of the wave packet and width of the spectrum has been derived. It is found that the phase mixing time crucially depends on the relative magnitude of amplitude and the spectral width. Theoretically derived dependence of phase mixing time on the amplitude and spectral width of the wave packet has been verified using numerical simulations based on the Dawson Sheet Model.

One dimensional PIC simulation of relativistic Buneman instability: Spatio-temporal evolution of the relativistic Buneman instability has been investigated in one dimension using an in-housedeveloped particle-in-cell simulation code. Starting from the excitation of the instability, its evolution has been followed numerically till its quenching and beyond. The simulation results have been quantitatively compared with the fluid theory and are found to be in conformity with the well known fact that the maximum growth rate of the instability reduces due to relativistic effects. Further it is observed that in contrast to the non-relativistic results at the saturation point, the ratio of electrostatic field energy density to initial drift kinetic energy density scales inversely with the square of the Lorentz factor. This novel result on the scaling of energy densities has been found to be in quantitative agreement with the scalings derived using fluid theory.

Impact of particle trapping undamped coherent structures on stability of collisionless plasma: The An outstanding notion for collisionless plasmas is the essential nonlinear character of its coherent structures, which in the stationary, weak amplitude limit are described by a continuum of cnoidal electron and ion hole modes being governed by a multiparametric nonlinear dispersion relation. The well-known discrete structure of undamped linear plasma modes is seamlessly embedded in this nonlinear continuum, as the microscopic texture of plasma begins to show itself up in the high temperature collisionless plasma limit. This transforms the linear-threshold-based operating mechanism of the plasma turbulence into a fundamental nonlinear, multifaceted one. Based on a comprehensive three-level description of increasing profundity that unifies discrete and continuum limits by resolving the inevitable resonant region, it is shown that coherent electrostatic equilibria are generally controlled by kinetic particle trapping and are hence fundamentally nonlinear. Forging a link between damped and growing wave solutions they render plasma stability complicated and difficult to seize due to the entangled pattern of the stability boundary in function and parameter space, respectively. A direct consequence of this is the failure of linear Vlasov approach in describing these coherent waves whenever resonant particles are involved. The breakdown of linearity and hence of Landau approach together with the necessity of incorporating nonlinear particle trapping effects constitutes a new, big challenge for stability theory to establish something like a single, Landau-like stability criterion, being independent of microscopic, initial conditions, that grasps deviations from marginal stability in both directions, damping and growth. High resolution, exact-mass-ratio, multispecies, collisionless plasma simulations are employed to illustrate exemplarily how tiny seed fluctuations in phase-space can act as a triggering agent for a subcritical plasma excitation involving these modes.

Collective dynamics of time-delay-coupled phase oscillators in a frustrated geometry: Many complex networked systems in nature relax in arrangement where their individual elements like to stay in opposite state from the elements they

are coupled to. A uniformly frustrated population is expected in a system where each element is coupled to more than one mutually coupled elements. However, a uniform frustration is often inaccessible and clusters of synchrony are present. We show that in such complex systems a complete synchrony can be achieved by introducing a time delay in the communication between elements. We study the effect of time delay on the dynamics of a system of repulsively coupled nonlinear oscillators that are configured as a geometrically frustrated network where each oscillator likes to be asynchronous to its neighbour. In the absence of time delay, this frustrated system is known to possess a high degree of multistability between a large number of coexisting collective states, except for the fully synchronized state that is normally obtained for attractively coupled systems. Time delay in the coupling is found to remove this constraint and to lead to a globally synchronized ground state over a range of parameter values. A quantitative study of the variation of frustration in a system with the amount of time delay has been made and a universal scaling behaviour is found. The variation in frustration as a function of the product of time delay and the collective frequency of the system is seen to lie on a characteristic curve that is common for all natural frequencies of the identical oscillators and coupling strengths. Thus time delay can be used as a tuning parameter to control the amount of frustration in a system and thereby influence its collective behaviour. Our results can be of potential use in a host of practical applications in physical and biological systems in which frustrated configurations and time delay are known to coexist.

A.4.2 Laser Plasma interaction studies

Molecular dynamics simulations of laser-driven atomic cluster: Anharmonic resonance (AHR) absorption of laser light is known to occur when the time-dependent frequency of a laser driven electron in the anharmonic electrostatic potential of a cluster becomes equal to the laser frequency. However, this mechanism is still a matter of debate. To examine AHR a three dimensional Molecular Dynamics (MD) code has been developed. We have studied multi-particle dynamics of the ionized cluster with electrons (e) and ions (i) interacting (with e-e, e-i, i-i interactions) via Coulomb potential. The pure Coulomb potential being singular (when two particles are very close), it leads to unphysical energy gain. The Coulomb singularity is mitigated using a soft-core Coulomb potential. It is found that only certain values of this soft core parameter close to the Wigner-Seitz radius lead to correct Mie-plasma frequency and correct plasma oscillation for a spherical system. Detailed studies on the absorption of laser light in deuterium clusters have been carried out which clearly show anharmonic resonance process is the dominant mechanism.

Effect of laser wavelength on the laser absorption and ionization of clusters: Laser-cluster interaction experiments earlier have demonstrated enhanced absorption of laser pulses when the Mie-plasma frequency of the expanding cluster resonates with the laser frequency. However, controversial results exists in the literature where role of above linear resonance was absent, thus violating the physical basis of the plasma resonance. In this work, we study the impact of laser wavelength on the absorption of short laser pulses irradiating a deuterium cluster by three dimensional molecular dynamics (MD) simulations. Results show that, for a given pulse energy, in the low intensity regime $< 10^{15}$ W/cm^2, there exist a wavelength at which cluster absorbs maximum energy accompanied by maximum outer-ionization of electrons due to the linear resonance that occurs at the early stage of the cluster expansion. As the intensity increases the maxima in the absorption curve and in the outer-ionization grow together but shift towards higher wavelengths and above a certain value of the laser intensity $> 5\text{x}10^{16}$ W/cm^2 the absorption maximum disappears when outer ionization saturates at 100%. Detailed studies are being carried out to understand the simulation results. In the next step we plan to incorporate self-consistent ionization mechanism for rare-gas clusters (e.g., Ar, Xe) and subsequent effect of laser wavelength on the ionization

A.4.3 Dusty plasma/ Complex plasma studies

Nonlinear effects in the bounded dust-vortex flow in plasma: The vortex structures in a cloud of electrically suspended dust in a streaming plasma constitutes a driven system that allows examining fundamental characteristics of many com-

plex systems surviving away from the thermodynamic equilibrium.. Experimentally recovered toroidal formations of this system have motivated study of its volumetrically driven–dissipative vortex flow dynamics using two-dimensional hydrodynamics in the incompressible Navier-Stokes regime. Nonlinear equilibrium solutions are obtained for this system where a nonuniformly driven two-dimensional dust flow exhibits distinct regions of localized accelerations and strong friction caused by stationary fluids at the confining boundaries resisting the dust flow. In agreement with observations in experiments, it is demonstrated that the nonlinear effects appear in the limit of small viscosity, where the primary vortices form scaling with the most dominant spatial scales of the domain topology and develop separated virtual boundaries along their periphery. This separation is triggered beyond a critical dust viscosity that signifies a structural bifurcation. Emergence of uniform vorticity core and secondary vortices with a newer level of identical dynamics highlights the applicability of the studied dynamics to gigantic vortex flows, such as the Jovian great red spot, to microscopic biophysical intracellular activity

A.4.4 Fusion Reactor Studies

India's energy demands are rising rapidly and to meet the future requirements, DEMO development strategy is planned. In the Indian scenario, Steady State Superconducting Tokamak-2 (SST-2) is an intermediate machine on the pathway of DEMO development. The main objective of SST-2 is to develop a D-T fusion reactor to test and qualify the proposed developmental activities for reactor. This machine will allow us to gain experience similar to ITER but there are other major advantages. First of all, it will allow an integrated test of indigenously developed technological components like breeding blanket, He cooled divertor, etc. It is planned to perform an integral test by covering the out-board side of SST-2 with breeding blanket while the in-board side with shielding blanket. This will simulate the blanket operation of DEMO reactor and will give feed-back to modify the design of DEMO if needed. Secondly, it will create the pool of experienced manpower, both within the national network of organizations and within the industry, which is crucial for building the DEMO. SST-2 design and performance analyses for preconception phase are under progress. Aspect ratio studies were done for SST-2 by checking the effect of increasing the aspect ratio (ratio of major to minor radius of the Tokamak). The study was performed as the current aspect ratio of SST-2 did not provide the required discharge duration for SST-2 due to the smaller space available for the Central Solenoid (CS). Increasing the aspect ratio increases the pulse duration, but decreases the fusion output. Based on the aspect ratio studies, physics parameters were generated for SST-2 for different aspect ratios.

Reactor Design: Conceptual design of SST-2 vacuum vessel is under progress. Engineering requirements and design basis with the identified thermal, seismic and structural loads on the double walled 'D' shaped vacuum vessel for SST-2 were assessed. Parametric modelling of VV as a 2D surface geometry modelled in CAD environment, while the actual thickness of shell and ribs were defined at the time of FEM sensitivity analyses. The preliminary assessment of the impact of these events has been performed on the structural margins calculated to guarantee the Vacuum Vessel's structural integrity with regards to the ASME and RCC-MR codes. Prediction of welding distortion and optimization of manufacturing sequence of VV, computational simulations were carried out considering multiple factors like process, weld parameters, geometry, type of joint, sequence, clamping conditions, welding direction, thermal, metallurgical, mechanical material behaviour and the local-global approach. The magnets of SST-2 will be superconducting in nature to have steady state operation of plasma. The Toroidal Field (TF) coils required to confine the plasma are eighteen in number. Poloidal Field (PF) coils are required to shape the plasma. TF coils with allowable maximum field (BTmax) at the conductor ~ 12 T are considered with ripple of less than 0.03%. The poloidal field (PF) coils along with central solenoid (CS) will provide volt-sec to initiate and sustain ohmic plasma. The CS and PF coils of SST-2 consists of three pairs of modules and three pairs of top-down symmetric coils which are considered for plasma equilibrium. The estimated volt-sec capability of CS coil for magnetic field of 12 T is ~ 50 Wb, which can be doubled with negative convertor operation. Additional volt-sec of ~26 Wb

has also been estimated from PF coils using VMOM code.

Nuclear analyses : This plays a key role in the design of fusion reactors. Nuclear analyses of SST-2 were carried out to assess the shielding performance and tritium breeding capabilities. A modified radial build has been prepared and its nuclear analyses have been carried. Nuclear analyses of this modified radial build have been carried to assess the tritium breeding performance and shield capability for 5 FPY. The neutronics and shielding calculations reported herein were performed using the one-dimensional discrete-ordinates code, ANISN with the P5-S8 approximation and the FENDL-2.1 cross-section library in the 46n-21g group structure. The SST-2 reactor geometry was modeled by using a toroidal cylindrical model with height of 1 cm. IB and OB components are modeled as concentric cylindrical rings with the plasma chamber in between, and the torus axis as the model symmetry axis. The 14 MeV source neutrons are uniformly distributed in the cylindrical plasma ring with the scrape-off zones of 9 cm each on IB and OB. The reflective boundary condition has been applied at the torus axis as one half of the geometry has been used in the calculation. In this way the 1-d geometry of the SST-2 model is simulated in the ANISN calculation. In each zone the materials are homogeneously mixed for the neutronics calculations. Coupled neutron/gamma calculations have been carried out to obtain the spatial and energy distribution of neutron and gamma-flux, the tritium breeding ratio (TBR) and radiation loads to TF coil. Two breeder blanket concepts have been considered as options for the SST-2 reactor. The primary blanket concept is Lead-Lithium Ceramic Breeder (LLCB) blanket and the other is a conventional Helium-Cooled Ceramic Breeder concept (HCCB) with variance in geometrical design. The nuclear performance of these two concepts has been evaluated by placing them in the outboard breeder blanket region of SST-2 reactor. The radial profiles of neutron and gamma fluxes have been obtained both in the IB and OB of the SST-2 reactor

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CHAPTER B

Activities of ITER-India

In the past one year ITER-India made significant progress in the ITER project. During this period, the ITER-India project has entered into the manufacturing for few packages. The details of the activities completed under different packages/ heads are given below.

B.1 In-Wall Shielding (IWS)

The In-Wall Shielding (IWS) blocks shall be placed between outer and inner shells of ITER Vacuum Vessel (VV) which is a double wall structure. The main function IWS is to stop escaping the neutrons and to reduce the toroidal magnetic field ripple. These shielding blocks are made of SS 304B4, SS 304B7, SS 430 and SS 316L (N)-IG and Fasteners (Bolts, Nuts, Spacers, Washers etc.) are made from XM-19 and Inconel-625. The manufacturing of IWS blocks is in progress at Avasarala Technologies Ltd. Bangalore. Rigorous Factory Acceptance Tests (FAT) of (i) IWS blocks, (ii) Support Rib + Lower Bracket welded and machined assemblies, (iii) Platforms and (iv) Studs, to check actual assembly issues were carried out. Dimensional inspection, assembly of IWS blocks with different shapes and high accuracy and vacuum packing for high cleanliness during transportation and storage were carried out. At every stage of production several technical challenges were addressed. Large numbers of blocks and components have been successfully manufactured, assembled, inspected, packed and shipped to Europe and Korea where it will be further integrated in the vacuum vessel sectors. Fabrication and factory acceptance tests of rest of blocks and field joints are in progress.

Figure B.1 In-Wall Shielding Block Assemblies – manufactured and being readied for testing

B.2. Cryostat

The ITER Cryostat, to be the largest stainless steel vessel of its kind provides the high vacuum pressure ever built (16,000 m^3)—provides the high vacuum, super-cool environment for the ITER vacuum vessel and the superconducting magnets. Nearly 30 metres each in diameter and height and manufactured from stainless steel, the cryostat weighs 3,850 tonnes. The Cryostat will be manufactured in about 54 pieces that will form 4 main sections – Base Section, Lower Cylinder, Upper Cylinder and Top Lid. The base section—1,250 tonnes—will be the single largest load of ITER Tokamak assembly. Manufacturing of ITER Cryostat components is progressing at Larsen & Toubro Heavy Engineering, Hazira, Gujarat. Fabrication of Tier-2 components of Cryostat Base section was completed, followed by successful inspection & trial assembly at the manufacturer site. The 6 sectors (total weight approx. 720 tons) were shipped from Hazira port and delivered to the ITER site in two shipments of 3 sectors each in June 2016 and October 2016. Fabrication of Lower Cylinder Tier-1 (total weight approx. 240 tons) was completed

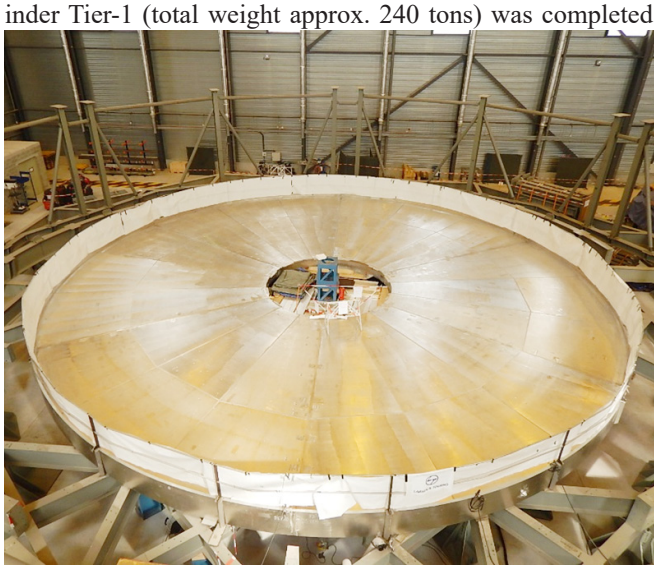

Figure B.2 Cryostat Base Section Tier-1 welding and testing at ITER site workshop

and shipped from Hazira port during January 2017 and delivered to ITER site in March 2017. At the Cryostat workshop at ITER site, welding and testing activities progressed for Base Section Tier-1.

B.3 Cooling Water system

Certain ITER systems/components will be working on specific temperature during the operation, this temperature is needed to be kept in the required margins. Cooling water system is needed to take away heat from the various components/systems and reject this in to the atmosphere. Piping fabrication progressed further and approx. 600 pipe spools were delivered to ITER site. The Ozonation System was delivered to ITER site. Manufacturing Readiness Reviews were conducted for several equipment like Cooling Tower, Stop Log Gates, Plate Heat Exchangers, Pressurizer, Chemical Dosing System, Plant Control System, Water-Cooled Chillers & Soft Starter. Successful Factory Acceptance Tests were conducted for 6 Plate Heat Exchangers and 4 Chillers at the manufacturer facilities (Kelvion and Kirloskar respectively) in Pune. Soft Starters for the Chillers were also successfully tested at the manufacturer premises (Solcon) in Israel and combined testing of Chiller and Soft Starter was done successfully at Pune. The items are being readied for packing and shipment to ITER.

B.4. Cryodistribution & Cryolines

Prototype Cryoline (PTCL-2) manufacturing was completed and was received at ITER-India cryogenics laboratory at IPR, where it was installed and provisional as well as final acceptance tests at cryogenic temperatures were successfully completed. Seven design reviews and three manufacturing readiness reviews of various lots of ITER Cryolines have been successfully completed, while three design reviews of various lots of ITER Warmlines have been successfully completed. Manufacturing and testing of Lot-Y1 Cryolines is in progress at INOX India Ltd. while manufacturing of Lot-X3 Cryolines is in progress at Air Liquide, France. For Cryodistribution system, final design of Cryoplant Termination Cold Box (CTCB) has been completed. Manufacturing Readiness Reviews have been completed for CTCB components like vacuum shell, cryogenic valves, internal piping, thermal shield, electrical cubicles, cryogenics filters, heaters and vacuum barrier/sleeves. Manufacturing has been completed for vacuum shell of CTCB with vacuum barrier, filter and heater casing. Preliminary design review of all Auxiliary Cold Boxes (ACBs) and Thermal Shield Cooling System has completed. Detail design of ACBs is ongoing.

Figure B.3 Ozonation System delivered to ITER site

B.5. Ion Cyclotron Heating & Current Drive Sources

One of the important auxiliary heating and current drive methods for ITER plasma is by using radio frequency waves in the Ion Cyclotron Resonant Frequency (ICRF) range. Total 20 MW of ICRF power will be launched using 8 nos. of sources, each unit of having 2.5 MW/Continuous Wave (CW) capabilities, a Prototype unit is also included in this package for demonstrating the technology. India is responsible for supplying total 9 (1 Prototype and 8 series production) complete ICRF sources for ITER project. To identify the best high power vacuum tube (Diacrode/Tetrode) and other criti-

Figure B.4 Cryoplant Termination Cold Box (CTCB) Vacuum Shell

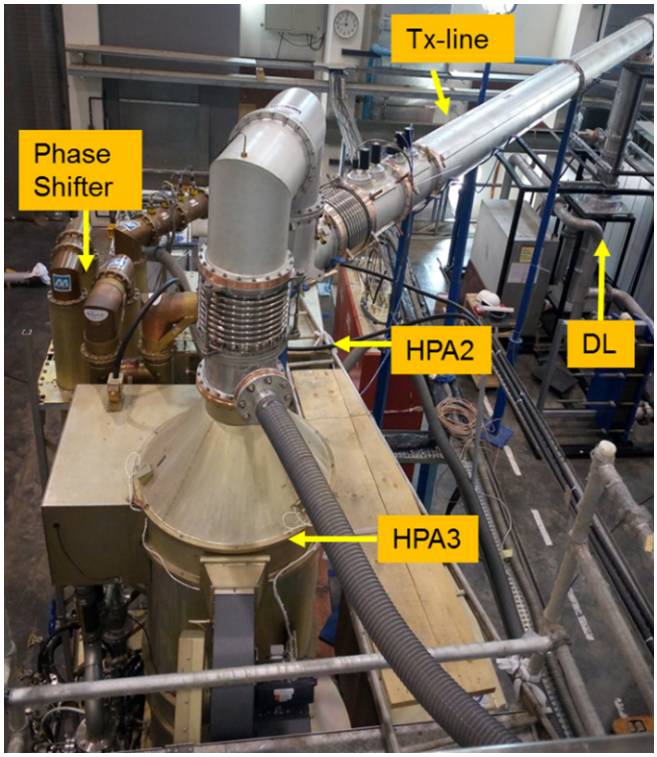

Figure B.5 Tetrode Based System at ITER-India lab

cal components for ITER application, an R&D program has been initiated. Two major contracts have been launched with Thales Electron Devices, France for Diacrode technology and with Continental Electronics Corporation, USA for Tetrode technology, to finalize technical choices of vacuum tube technologies for final stage amplifier. 3MW test rig simulating mis-match load condition has been developed at ITER-India test facility. For Diacrode based system, Burn test was conducted for 6000s to verify the ruggedness of the entire system & benchmark the technology for fusion application. Mis-Match Transmission Line (MMTL) system was installed with Diacrode based RF amplifier for conducting ITER like test scenarios and was tested at 1.5MW / 2000 s/35-65MHz with VSWR 2:1 at various reflection angles. These tests essentially ensured constant IC power to the ITER plasmas even with mismatch situation, for example, mismatch condition due to appearance of Edge Localized Modes (ELMs). During this reporting period, R&D activity using Diacrode based system completed successfully. Tetrode based Amplifiers have been assembled and integrated with auxiliaries & other sub-systems at ITER-India test facility. Initially high power RF test conducted on matched load at lower frequency side (36 MHz) of the operating frequency range and tested up to 1.5 MW/ 2000 seconds and 1.7MW/3600 seconds with required bandwidth (+/-1 MHz) successfully. At other operating frequencies (45 MHz, 50 MHz, 55 MHz and 60 MHz), up to 1MW of RF power could be extracted for several 100 seconds. Further testing as per ITER specification is ongoing. Expertise has been developed in high power RF design and fabrication methodology. Directional Coupler and Flexible Transmission Line were developed and tested for 1.5MW/2000 sec/35-65MHz. Wideband combiner was developed and tested for its functionality at kW level. Solid State Power Amplifier has been tested at 1.6 kW/CW and upgradation of power is underway.

B.6. Electron Cyclotron Heating (ECH) system

ITER requires 20 MW of RF power at Electron Cyclotron frequency (170 GHz) for Plasma Heating and Current Drive applications. As a part of in kind contributions to ITER project, ITER-India has a procurement package that includes delivery of two sets of High Power Gyrotron sources (170 GHz/1MW/3600 s) and auxiliary systems to ITER. The procurement package is being executed in two phases. In phase-1, a gyrotron test facility is being established at ITER-India, in IPR campus to enable the system integration and integrated performance testing of the deliverables with the help of a Test Gyrotron and prototype auxiliary systems. In phase-2 the actual ITER deliverables will be taken up. Currently the Phase-1 activities are being actively pursued. Following are some of the main progress highlights carried out during the current year. Towards the auxiliary systems for the gyrotron test facility, various developmental and procurement activities have been carried out. Contract has been placed to establish a large volume cooling distribution system for the Gyrotron test facility. A cost effective and modular solution using high voltage solid-state switches has been considered for prototype development to meet the high frequency mod-

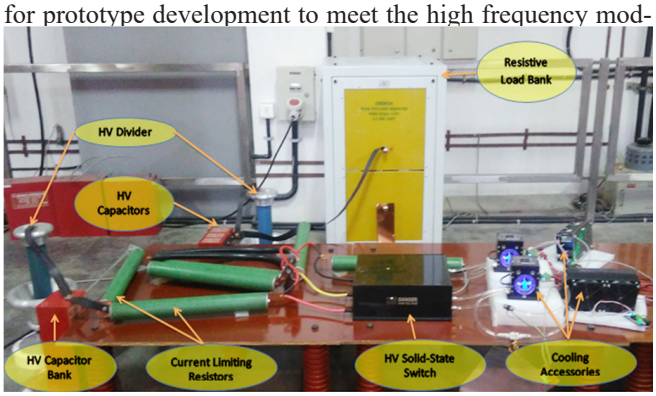

Figure B.6 Experimental Test Setup with Initial Test results of Gyrotron Body power supply

ulation requirement for the Gyrotron Body Power Supply (35kV/100mA/5 kHz). R&D for the same is in progress. First phase of testing was successful and results achieved were satisfactory. Further testing at enhanced parameters has been initiated. Towards development of Local Control Unit for the Gyrotron test facility few design and development activities have been carried out. A prototype industrial grade centralized Interlock Module has been developed indigenously. Functional and EMC/EMI qualification tests have been carried out with satisfactory results. Indigenous development trials for prototype corrugated waveguide (63.5mm) has been initiated. After several trials, the machining process has been optimized to produce the accurate corrugations within the waveguide section of about 300 mm length. In the context of ITER project a phased development roadmap for an indigenous Gyrotron design & development program at 170GHz has been worked out under a MoU with CSIR-CEERI.

B.7. Diagnostic Neutral Beam (DNB)

The Diagnostic Neutral Beam (DNB) (3 Seconds ON/20 Seconds OFF with 5 Hz modulation) in ITER is mandated to provide 100 kV, ~18-20 Amperes Hydrogen beam to support the Charge Exchange Recombination Spectroscopy (CXRS) for the measurement of Helium ash in the ITER machine.

Beam Source manufacturing: At the manufactuer M/s PVA TePla, Germany and their sub-contractors, almost all the major components of DNB Beam Source (accelerator grids, grid support flanges and frames, plasma driver plate, source case lateral walls, RF coil, faraday shields rear driver plate. Electron dump etc.) are under manufacturing. The manufacturing involves complexity in terms of material, welding, precision requirements and these are being addressed by using advanced technologies like deep-hole drilling, electron beam welding, copper electro deposition and precision machining. Upon completion of manufacturing in a year, acceptance tests would be carried out at factory as well as site prior to installation at INTF test bed.

Beam Line Components manufacturing: Manufacturing activities of Beam Line Components has been initiated by the manufacturer PVA TePla Germany and their subcontractors. Major raw material for manufacturing of Neutralizer panels & stainless steel has been procured. CuCrZr Raw material for manufacturing of RID Panels & Heat Transfer elements has been supplied by M/s NFTDC, Hyderabad. Other critical processes like deep-hole drilling of RID panels & Neutralizer panels have been successfully established. Electron Beam (EB) Weld qualification trials is ongoing to weld various similar & dissimilar material combination for manufacturing of Neutralizer, RID Panels & water cooling circuit.

Data Acquisition and Control System (DACS) for Indian Test Facility (INTF): To support INTF operations DACS is presently in advanced stage of design and implementation. Major hardware procurements related to control, data acquisition and signal conditioning have been completed. Development of data acquisition for long pulse upto 3600 sec has been completed. New technologies related to timing and synchronization system have been tested and integrated.

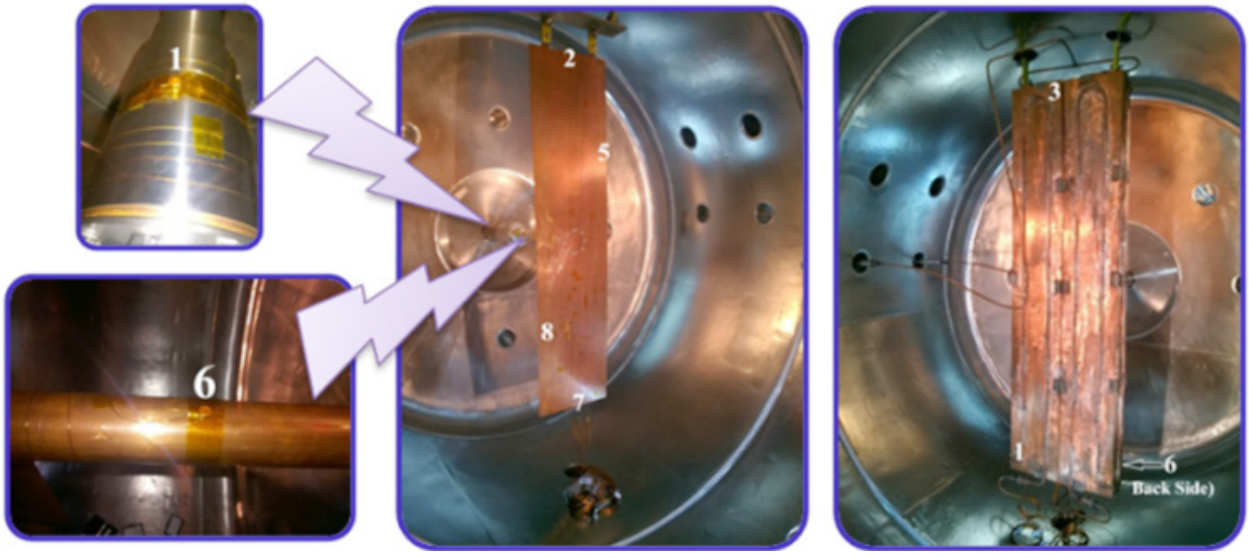

Figure B.7 Cryocooler based Cryopump experiment

RF Power Experiment in Vacuum: To mimic the RF operation in vacuum and to know the temperature rise of the 3 1/8 inch RF line for 180kW 1MHz RF power a setup is prepared. All the components (installed on the flange) are individually tested for vacuum. Vacuum of the order of 0.0088 mbar is achieved. Achievement of higher order of vacuum through Diffusion pump is under progress.

Cryocooler Based Cryopump Experiment: An experimental validation of the temperature distribution on the Helium section has been carried out on a prototype using a 20 W @ 15 K Cryocooler. The cryocooler experiments have been performed using a LN2 cooled radiation shield in vacuum vessel. In vacuum chamber the vacuum of the order of ~5x10-4 mbar are maintained. The prototype experiment indicates temperature profile on the cryopanel surface, cooled by a single cryocooler is sufficient for an efficient Cryosorption pump suitable for INTF operation.

Manufacturing of Cryopump Module LN2 Section (Radiation Shield): Each Cryopump consists of Liquid Nitrogen (LN2) cooled 210 V-shaped chevron baffles arranged in staggered way precisely as radiation shield around cryocooler cooled activated charcoal coated Cryopanel. The Chevron baffles are made of OFHC which are coated black with a ~50µm thick material (Al2O3 - TiO2) having high absorptivity and emissivity. All the baffles are stacked on one over the other using spacers and then vacuum brazed to (Liquid Nitrogen) LN2 pipes. Around 80% of chevron baffles have been black coated and vacuum brazing of chevron baffles with LN2 pipes have been initiated.

B.8. Power Supply Developments

Power Supply Group is responsible for design, development and supply of various High Voltage Power Supplies (HVPSs) for DNB, ICH&CD and ECH&CD system of ITER, France and for SPIDER experiments at Neutral Beam Test Facility, Padova, Italy. The group is responsible to support R&D for the same systems at ITER-India lab and is also engaged in developing Indian industry for their participation in ITER and similar programme, including prototype efforts. Manufactured components of SPIDER Acceleration Grid Power Supply (AGPS) have been delivered to Neutral Beam Test facility, Padua, Italy. Installation and integration activities including standalone tests for AGPS components have been carried out; integrated testing is ongoing. AGPS for DNB has been installed and being tested at ITER-India (II) Lab. As a part of R&D programme at ITER-India lab, solid state high frequency (1 MHz) power source has been developed; the source is interfaced with plasma load and tested successfully at ITER-India (I-I) lab. A motorized short circuit switch is developed in-house for high voltage application; specifically for wire burn test of HVPS. 300 kHz analogue optical link is developed for HVPS voltage and current measurement with optical isolation. The units are being used for AGPS at ITER-India lab. After successful testing of prototype at I-I lab, segments of 25m transmission line including two horizontal bends and one vertical bend are manufactured at Shell N Tube, Pune. Components are tested at sub-assembly level and ready for dispatch. High voltage deck for DNB power supply system is manufactured and installed at lab. Industrial prototype IC HV power supply is being operated continuously for site acceptance campaigns of ICRF sources diacrode and tetrode based systems.

B.9. Diagnostics

X-Ray Crystal Spectrometer - Survey System: First phase of Preliminary Design Review of XRCS-Survey sight tube was completed Further progress was made on technical activities including fire analysis, RAMI and HIRA analysis, integration with respective ports, integrated structural and neutronic analysis. For laboratory R&D experiments, most of the components for conventional X-ray source and optical setup required for testing curved diffractors are received and tested. The fixed anode x-ray source was assembled and integrated with vacuum system, power supplies, temperature monitors. The filament testing has been completed and progressing with operation for measuring x-ray beam spectrum and dose. The measurement of X-ray fluorescence was done and elemental concentration was found. The maturity of the Plant Instrumentation & Control design was assessed and the results showed fairly good level of functional analysis and operation procedures.

Electron Cyclotron Emission (ECE) diagnostic system: The preliminary design of this system and prototype works are progressing. Fast scanning Fourier Transform Spectrometer (FTS) has been delivered to ITER-India lab after successful completion of Factory Acceptance Tests at the manufacturer site (Bluesky, Canada). Transmission line components (5 pieces of straight WG sections each of length 2m, 3 Miter bends, 2 waveguide pump out tees) and window assembly were received, assembled and tested. The polarizer splitter unit was designed and analyzed for both prototype and ITER deliverables. Highly symmetric output beam waists with >99% power coupling into the fundamental beam mode was

observed. Quasi- Optical Notch Filter was designed and analyzed for protection of ECE diagnostic from high power stray radiation coming from ECRH at 140 GHz.

Charge Exchange Recombination Spectroscopy (CXRS): This system along with Beam emission spectroscopy (BES) provides impurity (He, Be, Ne, Ar, C) density information. Preliminary performance assessment of CXRS & BES diagnostic system for ITER pedestal region has been carried out to assess the ITER measurement requirements.

Upper Port Plug: First phase of System Integration Review for Upper Port integration is completed. Integration with the interfacing diagnostics and their requirements in the port plug are developed. Load specification report, Electromagnetic analysis, shutdown dose rate calculations, remote handling capability assessment are in progress while RAMI analysis for the preliminary design review is completed.

B.10. Activities of Fusion Physics Group

Modelling of disruptions in DIII-D and CMOD tokamaks for characterization of Halo currents during disruption and predictions for ITER - this work was started in early 2014 and has been completed in 2017. Integrated Modeling and Analysis Suite (IMAS) is a platform based on Kepler, where different tokamak related codes can be integrated elegantly. IMAS has been successfully implemented on ITER-India Servers. A model is developed to simulate the generation, diffusion and the mitigation through magnetic perturbations of runway electrons in tokamaks. The code is planned to use for ITER calculations, and a possibility of coupling the same with NOTEC to understand its implications on ECE diagnostics. A zero-dimensional (0-D) model has been developed that consists of five temporal equations: the electron and neutral density equations, the electron and ion energy density equations, and the electric circuit equation. The primary aim of this work is to couple the 0-D code with TSC for modeling the plasma discharge scenario of tokamaks. A model is developed to calculate loop voltages at all flux loop locations & eddy current in passive structures (Vacuum vessel & Cryostat). It has been used for comparing flux loops and magnetic probe data of various SST-1 and ADITYA-U experimental shots.

B.11. Activities common to all packages and project office

Regular schedule updates were made and reported at ITER International organization. Ensured compliance to Quality Management System through various documents (Quality plan, Manufacturing & Inspection Plans, Procedures etc.) reviews. Adherence to modern international project management practices and also implementation of Intellectual Property Management (IP) activities through pre-screening of publications for IP and implementing IP provisions in contracts with industry. Participation in Risk Management activities that included updating the project risk register and mitigation plans. Reporting of the developments to the public was also done through ITER Newsline and ITER Annual Report.

Neutronics group activities: Three state of art codes and few visualization techniques are developed: 1. ACTYS- fast and accurate activation solver for a point in material, 2. ACTYS-1-GO fast and accurate activation solver for entire machine in a GO!, 3. METTA – A code for optimizing nuclear materials, for those expected to be in intense neutron irradiation (Added to ACTYS and ACTYS-1-GO. Separate module for FISPACT). Visualization techniques have been developed using Python added to ACTYS family or can be used independently.

B.12. Activities of ITER-India Design Office

CAD and engineering support provided to technical groups of ITER-India. Fifty five Designs data (Data Exchange Task) were executed between ITER Organization, ITER domestic agencies and Suppliers and also provided associated technical support. Technical (Design and Analysis) and training (CAD, FEA) support provided to designers. Independent verification by Analysis on components like Valves, Pumps, Heat exchangers and chillers has been carried out. Thermo-hydraulic Analysis of Purge lines of ITER Cryogenics system and Transient Thermal analysis of Tungsten-copper Composite block have been carried out. Development of FE based Mathematical model for hinge support of vacuum vessel and analysis for flexibility performance was done. Design data preparation for Rectangular Bellows for external pressure condition based on EJMA and qualification procedure using the Finite Element method. Co-ordination in implementing the project changes via Configuration Control Board and participation in other working groups on document management, project lifecycle management and CAD.

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CHAPTER C, D & E

C. Academic Programme

D. Technical Services

E. Publications and Presentations

C. ACADEMIC PROGRAMMES

C.1 DOCTORATE PROGRAMME

In the Ph.D. programme conducted by the institute forty two (42) research scholars have been enrolled at present. Out of them, seventeen (17) are working in theoretical and simulation projects while fourteen (14) are engaged in experimental projects. Eleven (11) new students have joined this programme during the year and are going through the course work. After successful completion of this course work, they will be enrolled for their Ph.D. Presently twenty five (25) Post-Doctoral Fellows are engaged in their research work.

Ph.D. Thesis Submitted (during April 2016 - March 2017)

Collective Phenomena in Strongly Coupled Dusty Plasma Medium
Vikram Singh Dharodi
Homi Bhabha National Institute, 2016

Slow Wave Characteristics of Metamaterial Loaded Helical Guide
Dushyant Kumar Sharma
Homi Bhabha National Institute, 2016

Nonlinear Excitations in Flowing Complex Plasmas
Surabhi Jaiswal
Homi Bhabha National Institute, 2016

Study of Er2O3 Film Deposition by Different Techniques for the Fusion Reactor Applications
Pratipalsinh A. Rayjada
Sardar Patel University, 2016

C.2 TECHNICAL TRAINING PROGRAMME (TTP)

There were three candidates in TTP-2016, two from Physics and one from Mechanical branch. They have undergone a rigorous coursework in plasma science and technology and completed their project work. After their successful completion of coursework, they were absorbed into various projects of IPR.

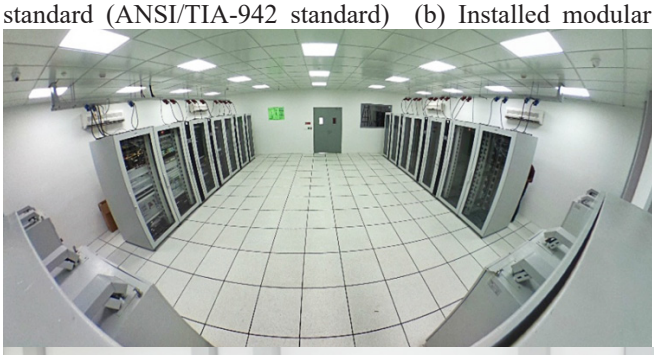
C.3 SUMMER SCHOOL PROGRAMME (SSP)

Forty six (46) students participated in this programme, which aimed at providing an opportunity to (28) students from M.Sc. Physics and (18) students from Engineering discipline which include Mechanical, Electronics and instrumentation, Electrical, Chemical and Metallurgy, to interact actively with scientists of the institute and learn about Plasma Physics and related areas through a project and series of lectures. Besides the above-mentioned training programme, project works are routinely offered in Computer, Electronics and Electrical Engineering for regular students as a part of their academic requirements.

D. TECHNICAL SERVICES

D.1 Computer Services

IPR Data Center: The state-of-the-art data center at IPR is now operational. Spread over an area of ~95 sq. meters, this 14 rack facility with in-rack cooling and many levels of protection will cater to the current and future computing / IT needs of IPR. To support this facility, a dedicated cooling system as well as a robust UPS system, both with backups have also been established. The health of the racks and other support systems can be remotely monitored to ensure a 24x7 operation of the data center. The main features of this Data center are ; (a) Complies with the TIER 3 international standard (ANSI/TIA-942 standard) (b) Installed modular



UPS of 250kW capacity (125KW in N+N mode), upgradable to 400KW (c) Two air cooled scroll chillers (60TR capacity each) functioning in N+N mode (d) In-rack cooling system (Liquid Cooling Package) with cooling capacity of 40KW each LCP (e) Dual independent electrical distribution paths serving the IT equipment / racks. All critical and core IT equipment installed in Data Center are dual-powered (f) Fire rated (120 min) partitions, doors, false floor, false ceiling etc. The new IPR Data Center was inaugurated by the Director, Dr. Shashank Chaturvedi on the 28th of March 2017. The inauguration was attended by several IPR staff.

D.2 Library Services

Institute for Plasma Research (IPR) Library caters to the specialized information needs of the user community involved in Research and Development activities in the areas of Plasma Physics and Fusion Science and Technology. Library is well equipped with modern infrastructure and continues to serve its user community with focused collection and services. Library is also involved in providing Publication Management activities and developed tools to manage internal publications. IPR library continues to subscribe to major databases such as SCOPUS, Online Archives of core journals. Library has access to SCIENCEDIRECT through DAE Consortium.

The library website (http://www.ipr.res.in/library/) is continuously updated with latest information and all subscribed resources and other large collection of in-house electronic resources such as Research and Technical Reports, Reprint, Thesis, etc. are made accessible to the user community. Library continues to provide current awareness services by delivering current content, widely to plasma physicists at national level. Total 297 News items were displayed and archived as an Alerting Service. Library started providing email alerting services for NucNet news.

During reporting period total of Rs. 24554314 budget was utilized. About 763 books and back volumes, 88 internal research reports, 49 technical reports, 34 research reports received from other research institutes, 130 reprints, 30 pamphlets and 46 software were added in to the library collection and subscribed to 109 periodicals. This year a total of 7 journal titles were migrated to only online and 4 new only online journals were added to e-collection.

Library also added 25 E-Books to its collection.
Library continued to provide Article Delivery Services through Inter Library Loan (ILL) to the user community. 89.80% of the requests made by staff members were satisfied through Inter Library Loan (ILL) service. IPR Library provided documents to other institutes against their queries and 100% of the total need were satisfied. Total 24152 photocopies supplied to users. 3252 scanned copies were provided to the users.

Library is actively carrying out Information Literacy and Training programmes for its users. Mendeley Training and Plagiarism detection software demonstration was conducted. Library orientation was given to newly joined members, Summer School Program Students, and Research Scholars.
IPR Library celebrated Kalam-Chandra Week during 17-21 October 2016 to mark Birth Anniversaries of two Great Scientists, viz., Dr A P J Abdul Kalam and Nobel Laureate Subrahmanyan Chandrasekhar. A collection of their books were exhibited in library, also Posters on Kalam and Chandrasekhar were be displayed.

Library actively participated in other Institutional activities, such as Hindi Seminars/Meetings, Safety Week, National Science Day, etc. Library provided internship training programme to 04 MLISc students, two each from Central University of Gujarat (CUG), Gandhinagar, and Gujarat University, Ahmedabad during the year 2016-17.

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E. PUBLICATIONS AND PRESENTATIONS

E.1 Articles Publications

E.1.1 Journal Articles

Thermal-Hydraulic Characteristics and Performance of 3D Straight Channel Based Printed Circuit Heat Exchanger
A.M. ANEESH, ATUL SHARMA, ATUL SRIVASTAVA, K.N. VYAS and PARITOSH CHAUDHURI
Applied Thermal Engineering, 98, 474, 2016

Growth and Structural Determination of He Bubbles in Iron/Chromium Alloys using Molecular Dynamics Simulations
A. ABHISHEK, M. WARRIER, R. GANESH, A. CARO
Journal of Nuclear Materials, 472, 82, 2016

0-D Modeling of SST-1 Plasma Break-Down & Start-Up using ECRH Assisted Pre-Ionization
AVEG KUMAR, SUBRATA PRADHAN
Fusion Engineering and Design, 105, 22, 2016

Nonlinearly Coupled Dynamics of Irregularities in the Equatorial Electrojet
J.K. ATUL, S. SARKAR, S.K. SINGH
Physics Letters A, 380, 1446, 2016

Experimental Study for Comparison of H2 and Ar–H2 Gas Mixture Glow Discharge Wall Conditioning in ADITYA Tokamak
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Thermal Contact Resistance Measurement of Conduction Cooled Binary Current Lead Joint Block in Cryocooler Based Self Field I-V Characterization Facility

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R. BHATTACHARYA, H. VAGHELA, B. SARKAR, P. PATEL, J. DAS, M. SRINIVASA, T. ISONO, and K. KAWANO
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Experimental Investigation of Two-Phase Nitrogen Cryo Transfer Line
G. K. SINGH, H. NIMAVAT, R. PANCHAL, A. GARG, G.L.N. SRIKANTH, K. PATEL, P. SHAH, V. L. TANNA and S. PRADHAN
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N. BAIRAGI, V. L. TANNA and S. PRADHAN
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B. SARKAR, H. VAGHELA, N. SHAH, R. BHATTACHARYA, K. CHOUKEKAR, P. PATEL, H. KAPOOR, M .SRINIVASA, H. S. CHANG, S. BADGUJAR, and E. MONNERET
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P. RAJ, M. GHATE, S. PRADHAN, A. SINGH,and M. M. HUSSAIN
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H. KAPOOR, A. GARG, N. SHAH, S. MURALIDHARA, K. CHOUKEKAR, B. DASH, V.GAUR, S. MADEENAVALLI, P. PATEL, U. KUMAR, M. JADON, V. SHUKLA, B. SARKAR, Y. SARVAIYA, D. MUKHERJEE, A. DUTTA, KV. MURUGAN, S. GAJERA, B. JOSHI and R. PANJWANI
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Development of Indigenous Insulation Material for Superconducting Magnets and Study of its Characteristics

under Influence of Intense Neutron Irradiation
RAJIV SHARMA, V. L. TANNA, C.V.S. RAO, MITUL ABHANGI, SUDHIRSINH VALA, SUNDARAVEL, S. VARATHARAJAN, S. SIVAKUMAR, K. SASI, and S. PRADHAN
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U PRASAD, S PRADHAN, P RAJ, P VARMORA, A PANCHAL, A BANO and M GHATE
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Assembly Installation Studies for the ITER Cryoline System
S BADGUJAR, N SHAH, A FORGEAS, N NAVION-MAILLOT, E MONNERET, D GRILLOT, L BENKHEIRA and B SARKAR
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Measurement of Thermal Conductivity of Materials Down To 4.5 K for Development of Cryosorption Pumps
RAVI VERMA, UPENDRA BEHERA, S KASTHURIRENGAN, N C SHIVAPRAKASH, S S UDGATA and R GANGRADEY
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Design and Implementation of Electromagnetic Diagnostics Electronics in SST-1 Tokamak
PRAVEENLAL EDAPPALA, CHANDRESH HANSALIA, RACHANA RAJPAL, HITESH MANDALIYA, VISMAY RAULJI, SAMEER KUMAR, RAJU DANIEL
International Conference on Advances in Electrical, Electronic and Systems Engineering (ICAEES), Malaysia, 14-16 November 2016, Article no.7888090, 2017

E.1.3 Book Chapters

Investigation of the Effect of Thermal Cycle on SS/CRZ Brazed Joint Sample
K.P SINGH, ALPESH PATEL, KEDAR BHOPE, S BELSARE, NIKUNJ PATEL, PRAKASH MOKARIA, S.S KHIRWADKAR
Plasma and Fusion Science from Fundamental Research to Technologies Applications, Apple Academic Press, CRC Press, October 2016, **ISBN: 9781771884532** (Book Chapter)

CFD Study on Thermal Hydraulic Performance of a Wavy Channel Based PCHE Model
A.M. ANEESH, ATUL SHARMA, ATUL SRIVASTAVA and PARITOSH CHAUDHURI

Fluid Mechanics and Fluid Power-Contemporary Research, Proceedings of the 5th International and 41st National Conference on FMFP 2014 (Lecture Notes in Mechanical Engineering), pp 497-506, Springer, October 2016, **ISBN: 9788132227410** (Book Chapter)

Thermo-Hydraulic Performance of Zigzag, Wavy, and Serpentine Channel Based PCHEs
A.M. ANEESH, ATUL SHARMA, ATUL SRIVASTAVA and PARITOSH CHAUDHURI
Fluid Mechanics and Fluid Power-Contemporary Research, Proceedings of the 5th International and 41st National Conference on FMFP 2014 (Lecture Notes in Mechanical Engineering), pp.507-516, Springer, October 2016, **ISBN:9788132227410** (Book Chapter)

E.2 INTERNAL REPORTS

E.2.1 Research Reports

OBSERVATION OF PLASMA SHIFT IN SST-1 USING OPTICAL IMAGING DIAGNOSTICS
MANOJ KUMAR, CHESTA PARMAR, VISHNU CHAUDHARY, AJAI KUMAR, and SST-1 TEAM
IPR/RR-789/2016 APRIL 2016

ACTIVATION ANALYSES OF INDIAN LEAD LITHIUM CERAMIC BREEDER TEST BLANKET MODULE IN ITER
A. K. SHAW, H. L. SWAMI and C. DANANI
IPR/RR-790/2016 APRIL 2016

LEBT OPTIMIZATION FOR BEAM MATCHING STUDIES
MRIDULA MITTAL and RENU BAHL
IPR/RR-792/2016 APRIL 2016

DESIGN OF COOLING SYSTEM FOR 1 MEV RADIO FREQUENCY QUADRUPOLE
SUMIT KUMAR, RENU BAHL, B. SARKAR and ANURAG SHYAM
IPR/RR-794/2016 APRIL 2016

SINGLE PARTICLE CLOSED ORBITS IN YUKAWA POTENTIAL
RUPAK MUKHERJEE and SOBHAN SOUNDA
IPR/RR-795/2016 APRIL 2016

TF RIPPLE ANALYSIS FOR SST-2 LIKE TOKAMAK FUSION REACTOR
SOMESWAR DUTTA, AASHOO SHARMA, UPENDRA PRASAD, VINAY MENON, C. DANANI, R. SRINIVASAN, S. PRADHAN, S. S. KHIRWADKAR, RAJENDRA KUMAR, S. DESHPANDE, AMITA DAS, D. BORA and P. K. KAW
IPR/RR-796/2016 APRIL 2016

USE OF LANGMUIR PROBES IN DUSTY (COMPLEX) PLASMA
SAYAK BOSE, MANJIT KAUR, P. K. CHATTOPADHYAY, J. GHOSH, Y. C. SAXENA and R. PAL
IPR/RR-797/2016 APRIL 2016

STRUCTURAL, MECHANICAL AND CORROSION RESISTANCE PROPERTIES OF TI/TIN BILAYERS DEPOSITED BY MAGNETRON SPUTTERING ON AISI 316L
K. SHUKLA, R. RANE, J. ALPHONSA, P. MAITY, S. MUKHERJEE and Y. K. AGRAWAL
IPR/RR-798/2016 APRIL 2016

COLLISIONLESS SHEATH FEATURES OF CAPACITIVELY COUPLED PLASMA DISCHARGES OPERATING WITH CURRENT DRIVEN TRIPLE FREQUENCY CONFIGURATION
S. SHARMA, S. K. MISHRA, P. K. KAW and M. M. TURNER
IPR/RR-799/2016 APRIL 2016

STUDY OF DIFFUSION BONDING OF WL10 TO SS JOINING WITH & WITHOUT TITANIUM INTERLAYER USING THERMO MECHANICAL SIMULATOR
K.PREMJIT SINGH, ALPESH PATEL, KEDAR BHOPE, NIKUNJ PATEL, S.S KHIRWADKAR
IPR/RR-801/2016 MAY 2016

CALCULATED DIFFERENTIAL & DOUBLE DIFFERENTIAL CROSS SECTION OF FUSION NEUTRON INDUCED REACTIONS ON NATURAL CHROMIUM
MAYANK RAJPUT, BHAWNA PANDEY, CVS RAO, T.K. BASU, and DHIRAJ BORA
IPR/RR-802/2016 MAY 2016

THEORETICAL CALCULATION OF DIFFERENTIAL AND DOUBLE DIFFERENTIAL CROSS SECTION OF 14 MeV NEUTRON INDUCED REACTIONS ON Fe
MAYANK RAJPUT, BHAWNA PANDEY, G. VAITHEESWARAN, CVS RAO, T.K. BASU, and DHIRAJ BORA
IPR/RR-803/2016 MAY 2016

TRANSIENT THERMAL, STRUCTURAL AND STATIC MAGNETIC FIELD ANALYSES OF 1:1 PROTOTYPE JET ELM CONTROL COILS
ANANYA KUNDU, SUBRATA PRADHAN, MAHESH GHATE, DEVEN KANABAR, SWATI ROY, and NITISH KUMAR
IPR/RR-805/2016 MAY 2016

BREAKING OF LARGE AMPLITUDE ELECTRON PLASMA WAVE IN A MAXWELLIAN PLASMA
ARGHYA MUKHERJEE and SUDIP SENGUPTA
IPR/RR-806/2016 MAY 2016

MOLECULAR SHEAR HEATING AND VORTEX DYNAMICS IN THERMOSTATTED TWODIMENSIONAL YUKAWA LIQUIDS
AKANKSHA GUPTA and RAJARAMAN GANESH
IPR/RR-808/2016 MAY 2016

ROLE OF THERMAL ANCHORING AND HEAT LOAD OPTIMIZATION OF CONDUCTION COOLED BINARY CURRENT LEAD USED IN CRYO-COOLER
ANEES BANO, ANANYA KUNDU, SUBRAT KUMAR DAS and SUBRATA PRADHAN
IPR/RR-809/2016 MAY 2016

MEASUREMENT OF OUTGASSING RATE FOR GTAW WELDED SS304 MATERIALS
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AROH SHRIVASTAVA, NARENDER SINGH and P. CHAUDHURI
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B. V. SHAH, A. K. SAHU, N. MAMGAIN, S. V. JAIN and P. SHARMA
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U. PRASAD, A. PANCHAL, P. RAJ, P. VARMORA and S. PRADHAN
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Conceptual Design Report for Development of Hydrogen Isotopes Removal System
V. GAYATHRI DEVI, DEEPAK YADAV, and AMIT SIRCAR
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Sealing Performance of Non-Metallic Gaskets with Indium Wire Seal at Temperatures Down to 10K for High Vacuum and Thermal Insulation Application in a Screw Extruder System
PARESH PANCHAL, SAMIRAN SHANTI MUKHERJEE, PRATIK NAYAK, JYOTI SHANKAR MISHRA, JYOTI AGRAWAL, and RANJANA GANGRADEY
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Establishment and Validation of "Unit for Thermal Properties Assessment at Low Temperature"(UTPAL) at IPR
JYOTI AGARWAL, JYOTISHANKAR MISHRA, VRUSHABH LAMBADE, S. KASTURIRANGAN, RANJANA GANGRADEY and SAMIRAN MUKHERJEE
IPR/TR-384/2016 (MAY2016)

Kinetics Studies of Carbon Doped Amorphous Nano- Boron in MgB2 Phase
NITISH KUMAR, SUBRAT KUMAR DAS and SUBRATA PRADHAN
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Hollow Circular Acrylic Waveguides for Far Infrared Interferometer of SST-1
ASHA ADHIYA, RAJWINDER KAUR and PABITRA KUMAR MISHRA
IPR/TR-386/2016 (JUNE 2016)

Development, Optimization and Validation of Ultrasonic Testing for NDE of ELM Coils
K. BHOPE, M. GHATE, M. MEHTA, A. PANCHAL, S. PRADHAN and S. KHIRWADKAR
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MINSHA SHAH, HITESH MANDALIYA, RACHANA RAJPAL and ELECTRONICS GROUP
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P. NAYAK, S. MUKHERJEE, P. PANCHAL, D. TRIPATHI, R. GANGRADEY, J. MISHRA and J. AGARWAL
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KIRAN PATEL, VISHAL PILLAI, NEHA SINGH, JINTO THOMAS and AJAI KUMAR
IPR/TR-391/2016 (JUNE 2016)

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PARESH PANCHAL, DEVESH TRIPATHI, SAMIRAN MUKHERJEE and RANJANA GANGRADEY
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Conceptual Design Report of Experimental Loop for Hydrogen Isotopes Extraction from Liquid Pb-Li
RUDREKSH B. PATEL, SUDHIR RAI and AMIT SIRCAR
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Development and Testing of Visual Inspection Applications for Tokamak Maintenance
PRAMIT DUTTA, NAVEEN RASTOGI, SHREYA JOSHI, AKSHAY PATEL, MIHIR TRIVEDI and K. K. GOTEWAL
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R. SUGANDHI, P. K. SRIVASTAVA, A. K. SANYASI, P. SRIVASTAV, L. M. AWASTHI and S. K. MATTOO
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KARISHMA QURESHI, P. J. PATEL, C. CHAKRAPANI, S. L. PARMAR, L. K. BANSAL, B. PANDYA, DIPAL THAKKAR, C. B. SUMOD, L. N. GUPTA, VIJAY VADHER, B. CHOKSI, NILESH CONTRACTOR, S. K. SHARMA, SRIDHAR, RAMBABU, BHARATHI, M. R. JANA, V. PRAHLAD and U. K. BARUAH
IPR/TR-396/2016 (AUGUST 2016)

Artificial Neural Network for Yield Strength Prediction of Irradiated RAFM Steels
H. T. IYER and A. ABHISHEK
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Electromagnetic and Structural Analysis of Jet Elm Control Coil Support Structure
PRAMIT DUTTA, MANOAHSTEPHEN MANUELRAJ, NAVEEN RASTOGI and CHRISTOPHER LOWRY
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Preliminary Design and Assessment of Beam Tube for Laser Interferometer Gravitational Wave Observatory (LIGO)-India Project
RAKESH KUMAR, YUVAKIRAN PARAVASTU and ZIAUDDIN KHAN
IPR/TR-399/2016 (SEPTEMBER 2016)

Development of Driver Amplifier Stage for Generator of the ADITYA ICRH System
SUNIL KUMAR, D. BORA, S.V. KULKARNI and HIGH POWER ICRH SYSTEMS DIVISION
IPR/TR-400/2016 (SEPTEMBER 2016)

Development of Pre-Driver Amplifier Stage for Generator of the ADITYA ICRH System
SUNIL KUMAR, D. BORA, S.V. KULKARNI and HIGH POWER ICRH SYSTEMS DIVISION
IPR/TR-401/2016 (SEPTEMBER 2016)

Development and Testing Of Prototype Soft X-Ray Camera Using 16channel AXUV Photodiode Array for Aditya Tokamak
JAYESH RAVAL, S. PUROHIT, Y.S. JOISA, A.K. CHATTOPADHYAY, PRAVEENA KUMARI, VISMAYSINH RAULJI, MINSHA SHAH and RACHANA RAJPAL
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A. SATYAPRASAD, C. BALASUBRAMANIAN and S. MUKHERJEE
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BHAVESH R. KADIA, K. M. PARMAR, Y. S. S. SRINIVAS and S. V. KULKARNI
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RITESH KUMAR SRIVASTAVA and PARITOSH CHAUDHURI
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Outgassing Measurement of Various Activated Carbon Sorbents for Application in Prototype Cryopump
PARESH PANCHAL, SAMIRAN MUKHERJEE and RANJANA GANGRADEY
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Electron Beam Welding Scenario: Non - Vacuum / Partial Vacuum
GAUTAM R. VADOLIA and K. P. SINGH
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R. SUGANDHI, P. K. SRIVASTAVA, PRABHAKAR SRIVASTAV, A. K. SANYASI, L. M. AWASTHI, V.

PARMAR, K. MAKADIA, I. PATEL and S. SHAH
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Design and Analysis of Manifolds for Indian HCCB Blanket Module
DEEPAK SHARMAA, PARITOSH CHAUDHURIA, ALICE YING
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Virtual Reality Applications in Remote Handling Development for Tokamaks in India
PRAMIT DUTTA, NAVEEN RASTOGI and KRISHAN KUMAR GOTEWAL
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Design and Optimization Study of First Wall for Indian HCCB Blanket Module
DEEPAK SHARMA, PARITOSH CHAUDHURI and ALICE YING
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Design of Efficient Oil Coalescer for Helium Compressor and Oil Removal System
V.B PATEL, A.K SAHU and K. PURANI
IPR/TR-412/2016 (DECEMBER, 2016)

A Technical Report on Radiation Shielding Calculation for the LINAC facility (IPR-SPEAR)
LALIT GUPTA, M. K. NAYAK, HARIDAS G. and RAVI A. V. KUMAR
IPR/TR-413/2016 (DECEMBER, 2016)

Development of a Prototype Work-Cell for Validation of ITER Remote Handling Control System Standards
NAVEEN RASTOGI, VAMSHI KRISHNA, PRAMIT DUTTA, MANOAH STEPHEN, KRISHAN KUMAR GOTEWAL, DAVID HAMILTON and J. K. MUKHERJEE
IPR/TR-414/2016 (DECEMBER, 2016)

Development of Output Amplifier Stage for Generator of the Aditya ICRH System
SUNIL KUMAR, D. BORA, S. V. KULKARNI and HIGH POWER ICRH SYSTEMS DIVISION
IPR/TR-415/2017 (JANUARY, 2017)

Design, Fabrication and Initial Testing of the Output Amplifier Stage for Generator of the SST-1 ICRH System
SUNIL KUMAR, D. BORA, S.V. KULKARNI and HIGH POWER ICRH SYSTEMS DIVISION
IPR/TR-416/2017 (JANUARY, 2017)

Lab Scale Experiment Study to Explore Thermal Deformation of P91 Structural Material with the use of Strain Gauges
RITESH KUMAR SRIVASTAVA, ABHISHEK SARASWAT and PARITOSH CHAUDHURI
IPR/TR-417/2017 (FEBRUARY, 2017)

Apparent Porosity and Bulk Density Measurement of Lithium Meta-Titanate Pebbles by Kerosene Intrusion & Archimedes Method
MAYANK MAKWANA, A. SHRIVASTAVA, M. PANCHAL, P. CHAUDHURI and E. RAJENDRAKUMAR
IPR/TR-418/2017 (MARCH, 2017)

Concept of Twin Screw Extruder for Solid Hydrogen Extrusion
SAMIRAN SHANTI MUKHERJEE, RANJANA GANGRADEY, DEVESH TRIPATHI, PARESH PANCHAL, PRATIK NAYAK, JYOTI SHANKAR MISHRA, JYOTI AGARWAL and KRISHANPAL PATIDAR
IPR/TR-419/2017 (MARCH, 2017)

SST-1 NBI: 6 Cryopumps Parallel Cooldown and Operational testing with LN2
CH. CHAKRAPANI, B. SRIDHAR, P. BHARGAV, Q. KARISHMA, C. NILESH, P. SANJAY and C. BHARGAV
IPR/TR-420/2017 (MARCH, 2017)

A Report on Crush Load of Lithium Ceramic Pebbles
SURAJ KUMAR GUPTA, MAULIK PANCHAL, RISCOB JAMES BRIGHT, AROH SRIVASTAVA, MAYANK MAKWANA and PARITOSH CHAUDHURI
IPR/TR-421/2017 (MARCH, 2017)

FPGA Based Reconfigurable Digital Filter in Measurement System for Plasma Diagnostic
AARTI N. ODEDARA, V. CHAUDHARI and A. H. DAFDA
IPR/TR-422/2017 (MARCH, 2017)

Radiation Heat Transfer Studies for Dome Fabrication Project
DEEPU S. KRISHNAN, K. P. SINGH, S. S. KHIRWADKAR and VINAY MENON
IPR/TR-423/2017 (MARCH, 2017)

Investigation on Turbulent Heat Transfer in Developing Flow Regime for Counter Current Arrangement in Double Pipe Heat Exchanger (Concentric Annulus) for PbLi Liquid Metal
ARVIND KUMAR, V. MEHTA, A. K. PRAJAPATI, A. SARASWAT, S. VERMA, R. BHATTACHARYAY, V. C. CHAUDHARI, K. T. SANDEEP, A. JAISWAL and S. GUPTA
IPR/TR-424/2017 (MARCH, 2017)

Tensile Testing of Pure Tungsten Material at Elevated Temperatures using Small Specimen
ALPESH PATEL, DHAVAL MAKVANA and S. S. KHIRWADKAR
IPR/TR-425/2017 (MARCH, 2017)

Refurbishment, Testing and Experiments on Ion Removal System Magnet of SST-1 NBI
SANJEEV SHARMA, BHARGAV CHOKSI, S. RAMBABU, SANJAY PARMAR, V. PRAHLAD and U. K. BARUAH
IPR/TR-426/2017 (MARCH, 2017)

Study of Spectral Characteristics and Operating Parameters of Twin Cavity CH3OH Laser for FIR Diagnostics of SST-1
ASHA ADHIYA and RAJWINDER KAUR
IPR/TR-427/2017 (MARCH, 2017)

E.3 CONFERENCE PRESENTATION

19th Joint Workshop (EC-19) on Electron Cyclotron Emission (ECE) and Electron Cyclotron Resonance Heating (ECRH), Institute for Plasma Research, Gandhinagar, 4-7 April 2016

Numerical Study on Contribution of Non- Thermal Electrons on ITER ECE Spectrum and Attempt to Parametrically Correlate it to Non- Thermal Parameters through Asymmetric Multiple Measurements
P.V. Subhash, Amit K. Singh, V.S. Divya, M.P. Aparna, T.K. Basitha Thanseem, Hitesh Pandya

Numerical Evaluation of Temperature Fluctuations due to NTM in the ECE Spectrum using a Combination of Perpendicular and Multiple Oblique Views
Amit K. Singh, P.V. Subhash, I. Bandyopadhyay

Trapped Particle Effects on Electron Cyclotron Current Drive
J.K. Atul, S. Sarkar, O.V. Kranvchenko, and S.K. Singh

Study of Edge Turbulence in ECRH Driven Slab Annular Plasma in SST-1
Santanu Banerjee, Navin Parmar, B.K. Shukla, M.V. Gopalakrishna, Jatin Patel, R. Manchanda, M.B. Chowdhuri, N. Ramaiya, S.K. Jha, J. Ghosh and SST-1 team

ECRH Induced Plasma Rotation Dynamics in Open and Closed Magnetic Field Configuration in Tokamak QUEST
Kishore Mishra, H. Zushi, H. Idei, T. Onchi, K. Hanada and QUEST Team

Status and Test Results of Indigenously Developed 42 GHz, 200 kW, 3 Sec. Gyrotron
S.V. Kulkarni, Rajan Babu, S. Pradhan, B.K. Shukla, K. Sathyanarayana, Nidhi Shah, Ejazuddin Shaik, Hetshree Shah, Harshida Patel, Piyush Raj, Upendra Prasad, Mahesh Ghate, Yohan Khristi, Moni Banaudha, Arun Panchal, Dhaval Panchal, D. Rathi and D. Bora

Update on the Status of the ITER ECE Diagnostic Design
G.Taylor, A. Basile, R. Feder, D.W. Johnson, A. Khodak, H.K. Pandya, S. Danani, R. Kumar, S. Kumar, S.B. Padasalagi, S. Thomas, M.E. Austin, S. Houshmandyar, P.E. Phillips, W.L. Rowan, J.H. Beno, A. Ouroua, D. Weeks, A.E. Hubbard, J. Stillerman, V.S. Udintsev, G. Vayakis, M. Walsh

Testing of the Prototype Receiver for ITER ECE Diagnostic
S. Danani, M.E. Austin, M.W. Brookman, H.K.B. Pandya, Vinay Kumar

Characterization of In-house Developed High Temperature Black Body Source in Frequency Range 70-1000GHz
Ravinder Kumar, S. Danani, Shivakant Jha, Sajal Thomas, Dass Sudhir Kumar, Hitesh Pandya, Vinay Kumar

In-Lab Calibration of Michelson Interferometer Diagnostics for Broadband ECE Measurement
Abhishek Sinha, S.K. Pathak, Stefan Schmuck and John Fessey

ECE Measurement Systems at IPR
S. Varsha and S.K. Pathak

A Design Approach to External Mode Conversion with Sensitivity Analysis for 42GHz Gyrotron
K. Sathyanarayana, Nidhi Shah, S.V. Kulkarni and D. Bora

Anode Modulator Power Supply (AMPS) along with a Crowbar Protection System for 82.6 GHz and 42 GHz Gyrotron
N. Rajanbabu, B.K. Shukla, Jatin Patel, Harshida Patel, Dharmesh Purohit, Pragnesh Dhorajiya

Design, Development and Functional Validation of Magnets System in Support of 42 GHz Gyrotron in India
Subrata Pradhan, Sunil Kedia, Upendra Prasad, Piyush Raj, Mahesh Ghate, Yohan Khristi, Arun Panchal, Moni Banudha, Dhaval Bhavsar, B K Shukla and Dhiraj Bora

Overview and Status of ITER-India EC RF Source Package for ITER
S.L. Rao, Vipal Rathod, Anjali Sharma, Ronak Shah, Deepak Mandge, Sharan Dilip, Amit Yadav and Rajiv Parmar

Primary Window Assemblies for Microwave Diagnostics on ITER
V.S. Udintsev, P. Maquet, T. Cornut, J.W. Oosterbeek, A. Sirinelli, N. Casal, B. Conway, J-M Drevon, G. Eaton, T. Giacomin, J. Guirao, S. Hughes, M. Dapena, H.K.B. Pandya, D. Shelukhin, G. Taylor, C. Vacas, G. Vayakis, V. Vershkov, M.J. Walsh

Commissioning of PXI based Data Acquisition and Control System for ECRH
Jatinkumar Patel, H. Patel, P. Dhorajiya, N. Rajanbabu, D. Purohit, B.K. Shukla

Design and analysis of steerable ECRH Launcher for SST-1 Tokamak
Hardik Mistry and B.K. Shukla

ITER-India Gyrotron Test Facility (IINTF): Overview and Status
Vipal Rathod, S.L. Rao, Anjali Sharma, Ronak Shah, Deepak Mandge, Sharan Dilip, Amit Yadav and Rajiv Parmar

Prototype Development of Gyrotron Body Power Supply Using HV Switches for ITER-India Gyrotron Test Facility (IIGTF)
Sharan Dilip, Vipal Rathod, Ronak Shah, Deepak Mandge, Amit Yadav, Anjali Sharma, Rajiv Parmar, Darshan Parmar, NP Singh, S.L. Rao, and Ujjwal Baruah

Overview and Status of Local Control Unit for ITER-India Gyrotron Test Facility (IIGTF)
Ronak Shah, Vipal Rathod, Deepak Mandge, Sharan Dilip, Rajiv Parmar, Amit Yadav, Anjali Sharma and S.L. Rao

Gyrotron Output RF Beam Diagnostics for ITER-India Gyrotron Test Facility (IIGTF)
Anjali Sharma, Vipal Rathod, Ronak Shah, Deepak Mandge, Sharan Dilip, Amit Yadav, Rajiv Parmar and S.L. Rao

Design & Status of EC Main High Voltage Power Supply for ITER & Indian Test program
Darshan Parmar, N P Singh, Thilbault Gassmann, Darbos Caroline, Oda Yasuhisa, Hayashi Kazuo, Aruna Thakae, Amit Patel, Bhavin Raval, Dishang Upadhay, Hitesh Dhola, Rasesh Dave, Sandip Gajjar, Vikrant Gupta, Takahashi Koji, S. L, Rao, Mark Henderson, Ujjwal Baruah

Design of C- Band Slot Coupled Profiled Orthomode Transducer (OMT)
Hetshree Shah and K.K. Sood

Instrumentation and Control System architecture of ECRH SST-1
Harshida Patel, Jatin Patel, Dharmesh P, B. K. Shukla, N. Rajanbabu, H. Mistry

6th Welding Research and Collaboration Colloquium (WRCC), International Institute Welding (IIW), Hyderabad Chapter, Hyderabad, India, 7-9 April 2016

Evaluation of Weld Joints Properties of 60mm Thick AISI 316L for Fusion Reactor Vacuum Vessel by TIG & EB Welding Processes
Ramesh Kumar Buddu

Taguchi ANOVA for Distortion Analysis of Laser Beam Welding Ansys Model
Suresh Akella, Ramesh K Buddu

Welding Development for ITER Cryostat Base Section
Mitul Patel, Vaibhav Joshi, Rajnikant Prajapati, Girish Gupta, Hemal Desai, and Jibin Jose

ITER-Cryostat Base-section and Lower Cylinder mock-up: Learnings and Implementation
Vaibhav Joshi, Mitul Patel, Rajnikant Prajapati, Girish Gupta, Hemal Desai, and Jibin Jose

11th International Conference on Tritium Science & Technology (Tritium 2016), Charleston, USA, 17-22 April 2016

Estimation of Tritium Release from LLCB TBM and its Ancillary Systems and Tritium Management in Different Locations of ITER
Priyanka Brahmbhatt, Amit Sircar, Rudreksh Patel, E. Rajendra Kumar, Sadhana Mohan, Kalyan Bhanja

CPP-IPR Silver Jubilee Symposium, Assam Don Bosco Institute (DBI), Kharghuli, Guwahati, 21-22 April 2016

Work Done Towards Beam Instrumentation for Diagnostics of High Energy Proton Beam at Fermilab, USA
Mukti Ranjan Jana

Langmuir probe measurements in a weakly magnetized dusty plasma
D. Kalita, B. Kakati, S. S. Kausik, B.K. Saikia and M. Bandyopadhyay

Activities in CIMPLE-PSI Laboratory, Applied Plasma Research Section CPP-IPR, Sonapur
M. Kakati

Status of the development of CIMPLE-PSI system
N. Aomoa, Trinayan Sarmah and M. Kakati

Plasma assisted synthesis of tokamak-relevant tungsten fine particles and studies of their hydrogen absorption properties
Trinayan Sarmah, N. Aomoa, M.Kakati and G.De. Temmermen

A supersonic plasma beam assisted reactor configuration for controlled synthesis of high temperature nanomaterials with material properties
N. Aomoa, Trinayan Sarmah, Lavita Sarma, and M Kakati

Investigation of H^- Ion Beam Properties Using Thermal Differential Calorimeter in ROBIN.
Kaushal Pandya, R. Pandey, M.Bandyopadhyay, M.Bhuyan, H.Tyagi, K.Patel, H.Mistri, M.Gauswami, A.Gahlaut, M.Vuppugalla, K.G.Parmar, B.Prajapati, J.Bhagora and A. Chakraborty

A Review on Dust Charging to Fusion Related Research at Dusty Plasma Laboratory, CPP-IPR
S.S. Kausik and B.K. Saikia

Recent experimental studies on IECF device at CPP-IPR
N. Buzarbaruah, D. Borgohain and S.R. Mohanty

7th International Particle Accelerator Conference (IPAC-2016), BEXCO, Busan Korea, 8-13 May 2016

Development of a Neutronics Facility using Radio Frequency Quadrupole for Characterization of Fusion Grade Materials
Renu Bahl, Sumit Kumar, Mridula Mittal, Biswanath Sarkar and Anurag Shyam

11th ITER Neutronics Meeting, Karlsruhe, Germany 23-27 May 2016

Neutronics Analysis and Activation Calculation for X-Ray Crystal Spectrometer of ITER,
P.V. Subhash, Gunjan Indauliya, T. Sai Chaitanya, Priti Kanth, Sanjeev Varshney, Siddharth Kumar, K. Raja Krishna, Nirav Bhaliya, Sejal Kamaliya, S. Jakhar, Robin Barnsley, Bernascolle Phillipe, P. Shrishail, and Vinay Kumar

Summer School Programme, Institute for Plasma Research, Gandhinagar, 31 May 2016

Vacuum Techniques
S. Sunil

22nd International Conference on Plasma Surface Interactions in Controlled Fusion Devices, Urbaniana University, Rome, Italy, 29 May 03 June 2016

On the design, present status and experiments in CPP-IPR Magnetized Plasma Experiment for Plasma Surface Interaction (CIMPLE-PSI)
Mayur Kakati, Ngangom Aomoa, Trinayan Sarmah, J. Ghosh and G. De. Temmerman

13th International Workshop on Hydrogen Isotopes in Fusion Reactor Materials, Milano, Italy, 06-08 June 2016

Tungsten microparticles with highly non-equilibrium morphologies for studies on hydrogen absorption in a fusion environment
Mayur Kakati, Ngangom Aomoa, Trinayan Sarmah, J. Ghosh and G. De. Temmerman

19th World conference on Non Destructive Testing (WCNDT-2016), Munich, Germany, 13-17 June 2016

Ultrasonic Testing of dissimilar metal joints present in Diverter Plasma Facing Components
Kedar Bhope, Mayur Mehta and S.S.Khirwadkar

43rd IEEE International Conference on Plasma Science (ICOPS-2016), Banff, Alberta, Canada, 19-23 June 2016

One dimensional particle-in-cell simulation of relativistic Buneman instability
Roopendra Singh Rajawat

27th Symposium on Plasma Physics and Technology (SPPT-2016), Czech Technical University in Prague, Czech Republic, 20-23 June 2016

Study of Arc Plasma Dynamic Behaviour using Combination

of Fast Imaging and Magnetic Diagnostics
Vidhi Goyal, G. Ravi, P. Bandyopadhyay and S. Banerjee

30th Meeting of the ITPA Topical Group on Diagnostics, Budker Institute of Nuclear Physics, Novosibirsk, Russia, 21-24 June 2016

Report of Passive Spectroscopy Specialist Working Group
Sanjeev Varshney, Changrae Seon, Robin Barnsley

Progress on ITER XRCS- Survey and Edge spectrometer systems
Sanjeev Varshney, Siddharth Kumar, Sapna Mishra, Namita Yadav, P. V. Subhash, Mitul Abhangi, Shivakant Jha, Vinay Kumar, Robin Barnsley, Philippe Bernascolle, Natalia Casal, Julio Guirao, Stefan Simrock, Prabhakant Patil, Vincent Martin, Jean-Marc Drevon, Richard O' Connor, and Michael Walsh

IN-DA Progress on Upper Port #09
Siddharth Kumar, Sanjeev Varshney, Shrishail Padasalagi Shrichand Jakhar, Mitul Abhangi, Shivakant Jha, Vinay Kumar, O'Connor Richard , Giocomin Thibaud, Victor Udintsev

"IN-DA progress on ITER ECE diagnostic system (TL & receiver)"
Hitesh Pandya, Suman Danani, Ravinder Kumar, Shrishail P., Sajal, Shivakant Jha, Vinay Kumar, Victor Udintsev, Natalia Casal

16th ITPA Topical Group Meeting on Energetic Particles & Workshop on Lost Alpha Diagnostics for ITER, ITER-IO, St Paul-lez-Durance, France, 27-30 June 2016

A possible detection method for ITER Lost Alpha Diagnostics: Infrared Imaging Video Bolometer
Santosh P. Pandya, Shwetang N. Pandya, Martin Kocan, M. Garcia-munoz and Evgeny Veshchev

18th International Congress on Plasma Physics (ICPP-2016), Kaohsiung, Taiwan, 27 June- 1 July 2016

Nonlinear mode-coupling via resonant particles in small amplitude "linear" regime in collisionless plasmas
Debraj Mandal

Experimental observation of Sheath-presheath Instabilities
Vara Prasad Kella, Joydeep Ghosh, Y.C. Saxena, Devendra Sarma and P.K. Chattopadhyay

Numerical modeling of laser-blow-off plume: lateral interactions of two plumes in presence of background pressure
Sharad K. Yadav, Bhavesh G. Patel, R. K. Singh, Amita Das, Predhiman K. Kaw, and Ajai Kumar

Disruption Characterization in ADITYA Tokamak
R.L. Tanna, Shishir Purohit, M. B. Chowdhuri, J. Ghosh, V.K. Panchal, P.K. Chattopadhyay, Harshita Raj, D. Raju, P.K. Atrey, Y.S. Joisa, C.V.S. Rao, R. Jha and the ADITYA team

Disruption Mitigation Experiments in ADITYA Tokamak
J. Ghosh, R.L. Tanna, Harshita Raj, P.K. Chattopadhyay, P. Dhyani, S.B. Bhatt, K.A. Jadeja, K.M. Patel, C.N. Gupta, M.N. Makwana, K. S. Shah, Chhaya Chavda, V.K. Panchal, N.C. Patel, Shishir Purohit, Y.S. Joisa, C.V.S. Rao, D. Raju, S.V. Kulkarni, B.K. Shukla, Praveenlal E.V., J. Raval, A. Amardas, P.K. Atrey, Umesh Nagora, R. Manchanda, N. Ramaiya, Nilesh, M.B. Chowdhuri, S.K. Jha, R. Jha, A. Sen, Y.C. Saxena, D. Bora

43rd European Physical Society Conference on Plasma Physics (EPS-2016), Leuven, Belgium, 4-8 July 2016

The ion resonance instability in a partially neutralized electron cloud that is also colliding elastically with an inert gaeseous background: PIC-MCC simulations
Meghraj Sengupta and Rajaraman Ganesh

IEEE International Power Modulator and High Voltage Conference, San-Francisco, USA, 5-9 July 2016

Development of 3 MW Dual Output High Voltage Power Supply for ICRH System
A. Patel, H. Dhola, D. Upadhyay, B. Raval, K. Mehta. N. Goswami, N. P. Singh, A. Thakar, D. Parmar, S. Gajjar, R. Dave, V. Gupta, U.K. Baruah, S. Athaullah, Y. Dileep, A. Rajakiran, D.H. Rathod, N. Appa Rao, K. Mahadev

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IPR Library Resources
Saroj Das

IEA Workshop on Disruptions, Princeton Plasma Physics Laboratory (PPPL), USA 20-22 July 2016

TSC Modeling of Disruptions and VDEs in DIII-D and CMOD
Indranil Bandyopadhyay

5th PSSI-Plasma Scholars Colloquium (PSC), Ravenshaw University, Cuttack, 27-28 August 2016

Measurement of Magnetic Fluctuation in LVPD: A Comparison of Results using Numerical and Inline Integrator Techniques
Prabhakar Srivastav, L. M. Awasthi, A. K. Sanyasi, P. K. Srivastava, and R. Sugandhi

Emission of fusion neutron from an inertial electrostatic confinement fusion device
N. Buzarbaruah, D. Borgahain and S.R. Mohanty

29th Symposium on Fusion Technology (SOFT-2016), Prague, Czech Republic, 5-9 September 2016

Initial Operation of 3MW Dual Output High Voltage Power supply with IC RF System
A. Patel, H. Dhola, D. Upadhyay, K. Mehta, N. Goswami, B. Raval, N. P. Singh, A. Thakar, D. Parmar, S. Gajjar, R. Dave , V. Gupta, S. Varma, K. Rajnish , R. Singh , R. G. Trivedi, D. Soni, A. Mukherjee, U. K. Baruah

Comparative Study between Code and Analytical Stress Intensification Factor in ITER Cooling System Piping
Aditya Singh, M. Jadhav, K. S. Bhatt, L. K. Sharma, D. K. Gupta, A. G. Ajith Kumar

Detailed Design of ITER CCWS, CHWS and HRS: Challenges Experienced and Their Solutions
Ajith Kumar, Dinesh Gupta, Nirav Patel, Mahesh Jadhav, Hiren Patel, Jinendra Dangi, Gumansinh Gohil, Lalit Sharma, Aditya Singh, Rakesh Ranjan, Mohit Kumar, Liliana Teodoros, Ployhar Steve, Dell'orco Giovanni

Recent Results on ECR Assisted Plasma Start-Up, Current Drive and Discharge Cleaning in SST-1
Braj Shukla

The West Plasma Facing Components Protection
Jean-Marcel Travere, Sutapa Ranjan, Philippe Moreau, Colette Balorin, Jerome Bucalossi, Vishnu Chaudhari, Yann Corre, Mehdi Firdaouss, Jonathan Gaspar, Hemant Joshi, Michel Jouve, Victor Moncada, Eric Nardon, Remy Nouailletas, Tran-Thanh Ngo, Nathalie Ravenel, Benjamin Santraine, West Team

Measurements and Controls Implementation for the West Project
Philippe Moreau, Jerome Bucalossi, Xavier Courtois, Christophe Gil, Philippe Lotte, Eric Nardon, Remy Nouailletas, Nathalie Ravenel, Jean-Marcel Travere, Olivier Meyer, Marc Missirlian, Frank Samaille, Jacqueline Signoret, Sylvain Bremond, Raju Daniel, Manisha Bhandarkar, Chhaya Chavda, Ritesh Sugandhi, Vishnu Chaudhari, Jigneshkumar Soni, Jasraj Dhongde, Sunil Belsare, Aveg Kumar, Praveena Kumari , Imran Mansuri, Harish Masand, Kirit Patel, Sutapa Ranjan, Manika Sharma, Hemant Joshi, Miteshkumar Patel, Christopher Rapson, Gerhard Raupp, Wolfgang Treuterrer, Annette Spring, Andreas Werner, Marc Lewerentz, West Team, Heique Laqua

Design and Implementation of Electromagnetic Diagnostic Electronics in SST-1 Tokamak
Praveenlal Edappala, Chandresh Hansalia, Rachana Rajpal, Hitesh Mandaliya, Vismay Raulji, Sameer Kumar, Raju Daniel

Conceptual Design Study of Toroidal Field Magnet System of SST-2 Fusion Reactor
Aashoo Sharma, S. Dutta, P. Dutta, R. Srinivasan, S. Pradhan, U. Prasad, V. Menon, C. Danani

Conceptual Study on Selection of Quench Detection System for CS Magnet of SST-1
Yohan Khristi, Subrata Pradhan, Moni Banaudha

Ultrasonic Testing of Different Shapes of Support Rib and Lower Bracket Assembly Weld Joints
Yatinkumar Sarvaiya, Haresh Pathak, Rahul Laad, C. H. Choi, Jigar Raval

Development of Prototype Elements for Beamline Components for ITER DNB and Indian Test Facility
Hitesh Kumar K. Patel, Chandramouli Rotti, Nirmal Panda, Nitin Kanoongo, K. Balasubramaniam, Arun Chakraborty

Manufacturing Technology Development for an 'Angled' Accelerator Grid Segment for Diagnostic Neutral Beam (DNB) Source
Jaydeepkumar Joshi, Arunkumar Chakraborty, Chandramouli Rotti, Mainak Bandyopadhyay, Christian Eckardt, Eberhard Pfaff, Jorg Schafer, Aron Metz, Dusan Stupar, Wischet Yannic

Helium Cooling Systems for Indian LLCB TBM
Brijesh Kumar Yadav

Rotating Tritium Target for Intense 14-MeV Neutron Source
Sudhirsinh Vala, Dhaval Rajyaguru, Mitul Abhangi, Ratnesh Kumar, Anurag Shyam, Biswanath Sarkar

SST-1 Up-Gradation Update & Recent Experiments in SST-1
Subrata Pradhan, Ziauddin Khan, Vipul L. Tanna, Dilip Raval, Upendra Prasad, Harish Masand, Aveg Kumar, Kiritkumar B. Patel, Manisha K. Bhandarkar, Jasraj R. Dhongde, Braj Kishor Shukla, Imran A. Mansuri, Yohan S. Khristi, Yuvakiran Paravastu , Chet Narayan Gupta, Dinesh Kumar Sharma, Kalpeshkumar R. Dhanani, Pratibha Semwal, Siju George, Subrata Jana, Pradip N. Panchal, Rohitkumar N. Panchal, Rakeshkumar J Patel, Hitesh Kumar Gulati, Kirti Mahajan, Mohammad Shoaib Khan, Prashant L. Thankey, Firozkhan S. Pathan, Azadsinh R. Makwana, Gaurang I. Mahsuriya, Pradeep K. Chauhan, A. Arun Prakash, Murtuza M. Vora, Akhilesh Singh, Dashrath P. Sonara, Pankaj Varmora, G. Srikanth, Dikens R. Christian, Atul Garg, Arun G. Panchal, Nitin Bairagi, Manika Sharma, Gattu R. Babu, Prosenjit Santra, Tejas J. Parekh, Hitesh S. Patel, Prabal Biswas, Snehal P. Jayaswal, Tusharkumar Y. Raval, Hitesh H. Chudasma, Atish L Sharma, Amit Ojha, Bhadresh R. Praghi, Moni Banaudha, Ketan G. Patel, Hiren D. Nimavat, Pankil R. Shah, J. C. Patel, Rajiv Sharma, A. Varadharajulu, Ranjana Manchanda, P. K. Atrey, S. K. Pathak, Y. Sankar Joisa, Kumudni Asudani, Manoj Kumar, Debashis Ghosh, Bhumi Chaudhari, Amita Das, D. Bora, SST-1 Team

Demonstration of Synchronous Control of EC TL Switch and Gyrotron for ITER EC System
Yasuhisa Oda, Katsumi Ohshima, Kazuo Hayashi, Ryosuka Ikeda, Koji Takahashi, Keishi Sakamoto, Franco Gandini, Dharmesh Purohit, Izuru Yonekawa, Caroline Darbos, Mark Henderson

Integration of Epics Based Monitoring for ION Cyclotron high Voltage Power Supply
Hiteshkumar Dhola, Darshit Pandya, Rasesh Dave, Aruna Thakar, Amitkumar Patel, Narindarpal Singh, Ujjwal Baruah

Data Acquisition System for LN_2 Cool Down Experiment for 6 Nos. of Cryogenics Pumps
Karishma Qureshi, Paresh J. Patel, Chodimella Chakrapani, Sanjay L. Parmar, Laxmikant K. Bansal, Bhargav Pandya, Dipal Thakkar, C. B. Sumod, Laxminarayan Gupta, Vijay Vadher, Bhargav Choksi, Nilesh Contractor, Sanjeev Sharma, B. V. V. S. N. N. P. Sridhar, Siddibomma Rambabu, Punjapyu Bharathi, Mukti Ranjan Jana, Vattipelle Prahlad, Ujjwal Kumar Baruah

ADITYA Upgrade Vacuum Vessel: Design, Construction, Testing, Installation and Operation
Kumarpalsinh Jadeja, Shailesh Bhatt, Joydeep Ghosh, Kaushal Patel, Kulav Rathod, Vishnu Prajapati, Rakesh Tanna, Yogesh Saxena, Dhiraj Bora

Development and Characterization of Thick Copper Coating by Laser Cladding for in Vessel Components
Ramesh Buddu, Shamsuddin Shaikh, P. M. Raole, N.Chauhan, Harshad Natu, Harpreet Singh

Fault Energy Dump & Repeated Breakdown Validations of HVPS Commissioned for Negative ION Source-Robin
Mahesh Vuppugalla, Agrajit Gahlaut, Arun Chakraborty, Ratnakar Yadav, Kanubhai Parmar, Bhavesh Prajapati, Gourab Bansal, Jignesh Soni, Mainak Bandyopadhyay, Kaushal Pandya, Varunesh Kumar

Progress in Development of Pellet Injector Technology in India
Ranjana Gangradey, Jyoti Shankar Mishra, Samiran Mukherjee, Paresh Panchal, Pratik Nayak, Jyoti Agarwal

Design of Highpower RF Amplifier for 3MW/CW transmission Line Test Rig
Raghuraj Singh, Aparajita Mukherjee, Ajesh P., Akhil Jha, J. V. S. Hari, R. G. Trivedi, Rajnish Kumar, Gajendra Suthar, Rohit Anand

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Manojkumar Patel, Akhil Jha, Harikrishna J. V. S, Rajnish Kumar, Rajesh Trivedi, Aparajita Mukherjee

Development of Cryoadsorption Cryopump & its Related Auxiliary Technologies in India
Ranjana Gangradey, Samiran Mukherjee, Jyoti Agrawal, Jyotishankar Mishra, Paresh Panchal, Pratik Nayak, S. Kasthurirengan, S. Udgata, V. S. Tripathi

Implementation of Synchronous Reference Frame Theory based Shunt Active Power Filter using DSP Controller
Chandra Kishor Gupta

Design and Development of High Pressure High Temperature Water Circulation System for HHFTF
Rajamannar Swamy Kidambi, Samir Khirwadkar, Sunil Belsare, Sudhir Tripathi, Tushar Patel

Progress Development of Medium Size Dome & Refector Plate for ITER like Tokamak Application
Premjit K. Singh, S. Khirwadkar, Deepu Krishnan, Kedar Bhope, Vinay Menon, Sunil Belsare, Nikunj Patel, Prakash Mokaria, Mayur Mehta

Development of a Prototype Work-Cell for Validation of ITER Remote Handling Control System Standards
Naveen Rastogi, Vamshi Krishna, Pramit Dutta, Manoah Stephen, Krishan Gotewal, Hamilton Kumar, David, J. K. Mukherjee

Design Status of Remote Handling Compatibility of ITER DNB Components
Roopesh Gangadharan Nair

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In-Situ RBS study of the sticking behaviour of silver atoms on low energy ion produced ripple patterned SiO_2 substrate
Mukesh Ranjan

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Effect of Driving frequency on the electron-sheath interaction and energy distribution function in low pressure capacitively coupled plasmas
Sarveshwar Sharma, Nishant Sirse, Predhiman Kaw, Miles Turner, Albert R. Ellingboe

Effect of weak static magnetic field on electron and ion dynamics in low pressure capacitive discharges
Sarveshwar Sharma, Igor Kaganovich, Predhiman Kaw, Sanjay Mishra, Alexander Khrabrov, Dmytro Sydorenko

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Overview of SST-1 Upgrade & Recent Experiments in SST-1
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Overview of Recent Experimental Results from ADITYA Tokamak
R. Tanna, J. Ghosh, P. K. Chattopadhyay, H. Raj, S. Patel, C. Gupta, P. Dhyani, K. A. Jadeja, K. M. Patel, S. B. Bhatt, V. K. Panchal, N. C. Patel, C. Chavda, E. V. Praveenlal, K. S. Shah, M. N. Makwana, S. K. Jha, M. V. Gopalakrishna, K. Tahiliani, D. Sangwan, D. Raju, U. C. Nagora, S. K. Pathak, P. K. Atrey, S. Purohit, Y. S. Joisa, J. V. Raval, C. V. S. Rao, M. B. Chowdhuri, S. Banerjee, J. Thomas, N. K. Ramaiya, R. Manchanda, A. Kumar, P. K. Sharma, S. V. Kulkarni, K. Sathyanarayana, B. K. Shukla, A. Das, R. Jha, Y. C. Saxena, A. Sen, P. K. Kaw, and D. Bora

Energy Exchange Dynamics across L-H Transitions in NSTX
A. Diallo, S. Banerjee, S. Zweben, and T. Stoltzfus-Dueck

Observation of Large Filaments during the Disruptive Phase of ADITYA Tokamak Plasma
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Plasma Startup Studies and Electromagnetic Field Computation for SST-1 Tokamak
S. Jana, D. Ghosh, S. Pradhan, and D. C. Raval

MHD Phenomena and Disruption Characteristics in SST-1 Early Plasma
J. R. Dhongde, M. K. Bhandarkar, and S. Pradhan

Observation and Study of Lock Mode Characteristics in SST-1Plasma
M. K. Bhandarkar, J. R. Dhongde, and S. Pradhan

Low Density Plasma Regimes in SST-1 with and without Suprathermal Electrons
K. Patel, and S. Pradhan

Plasma Facing Components Technologies in SST-1
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Experimental Observations and Modelling of Poloidal Asymmetries in Radiation Profiles during N_2 Seeding Compared with Ne Seeding in LHD
B. Peterson, G. Kawamura, K. Mukai, S. Dai, S. Masuzaki, T. Akiyama, M. Kobayashi, H. Tanaka, S. N. Pandya, R. Sano, M. Goto, G. Motojima, R. Sakamoto, N. Ohno4, T. Morisaki, and J. Miyazawa

Role of Neutral Gas in Scrape-Off Layer of Tokamak Plasmas
N. K. Bisai, and P. K. Kaw

Excitation of Zonal Flows and their Impact on Dynamics of Edge Pedestal Collapse
H. Jhang, H. H. Kaang, S. S. Kim, T. S. Hahm, R. Singh, and T. Rhee

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I. Bandyopadhyay, A. K. Singh, N. W. Eidietis, D. A. Humphreys, R. S. Granetz, G. Pautasso, A. Isayama, and S. C. Jardin

Nonlinear Simulation of ELM Dynamics in the Presence of RMPs and Pellet Injection
D. Chandra, A. Thyagaraja, A. Sen, and P. K. Kaw

Progress in the ITER Integrated Modelling Programme and the use and Validation of IMAS within the ITER Members
S. D. Pinches, R. Akers, R. Andre, T. Aniel, I. Bandyopadhyay, V. Basiuk, E. A. Belli, X. Bonnin, J. Candy, A. K. Chattopadhyay, W. Dekeyser, L. T. H. van Dellen, B. Faugeras, A. Fukuyama, M. Gorelenkova, M. Hosokawa, P. Huynh, S. Ide, F. Imbeaux, H. Jhang, I. Johnson, T. Johnson, L. Jung, R. R. Khayrutdinov, S. H. Kim, S. Konovalov, L. Kos, L. L. Lao, Y. Liu, L. LoDestro, V. E. Lukash, I. Lupelli, S. Medvedev, O. Menghini, W. H. Meyer, D. Muir, O. Naito, E. Nardon, F. Poli, A. Polevoi, O. Sauter, M. B. Schneider, A. K. Singh, P. B. Snyder, G. M. Staebler, P. Strand, M. Suzuki, S. Wiesen, and D. Zhao

Effect of Magnetic Shear and Equilibrium Flows on Collisionless Microtearing and Mixed Parity Modes in Hot Tokamak Plasmas
D. Verma, A. K. Swamy, R. Ganesh, S. Brunner, and L. Villard

Residual Stress and Momentum Transport in Electromagnetic ITG Turbulence
H. H. Kaang, S. S. Kim, H. Jhang, R. Singh, and J. Kim

Investigation of Neutral Particle Dynamics in ADITYA Tokamak Plasma with DEGAS2 Code
R. Dey, J. Ghosh, M. B. Chowdhuri, P. N. Maya, R. Manchanda, S. Banerjee, N. K. Ramaiya, and D. P. Stotler

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Progresses on WEST Platform Construction towards First Plasmas
J. Bucalossi, M. Missirlian, P. Moreau, F. Samaille, E. Tsitrone, T. Alarcon, S. Antusch, M.-H. Aumeunier, S. Balme, T. Batal, J. M. Bernard, F. Bouquey, C. Bourdelle, S. Bremond, S. Brezinsek, C. Brun, H. Bufferand, Y. Camenen, B. Cantone, M. Chantant, M. Chernyshova, G. Ciraolo, G. Colledani, J. Colnel, E. Corbel, Y. Corre, X. Courtois, R. Daniel, T. Daudel, R. Dejarnac, E. Delmas, L. Delpech, C. Desgranges, L. Doceul, D. Douai, H. Dougnac, A. Ekedahl, D. Elbeze, A. Escarguel, F. Escourbiac, K. Ezato, F. Faïsse, C. Fenzi, F. Ferlay, M. Firdaouss, J. L. Gardarein, L. Gargiulo, J. Gaspar, P. Gavila, S. Gazzotti, J. C. Giacalone, C. Gil, E. Grigore, D. Guilhem, J. P. Gunn, A. Hakola, J. C. Hatchressian,W. Helou, P. Hennequin, C. Hernandez, M. Houry, M. Jouve, C. Klepper, G. Laffont, P. Languille, S. Larroque, Q. Li, J. Linke, M. Lipa, P. Lotte, G.-N. Luo, Y. Marandet, C. Martin, A. Martinez, D. Mazon, O. Meyer, P. Mollard, E. Nardon, R. Nouailletas, H. K. Park, J. Y. Pascal, B. Pégourié, R. A. Pitts, C. Pocheau, S. Poli, N. Ravenel,

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Development of Sensors for High-Temperature High-Pressure Liquid Pb/Pb-16Li Applications
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Electro-Mechanical Design and Experimental Validation of Post Insulators for Beam Source for ITER Diagnostic Neutral Beam
V. N. Muvvala, J. Joshi, S. Shah, D. Parmar, C. Rotti, M. Bandyopadhyay, and A. K. Chakraborty

Concept Design of the Heavy Duty Multipurpose Deployer for ITER
K. K. Gotewal, N. Rastogi, S. M. Manoah, P. Dutta, and C.-H. Choi

The ITER Neutral Beam Test Facility toward SPIDER Operation
V. Toigo, D. Boilson, T. Bonicelli, A. K. Chakraborty, and U. Fantz

Manufacturing and Commissioning of Large Size UHV Class Vacuum Vessel for Indian Test Facility (INTF) for Neutral Beams
J. Joshi, A. Yadav, K. Joshi, D. Singh, H. Patel, S. Ulahannan, V. Abbavaram, G. Hebbar, M. Alaparthi, M. Khan, C. Rotti, M. Bandyopadhyay, and A. K. Chakraborty

Upgrade of ADITYA Tokamak with Limiter Configuration to ADITYA Upgrade Tokamak with Divertor Configuration
J. Ghosh, R. Tanna, S. B. Bhatt, P. K. Chattopadhyay, K. Sathyanarayana, C. Chavda, C. Gupta, K. A. Jadeja, K. Patel, V. K. Panchal, V. Patel, K. Rathod, S. Patel, S. Jaiswal, P. K. Chauhan, V. Ranjan, R. Kumar, H. Raj, K. Kumari, D. Sadharakiya, M. Kalal, D. Varia, R. N. Panchal, K. Acharya, N. Patel, K. Chaudhary, M. N. Makwana, K. S. Shah, D. Raju, R. Srinivasan, D. K. Sharma, S. Dutta, B. Doshi, M. Gupta, U. Baruah, A. Varadharajulu, A. Das, Y. Saxena, D. Bora, R. Pal, S. Saha, A. Apte, and D. Patel

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V. Menon, R. Daniel, R. Srinivasan, U. Prasad, C. Danani, A. L. Sharma, J. Agarwal, P. Dutta, N. Rastogi, R. Srivastava, S. Dutta, M. Himabindu, D. K. Sharma, K. K. Gotewal, A. K. Chakraborty, S. Khirwadkar, R. Kumar, S. Pradhan, S. P. Deshpande, and P. K. Kaw

Progress towards Achieving Large Pumping Speed for Exhaust from Fusion Grade Machines
R. Gangradey, S. Mukherjee, J. Agarwal, J. Mishra, P. N. Panchal, P. Nayak, S. Kasthurirengan, S. Udgata, and V. S Tripathi

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C. Danani, K. Chandrasekhar, B. J. Saikia, A. L. Sharma, D. K. Sharma, M. Himabindu, J. Agrawal, K. K. Gotewal, S. M. Manoah, N. Rastogi, P. Dutta, S. Dutta, U. Prasad, V. Menon, A. K. Chakraborty, S. Khirwadkar, R. Ellappan, S. Pradhan, S. P. Deshpande, and P. K. Kaw

Overview of Indian LLCB TBM Programme and Status of R&D Activities
R. Bhattacharyay, A. Saraswat

Techno-Economic Aspects of High Current Leads for Fusion Devices
V. L. Tanna, S. Pradhan

India's Pellet Fueling Programme
J. Mishra, S. Mukherjee, R. Gangradey, J. Agarwal, P. N. Panchal, and P. Nayak

Design of Charge Exchange Recombination Spectroscopy (CXRS) on SST-1 Tokamak
M. B. Chowdhuri, G. Shukla, K. S. Shah, J. Ghosh, K. H. Burrell, B. A. Grierson, V. Prahlad, S. Sharma, P. Bharthi, R. Manchanda, S. Banerjee, and N. K. Ramaiya

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S. M. Manoah, P. Dutta, N. Rastogi, K. K. Gotewal, R. Srinivasan, C. Danani, V. Menon, A. L. Sharma, U. Prasad, M. Himabindu, D. K. Sharma, J. Agarwal, S. Dutta, R. Gangradey, R. Ellappan, S. Khirwadkar, A. K. Chakraborty, S. Pradhan, D. Shishir, and P. K. Kaw

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Sayak Bose, PK Chattopadhyay, J Ghosh, YC Saxena

Flow past an obstacle immersed in a Yukawa liquid: An atomistic study
Harish Charan and Rajaraman Ganesh

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Report of Passive spectroscopy Specialist Working Group
Sanjeev Varshney, Changrae Seon, Robin Barnsley

Progress on ITER XRCS-Survey and XRCS-Edge Spectrometer Systems
Sanjeev Varshney, Siddharth Kumar, Sapna Mishra, Shivakant Jha, Chirag Khairnar, Ravi Patel, Dharmesh Bhatia, Sejal Kamaliya, P. V. Subhash, Mitul Abhangi, Vinay Kumar, Robin Barnsley, Philippe Bernascolle, Julio Guirao, Vincent Martin, Stefan Simrock, Jean-Marc Drevon, Richard O' Connor, Michael Walsh

IN-DA Progress on Upper Port #09
Siddharth Kumar, Sanjeev Varshney, Shrishail Padasalagi Shrichand Jakhar, Mitul A, Shivakant Jha, Vinay Kumar, O'Connor Richard, Julio Guirao, Victor Udintsev

IN-DA progress on ITER ECE diagnostic system (TL & receiver)
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Charging of Dust Grains in Low-Pressure Filament Discharge Plasma
S.S. Kausik, B. Kakati, D. Kalita, B.K. Saikia and M. Bandyopadhyay

Shielding analyses for a portable neutron source
D. Borgohain, N. Buzarbaruah and S.R. Mohanty

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An Accurate Electrical Model for Atmospheric Pressure DBD Plasma in Air with Experimental Validation
Vishal Jain, R. Srinivasan, V. Agarwal

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Unstable Shear Flows in Two-Dimensional Strongly Correlated Liquids - A Hydrodynamic and Molecular Dynamics Study
Akanksha Gupta, Rajaraman Ganesh and Ashwin Joy

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Experience with Cryogenics Safety, Problems and Solutions
Rajiv Sharma, V.L. Tanna

Advanced Fire Prevention Techniques for ITER-INDIA Laboratory Building, IPR
D.V. Modi, D. Chenna Reddy

High Voltage Discharge Switch for operational safety of Neutral Beam High Voltage Power Supply System
L.N. Gupta, Paresh Patel, C.B. Sumod, Dipal Thakkar, N.P Singh, Ujjwal Baruah

Safety Legislation and Regulations for Electron Beam Welding
Gautam R. Vadolia, K. P. Singh, Devendra Modi

Safety Management and Safe Handling of Materials in Lithium Ceramic Development Process
Mayank Makwana, P. Patel, M. Panchal, B. Riscob, A. Srivastava, P. Chaudhuri

Safety and Shielding Management for Pulse Power Lab at IPR.
Shweta Upadhyay, Akash Faldu, Rahul Koshti, and Rajesh Kumar

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Design and Simulation of Feedback System to Generate Plasma Arc in Current Source Mode.
Vishal Jain, S K Nema, V. Agarwal

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Sputtering yield shape profile under stationary plasma thruster conditions
Mukesh Ranjan

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Plasma jet using atmospheric pressure dielectric barrier discharge
C. Patil, R. Rane, A. Vaid, A. Sanghariyat, S. Mukherjee

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Helium Flow Dynamics and Heat Transfer in a Cable in Conduit Conductor of Superconducting Magnets: A review
Hitensinh Vaghela, Vikas Lakhera, Biswanath Sarkar

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Repairing and welding experience of LN_2 cryogenic transfer line of 80 K distribution system of SST-1
Rajiv Sharma, V. L. Tanna, Hiren Nimawat, Gaurav Purwar

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Integration of Python based MDSPLUS Interface for ICRH DAC Software
Ramesh Joshi, Swanand Kulkarni & S.V. Kulkarni

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Estimation of Cesium fraction in ROBIN Ion Source using Spectral Analysis of Line Emissions and the Correlation with the Extracted Current Density.
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Studies of Aditya tokamak plasma using visible spectroscopic diagnostics
M. B Chowdhuri, J. Ghosh, R. Dey, R. Manchnada, N. Yadava, S. Banerjee, N. Nimavat and Aditya Team

Role of atomic and molecular processes in Hα emission of Aditya tokamak
Ritu Dey, Joydeep Ghosh, M. B. Chowdhuri, R Manchanda, S. Banerjee, N. Nimavat, N. Yadava and ADITYA Team

Semi-implicit method for solving the radial impurity transport equation and comparison with impurity transport code STRAHL
Amrita Bhattacharya, Joydeep Ghosh, M. B. Chowdhuri, Prabhat Munshi

Simulation of Hydrogen-alpha (Hα) spectral line shape emitting from the edge region of Aditya Tokamak
Nandini Yadava, Joydeep Ghosh, M. B. Chowdhuri, R. Manchanda, S. Banerjee, Ritu Dey, N. Nimavat and D. Tripathi

Simulation of Spectral Distribution of radiation emission in Aditya tokamak and its comparison with experimental measurements
Kumudni Tahiliani, M. B. Chowdhuri, R. Jha, M.V. Gopalakrishna, Sameer Kumar, D. Raju, U. C. Nagora, P.K. Atrey, J. Raval, Y. Shankar Joisa, R.L. Tanna, J. Ghosh, Ajai Kumar and Aditya Team

Spectroscopic measurements of gas temperature in the neutralizers of DIII-D neutral beam injectors
S. K. Sharma, B. Choksi, B. Crowley, J. Rauch and J. T. Scoville

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Influence of Capping Agent on the Magnetic Properties of Copper Ferrite Nanoparticles
Anurag Kashyap, Seikh Mustafa Radiul, Lavita Sarma, Mayur Kakati, A. Srinivasan and Sidananda Sarma

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Studies of magnetic properties of Iron oxide nanoparticles prepared by Green chemical method and supersonic nozzle

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Lavita Sarma, Trinayan Sarmah, N.Aomoa, Sidananda Sarma, Mayur Kakati

Tokamak relevant tungsten dust particles synthesized by plasma assisted method and studies of their hydrogen absorption properties
Trinayan Sarmah, N. Aomoa, Sanjiv Kuumar and M. Kakati

Studies on controlled synthesis of superparamagnetic carbon encapsulated magnetic nanoparticles (CEMN) by plasma expansion technique
N. Aomoa, Lavita Sarma, Trinayan Sarmah, Sidananda Sarma and M. Kakati,

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Effect of heat treatment on the magnetic properties of copper ferrite nanoparticles
Lavita Sarma, M. Kakati, K. K. Singh, A. Srinivasan and Sidananda Sarma

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Preparation, Characterization and Oxidation Behaviour of Silicon Oxide Based Inter-face Layer Coating on Carbon Fiber for C_f/SiC Composites
C. Jariwala, Kundan Kumar and R. Pillai

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Study of chemical, structural and morphological properties of tungsten nanopowder produced in a DC thermal plasma reactor from an oxide feedstock
Trinayan Sarmah, N. Aomoa, Sidananda Sarma, D.N. Srivastava, U. Deshpande and M. Kakati

Magnetized Plasma Experiment for Plasma Material Interaction (CIMPLE- PMI) device, its development and experiments
N. Aomoa, Trinayan Sarmah, J Ghosh and M. Kakati

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Scientific software tool for calculation of static heat-in-leak and materials specific heat for cryogenic applications
D. Sonara, V. L. Tanna and S. Pradhan

Instrumentation and Control aspects of MgB_2 Current Leads Test activities
Rohit Panchal, Rakesh Patel, Gaurang Mahesuria, Dashrath Sonara, Pradip Panchal, Dikens Christian, Hiren Nimavat, G. K. Singh, Jal Patel, Vipul L Tanna, Subrata Pradhan

Helium inventory management, quality control and helium losses during SST-1 cryo plant operations
N. Bairagi, J.C. Patel, P. Panchal, R. Panchal, D. Sonara, R. Patel, L.N. Srikanth G, A. Garg, G. Mahesuriya, D. Christian, R. Sharma, H. Nimavat, K. Patel, P. Shah, G. Purwar and V.L. Tanna

Overhauling of Compressor for 1.3 kW/4.5 K capacity Helium Refrigeration / Liquefaction (HRL) Plant at IPR
J. C. Patel, P. R. Shah, K. Patel, Srikanth GLN, R. Panchal, D. Sonara, D. Christian, R. Patel, G. Mahesuriya, P. N. Panchal, N. Bairagi, H. Nimavat, R. Sharma, A. Garg and V. L. Tanna

Design and fabrication of Vacuum Jacketed Transfer Line for Helium Services
Pankil Shah, G.L.N. Srikanth, Ketan Patel, Hiren Nimavat, Jal Patel, Vipul Tanna and Subrata Pradhan

Thermal Performance Enhancement of Liquid Nitrogen Distribution System of SST-1
Rajiv Sharma, Atul Garg, Hiren Nimavat, Gaurav Purwar and V. L. Tanna

National Conference on Renewable Energy Technology Utilization for Rural Development & Trade Show, North Eastern Hill University, Shillong, India, 27 February -1 March 2017

Current status of surface assisted volume negative hydrogen ion source at CPP-IPR and its prospect in fusion experiment
S.S. Kausik, B. Kakati, B.K. Saikia, M. Bandyopadhyay, D. Kalita and A.G. Gahlaut

Joint ICTP-IAEA School on Atomic Processes in Plasmas, ICTP, Trieste, Italy, 27 February - 3 March 2017
Electron temperature measurement using Line intensity ratio

method and Langmuir probe in Argon plasma
Vara Prasad Kella and Joydeep Ghosh

International Symposium on Nonlinear Waves in Fluids and Plasmas (BUTIFEST 2017), IIT Delhi, 1-2 March 2017

A novel approach to produce H^- ions to improve the production and extraction efficiency of high current H^- ion source
B. Kakati, S.S. Kausik, M. Bandyopadhyay, B.K. Saikia and P. K. Kaw

9th ITER International School (IIS-2017), Aix en Provence, France, 20-24 March 2017

Observations of MHD modes prior to Disruption in ADITYA-Upgrade Tokamak
Harshita Raj, J. Ghosh, R. L. Tanna

A two days symposium on two decades of Ion beam analysis at 3 MV tandetron, NCCCM, National Centre for Compositional Characterization of Materials, BARC, Hyderabad, 23-24 March 2017

Fusion relevant tungsten dust particles produced by plasma assisted method and studies of their hydrogen absorption properties by NRA technique
T. Sarmah, N. Aomoa, Sanjiv Kumar and M. Kakati

UGC-SAP (DRS III) Sponsored National Seminar on Recent Advances in Material Science and their applications, BN College, Dhubri, Assam, 24-25 March 2017

Tungsten Dust Containing Hydrogen Plasma and its importance of study
D. Kalita, B.K. Saikia, B. Kakati and S. S. Kausik

An ion source based on Inertial Electrostatic Confinement Fusion for material studies
N. Buzarbaruah, D. Borgahain and S.R. Mohanty

Size controlled synthesis of super paramagnetic nanoparticles by plasma expansion technique
Lavita Sarma, Trinayan Sarmah, N. Aomoa, and M. Kakati

Rietveld refinement of tungsten nanoparticles prepared by plasma method
Trinayan Sarmah, Ngangom Aomoa, Sidananda Sarma and M. Kakati

AWARDS and ACHIEVEMENTS

Dr. Mukesh Ranjan won the **best oral presentation** in Young Scientist Meet conducted in the International Conference on Nanotechnology for Better Living at NIT, Srinagar jointly organised by IIT-Kanpur and NIT-Srinagar from 25-29 May 2016. The title of his presentation was "Sub-monolayer growth of Ag on flat and nanorippled SiO_2 surfaces"

Shri. Sunil Misal of Administration Division of IPR was awarded the DAE **"Hindi Sevi Samman Puraskaar"** for the year 2014-15 on 31st May 2016 for his commendable contributions in propagation and use of Hindi language in office. The award consisted of a citation and a medal, which was presented to him by the Chief Guest Shri. Anil Kumar, Director General (Security), Dept. of Atomic Energy, Mumbai, at the 17th All India Official Language Conference held at Anushakti Bhavan, DAE Secretariat, Mumbai.

Diagnosis of Trapped Energetic Particles in Source Plasma of LVPD
A. K Sanyasi, L. M. Awasthi, P. K. Srivastava, S. K. Mattoo, P. K. Kaw and R. Paikaray received **best poster award** at 5th PSSI-Plasma Scholars Colloquium (PSC), Ravenshaw University, Cuttack, 27-28 August 2016

Driving frequency effect on the electron energy distribution function and electron sheath interaction in capacitive discharges: A simulation study
Nishant Sirse, Miles Turner and Albert R Ellingboe, Sarveshwar Sharma and Predhiman K Kaw received **best poster award** at 6th International Conference on Microelectronics and Plasma Technology (ICMAP 2016), Gyeongju, Korea, 26-29 September 2016

Observation of nonlinear coupling between Kelvin-Helmholtz and drift wave instability in IMPED
Sayak Bose, Neeraj Wakde, P.K. Chattopadhyay, J. Ghosh and Y.C. Saxena received **best poster award** at Joint ICTP-IAEA College on Plasma Physics, International Center for Theoretical Physics, Italy, 7-18 November 2016

Design and Implementation of Electromagnetic Diagnostics Electronics in SST-1 Tokamak
Praveenlal Edappala, Chandresh Hansalia, Rachana Rajpal, Hitesh Mandaliya, Vismay Raulji, Sameer Kumar and Raju Daniel received **best paper award** in the thread of Applied Electronics and System Engineering, at 2016 International Conference on Advances in Electrical, Electronic and

Systems Engineering (ICAEESE 2016), Putrajaya, Malaysia, 14-16 November 2016

Studies on controlled synthesis of super paramagnetic carbon encapsulated magnetic nanoparticles (CEMN) by plasma expansion technique
Ngangom Aomoa, Lavita Sarma, Trinayan Sarmah, Sidananda Sarma and M. Kakati received **best poster award** at International conference on Advances in Nanotechnology (iCAN-17), Assam Don Bosco University, Guwahati, Assam, India, 9-13 January 2017

Influence of Cold Plasma Treatment on Seed Germination
R. Rane, A. Vaid, C. Nalwa, A. Vikram, A. Thakur, S. Mukherjee received **best oral presentation award** at National Symposium on Advances in Agriculture through Sustainable Technologies & Holistic Approaches (AASTHA-2017), at International Centre, Dona Paula, Goa, 15-17 February 2017

Overview and Status of ITER-India Gyrotron Test Facility (IIGTF)
Vipal Rathod, S.L. Rao, Anjali Sharma, Ronak Shah, Deepak Mandge, Sharan Dilip, Amit Yadav, Rajvi Parmar received **best poster award (second prize)** at National Conference on Emerging Trends in Vacuum Electronic Devices & Applications VEDA 2016, Institute for Plasma Research, India, 16 - 18 March 2017

Professor Subroto Mukherjee, Head, FCIPT and Associate Dean, Academics, was awarded (jointly with Dr. S C Sharma of ISRO, Thiruvananthapuram) the **VASVIK Award** for the year 2016 in the category of Material & metallurgical Sciences & Technology. This award is instituted by the Vividhlaxi Audyogik Samshodhan Vikas Kendra, Mumbai. The award was presented to him by Shri Pankaj Patel, President, Federation of Indian Chambers of Commerce & Industry (FICCI) during the ceremony organized at BJ Hall, Vile Parle, Mumbai, 3 March 2017

E. 4. INVITED TALK DELIVERED BY IPR STAFF

MODHUCHANDRA LAISHRAM

Gave an Invited talk on "Collective dynamics in complex fluid system" at EMN Meeting on Microfluidics and Nanofluidics-2016, Dubai-United Arab Emirates, 5-8 April 2016

MAINAK BANDYOPADHYAY
Gave an Invited talk on "ROBIN India's First Fusion Grade Negative Ion Source & its Performance Journey" at CPP-IPR Silver Jubilee Symposium, Assam Don Bosco Institute (DBI), Kharghuli, Guwahati, 21-22 April 2016

M. KAKATI

Gave an Invited talk on "Controlled plasma fusion research, reports from CPP-IPR on development of a major experimental facility to study plasma surface interaction processes relevant to future fusion machines" at National seminar on Green Energy- Prospects and Challenges, Assam Science and Technology University, Guwahati, Assam, 26 April 2016

MRITYUNJAY KUNDU

Gave an Invited talk on "Collisional absorption of laser pulses in under-dense plasmas: Anomalous versus normal scenario" at 10th West Lake Symposium and 12th Asia Pacific Plasma Theory Conference (APPTC-2016), West Lake Hillview International Hotel, Hangzhou, China, 9-13 May 2016

Gave an Invited talk on "Anomalous collisional absorption of femto-second laser in plasma: PIC and Monte-Carlo simulations" at International Centre for Theoretical Sciences program on Laser Plasma Accelerator, ICTS-TIFR, Bangalore, 6-17 March 2017

D CHANDRA, A THYAGARAJA, A SEN and P KAW

Gave an Invited talk on "Shear flow effects on neoclassical tearing modes" at 10th West Lake Symposium and 12th Asia Pacific Plasma Theory Conference (APPTC-2016), West Lake Hillview International Hotel, Hangzhou, China, 9-13 May 2016

P. A. RAYJADA

Gave an Invited talk on "Hydrogen permeation barrier coatings for fusion reactor applications" at Institute of Minerals and Materials Technology (CSIR-IMMT), Bhubaneswar, Orissa, 23 August 2016

Gave an Invited talk on "Study of Er_2O_3 film deposition for the fusion reactor applications" at Recent trends in experimental condensed matter Physics (RTECMP-2017), Saurashtra University, Rajkot, 21st March 2017

Gave an Invited talk on "Energy & Nuclear Fusion: Challenges for Materials" at Center for Advanced Materials Engineering Research and Application, Rajiv Gandhi College of Engineering and Technology, Puducherry, 30th March, 2017

S. R. MOHANTY

Gave an Invited talk on "Basics and Applications of Inertial Electrostatic Confinement Fusion" at Faculty Development Program on Advances in Microelectronics and Plasma Diagnostics, Delhi Technological University, Delhi, 29 August – 02 September 2016

Gave an Invited talk on "High energy density pinch plasma- an unique tool for plasma processing and deposition" at UGC Sponsored National Seminar on Recent advances in material science and their applications, BN College, Dhubri, Assam, 24-25 March 2017

V. TOIGO, D. BOILSON, T. BONICELLI, R. PIOVAN, M. HANADA, A. CHAKRABORTY

Gave an Invited talk on "A Substantial Step Forward in the Realization of the ITER HNB System: The ITER NBI Test Facility" at 29th Symposium on Fusion Technology (SOFT-2016), Prague, Czech Republic, 5-9 September 2016

SAROJ DAS

Gave an Invited talk on "Library Spaces and Services" at STC-2016 UGC-HRDC, Rashtriya Uchchatar Shiksha Abhiyan (RUSA), DLIS Gujarat University, Ahmedabad, 30 September 2016

Participated in panel discussion on topic "R&D Library & Information Landscape: Where are we and where are we headed?" at International Conference on Changing Landscape of Science & Technology Libraries, IIT Gandhinagar, 02-04 March 2017

RAMESH KUMAR BUDDU

Gave an Invited talk on "Laser Welding Process of Austenitic stainless steels and weld properties characterization studies: Few challenges and experience" at Advances in Welding Technology and Automation, Young Professionals Seminar, Indian Institute of Welding, Baroda Branch, Ahmedabad, 1 October 2016

Gave an Invited talk on "Electron beam welding and Laser Beam welding processes: Prospects and Potential applications in manufacturing sector" at TEQIP-II Sponsored Workshop On" Welding Technologies and NDT Techniques "Organized by Engineering Staff College of India, at Hotel Inder Residency, Ahmedabad, 04 March 2017

SARVESHWAR SHARMA

Gave an Invited talk on "Effect of driving frequency on the electron-sheath interaction and plasma parameters in capacitively coupled plasma discharges" at School of Physical Sciences, Dublin City University, Ireland, 11 October 2016

Gave an Invited talk on "Driving frequency effect on the electron-sheath interaction and electron energy distribution function in Capacitive discharges" (Co-authors: N Sirse, P K Kaw, M M Turner, A R Ellingboe) at Indo-Taiwan Low Temperature Plasma Physics collaborative work, Aerothermal & Plasma Physics Laboratory, National Chiao Tung University, Hsinchu, Taiwan, 21 February 2017

NIRAV I. JAMNAPARA

Gave an Invited talk on "Applications of plasma technologies in Defense Sector: Development, Performance & Disposal" at International Conference on Emerging Materials & Processes for Defense & Infrastructure, CIDCO Exhibition Centre, Vashi, Navi Mumbai, 13 October 2016

Gave an Invited talk on "Plasma Aided Surface Engineering: Exploring Novel Applications" at TEQIP-II research strand lecture series, SS Engineering College, Govt. of Gujarat, Bhavnagar, 07 March 2017

Gave an Invited talk on "Development of hard automobile components using plasma" (Co-authors: Alphonsa Joseph, S. Mukherjee) at AES Seminar - Convergence of Technologies in Automotive Plant & Workshop on Surface Engineering in Automotive Industry, New Delhi, 21 March 2017

MUKESH RANJAN

Gave an Invited talk on "Plasma Based Nanotechnologies at FCIPT/IPR" at XXXI Annual IAPT Convention 2016 & Symposium on Excellence in Research, LDRP, Gandhinagar, 20-22 October 2016

Gave an Invited talk on "Plasma based technologies in

Nanotechnology" at Samvad, Aditya Silver Oak Institute of Technology, Ahmedabad, 22 December 2016

G. RAVI

Gave an Invited talk on "Physics and Technology of Thermal Plasmas" at 31st National Convention of Indian Association of Physics Teachers and Symposium on Excellence in Research, Kadi Sarva Vishvavidyalaya, Gandhinagar, 21 October 2016

DEVENDRA SHARMA

Gave an Invited talk on "Simulations of nonlinear plasma structures, phase space coherence to vortex dynamics" at International Conference on Frontiers of Physics and Plasma Science, Dep. of Physics and Mathematics, Ujjain, India, 7 November 2016

AMITA DAS

Gave series of Invited lectures on topics: fluid models, plasma instabilities, nonlinear processes, coherent structures and plasma turbulence, at SERB school organized by Dr. H. Bailung at The Institute of Advanced Study in Science & Technology (IASST), 21-25 November 2016

Organized a workshop along with G. Ravindra Kumar (TIFR), M. Krishnamurthy (TIFR Hyd), Srinivas Krishnagopar (BARC) and Rajeev Pattathil (RAL, UK) on "Laser Plasma Accelerator", at International Centre for Theoretical Sciences, Bangalore and gave an Introductory talk on "Plasma Based Particle Acceleration" and a Technical talk on "Magnetic field generation in finite beam Plasma System", 6-17 March 2017

RAMESH JOSHI, H M JADAV, ANIRUDDH MALI and S.V. KULKARNI

Gave an Invited talk on "Integration of PLC based Offline impedance Matching system for ICRH Experiments" at 2nd international conference on contemporary computing and informatics, Amity University, Noida, 14-17 December 2016

JOYDEEP GHOSH, RITU DEY, M. B. CHOWDHURI, R MANCHANDA, S. BANERJEE, N. YADAVA, NILAM NIMAVAT and ADITYA TEAM

Gave an Invited talk on "Neutral Particle Transport in Aditya Tokamak Plasmas" at 21st National Conference in Atomic and Molecular Physics (NCAMP-2017), Physical Research Laboratory, Ahmedabad, Gujarat, India, 3-6 January 2017

HITENSINH VAGHELA

Gave an Invited talk on "Cryogenic System of ITER: Cryogenic Distribution and System of Cryolines" at TKM College of Engineering, Karicode, Kerala, 27 January 2017

RAJESH TRIVEDI

Gave an Invited talk on "Lesson learnt from development of ITER MW level R&D RF source in MHz frequency range" at Workshop on RF Systems for Accelerators, Inter-University Accelerator Centre, New Delhi, 6-8 February 2017

S.V. KULKARNI

Gave an Invited talk on "High Power RF and Microwave requirements for Fusion Reactor and Safety Aspects" at Workshop on RF Systems for Accelerators, Inter-University Accelerator Centre, New Delhi, 6-8 February 2017

V. L. TANNA

Gave an Invited talk on "SST-1 Cryogenics and related facilities at IPR" at 26th National Symposium on Cryogenics and Superconductivity (NSCS), Variable Energy Cyclotron Center (VECC), Kolkata, 22 February 2017

NITIN SHAH

Gave an Invited talk on "ITER Cryolines" at 26th National Symposium on Cryogenics and Superconductivity (NSCS), Variable Energy Cyclotron Center (VECC), Kolkata, 23 February 2017

MUKTI RANJAN JANA

Gave an Invited talk on "High Power Ion Acceleration System for Tokamak Plasma Heating" at Indo Japan Accelerator School (IJAS) 2017, Department of Physics, Indian Institute of Technology Roorkee, 9-11 March 2017

KUSHAGRA NIGAM

Gave an Invited talk on "Physics of 4th State of Matter" and "Quantum Dynamics of Casimir Forces" at BITS Pilani K.K. Birla Goa Campus, on 17 and 18 March 2017

Endowment Lecture / Invited talks given at 33rd DAE Safety & Occupational Health Professionals Meet, Institute for Plasma Research, Gandhinagar, 23-25 November 2016

P. I. JOHN gave an Endowment Lecture on "Energy and Environment: Plasma Processes for Decarbonization

U.K. BARUAH gave an Invited talk on "Occupational Hazards with Experimental High Voltage Systems"

SANJAY V. KULKARNI gave an Invited talk on "Safety Aspects of High Power RF and Microwave Sources for Fusion Reactor"

E.5 TALKS DELIVERED BY DISTINGUISHED VISITORS AT IPR

Dr. Charu Lata Dube, Immobilisation Science Laboratory, Department of Materials Science and Engineering, University of Sheffield, UK, gave a talk on "Radiation stability of nuclear materials for nuclear power generation"

Dr. Manis Chaudhuri, School of Engineering and Applied Sciences, Harvard University, USA, gave a talk on "Exploring strong coupling phenomena in classical many body systems: from dusty plasma to colloids"

Dr. Dinesh Nath, Indian Institute of Technology, Kanpur, gave a talk on "Application of meshless methods to the computation of fixed boundary equilibria and current-hole simulation in tokamak"

Mr. Satish Badgujar, ITER Organization, France, gave a talk on "Realization of the Cryoline System for ITER"

Mr. Shailesh Kanpara, Institute for Magnetic Fusion Research, IRFM-CEA, Cadarache, France, gave a talk on "Development of Tungsten (W) Coating technologies for Plasma Facing Component application"

Dr. Gopikishan Sabavath, Birla Institute of Technology, Mesra, Ranchi, gave a talk on "Plasma parameters and instability during thin film deposition"

Dr. J. K. Atul, Magadh University, Bodh Gaya, India, gave a talk on "Secondary Instabilities in the Dynamics of Farley Buneman Fluctuations"

Dr. Sanat Kumar Tiwari, Department of Physics and Astronomy, University of Iowa, U.S.A, gave a talk on "Thermodynamic State Variables in Ultracold Plasmas"

Dr. Arvind Kumar Saxena, Max-Planck Center for Attosecond Science, POSTECH, South Korea, gave a talk on "Study of Clusters using Mass Spectrometry, Optical Spectroscopy and Imaging technique"

Dr. Karan Pankaj Jani, Georgia Institute of Technology-USA, LIGO Scientific Collaboration, gave a talk on "Journey of Binary Black Holes: From Supercomputer to LIGO to Universe"

Dr. Bernard Bigot, Director-General, ITER Organization, gave a talk on "Progress of the ITER Project"

Dr. A K Patra, National Atmospheric Research Laboratory, Gadanki, AP, India, gave a talk on "The puzzling daytime 150-km echoes: Are they due to plasma instability or naturally enhanced plasma waves?"

Dr. Tapan Barman, Institute of Advanced Study in Science and Technology, Guwahati, Assam, gave a talk on "Synthesis of polyaniline-Au nanocomposite thin films by plasma-based techniques for flexible self-powered photodetectors"

Dr. Payal H. Pandit, Kadi Sarva Vishwavidyalaya, Gandhinagar, gave a talk on "Direct Measurement of Plasma Potential using Laser Heated Emissive Probes"

Dr. Prabal Singh Verma , Technische Universitat Berlin, Germany, and Max-Planck/Princeton Center for Plasma Physics, gave a talk on "Fourth order accurate finite volume numerics for simulating accretion disks"

Dr. Yeshwant R. Waghmare, (Former Prof. and Dean), Indian Institute of Technology, Kanpur, gave a talk on "Is Quantum Theory the Ultimate Reality?"

Dr. Mohit P Sharma, DGFS PhD, HBNI, BARC, Mumbai, gave a talk on "Investigation on the flow distribution within the rod bundle of AHWR"

Dr. Ravi B. Grover, Homi Bhabha National Institute, Mumbai, gave a talk on "The Journey Leading to India Joining ITER"

Prof. James Bradley, Department of Electrical Engineering and Electronics, University of Liverpool, UK, gave a talk on

"Plasma discharges for the ambient processing and detection of materials"

Dr. Rahul Kumar, Institute for Cosmic Ray Research (ICRR), University of Tokyo, gave a talk on "KAGRA detector: Large-Scale Cryogenic Gravitational Wave Telescope"

Dr. Subir Biswas, Weizmann Institute of Science, Israel, gave Dr. Parvez Guzdar award talk on "Spectroscopic Diagnosis of Magnetic and Electric Field and Plasma Properties in a Relativistic Electron Beam Diode"

Dr. Ujjwal Sinha, GoLP/IPFN, Instituto de Plasmas e Fusao Nuclear, Insituto Superior Tecnico, Lisbon, Portugal, gave a talk on "Circularly Polarized Light from Magnetized Current Filaments: implications to Gamma Ray Bursts"

Dr. M.D. Pandya, University of Wisconsin-Madison, USA, gave a talk on "Low edge safety factor disruptions in the Compact Toroidal Hybrid: Operation in the low-q regime, passive disruption avoidance and the nature of MHD precursors"

Dr. Sukanya Mitra, Indian Institute of Technology, Gandhinagar, gave a talk on "Electromagnetic Responses and Dissipative Properties in Hot QCD Medium"

Mr. M.Y. Jamal, Indian Institute of Technology, Gandhinagar, gave a talk on "Collective Modes and the Refractive Index of hot QCD/QGP medium"

Dr. Sunil Kumar, Inter University Accelerator Centre (IUAC), New Delhi, gave a talk on "Irradiation induced structural and electrical modification in graphene"

Mr. Avdhesh Kumar, Physical Research Laboratory, Ahmedabad, gave a talk on "On the Chiral Imbalance and Webel Instabilities"

E 6. COLLOQUIA PRESENTED AT IPR

Prof. Krishna Kumar, Department of Physics, Indian Institute of Technology, Kharagpur, West Bengal, on "Fluid patterns in thermal convection with rotation" (Colloquium # 259)

Prof. Edward Thomas Jr., Physics Department, Auburn University, Auburn, Alabama, USA, on "The Magnetized Dusty Plasma Experiment (MDPX) as a platform for basic and applied plasma physics research" (Colloquium # 260)

Prof. Jayanta Bhattacharjee, Harish-Chandra Research Institute, Allahabad, India, on "Scaling Law for Turbulence in Stratified Fluids: Kolmogorov or Bolgiano?" (Colloquium # 261)

Dr. Nirmal Kumar Bisai, Institute for Plasma Research, Gandhinagar, Gujarat, on "Role of neutral gas in Scrape-off Layer of tokamak plasmas in the presence of finite electron temperature gradient" (Colloquium # 262)

Prof. Vijay A. Singh, Raja Ramanna Fellow, Mumbai University, Mumbai, on "The Golden Ratio, the Centre of Mass and Aesthetics" (Colloquium # 263)

Prof. Vijay A. Singh, Raja Ramanna Fellow, Mumbai University, Mumbai, on "Science Education: An Art or a Science?" (Colloquium # 264)

Dr. Vinod Chandra, Indian Institute of Technology, Gandhinagar, on "Exploring the heart of the matter: the hottest and most fluid, liquid in nature at extreme temperature/ energy density" (Colloquium # 265)

Prof. Rajesh Gopakumar, International Centre for Theoretical Sciences-TIFR, Bangalore, on "Down-To-Earth String Theory" (Colloquium # 266)

Prof. H. Bailung, Professor and Head, Physical Sciences Division, IASST, Guwahati, on "Ion Acoustic rouge waves in multicomponent plasma" (Colloquium # 267)

Prof. G.P. Zank, Eminent Scholar, Distinguished Professor and Director, Centre for Space Physics and Aeronomic Research, University of Alabama, Huntsville, USA, on "A Nearly Incompressible Description of Low-Frequency Turbulence" (Colloquium # 268)

Prof. Avinash Khare, Department of Physics and Astrophysics, University of Delhi, on "Creation of General relativity: Einstein and Hilbert" (Colloquium # 269)

E.7 SCIENTIFIC MEETINGS HOSTED BY IPR

National Conference on Emerging Research Trends

in Engineering (NCERTE), Vishwakarma Govt. Engg. College, Ahmedabad, 4-6 April 2016

National Conference on Emerging Research Trends in Engineering (NCERTE) – 2016 was organized at Vishwakarma Govt. Engg. College – Chandkheda, Ahmedabad from 4th – 6th April 2016 in collaboration with SPFU, CTE, Institute for Plasma Research, and TEQIP – II Institutes of the state. The conference received more than 250 papers in various engineering disciplines, and out of that, approximately, 200 papers were selected for oral/poster presentations. There were three plenary talks and 27 expert talks throughout the conference. Prof. Amita Das (Dean – IPR) was one of plenary speakers in addition to Dr. Sudhir Jain (Director, IIT – Gandhinagar) and Shri N. M. Desai (Deputy Director – SAC, Ahmedabad). Prof. Amita Das talked about plasma physics, nuclear fusion and various societal benefits of plasma science. She also briefed participants about various research activities carried out at IPR. It was well received by the attendees. The conference was inaugurated on 4th April in the presence of Dr. M. N. Patel (Vice Chancellor, Gujarat University), Dr. Sudhir Jain (Director, IIT – Gandhinagar), Dr. V. S. Purani (Jt. Director, CTE), Prof. Usha Neelakantan (SPFU – Coordinator), Dr. Subroto Mukherji (Associate Dean, IPR), Dr. R. K. Gajjar (Principal, VGEC – Chandkheda), Dr. R. A. Thakker (Coordinator, NCERTE – 2016) and other dignitaries, authors, faculty and student participants of VGEC and other Institutes. Overall, there was excellent response from the participants, hence making the NCERTE – 2016 a very successful event.

19th Joint Workshop (EC-19) on Electron Cyclotron Emission (ECE) and Electron Cyclotron Resonance Heating (ECRH), Institute for Plasma Research, Gandhinagar, 04-07 April 2016

19th Joint workshop in Electron Cyclotron Emission (ECE) and Electron cyclotron Resonance Heating (ECRH) was hosted by Institute for Plasma Research, from 4th -7th April, 2016 at Narayani Heights, located near its premises at Bhat, Gandhinagar. This bi-annual meeting, mainly covered the major areas as: Electron cyclotron (EC-wave) theory, electron cyclotron emission (ECE), electron cyclotron resonance heating (ECRH), electron Cyclotron current drive (ECCD), Experiments on various tokamaks and Stellarators and Technology associated with ECE and ECRH. More than 60 members of the science and fusion community participated in this important event, which included more than 30 international participants. The conference was inaugurated by the traditional lighting of the lamp by the various dignitaries attending the conference. Along with the technical sessions related ECE and ECRH, members participated and enjoyed an evening of Indian cultural program and the dinner hosted by Director at IPR. Local sightseeing was also arranged for the participants and they visited the Adalaj step well, Gandhi Ashram and ended with a traditional Gujarati dinner at Vishala, Ahmedabad.

Centre of Plasma Physics – Institute for Plasma Research (CPP-IPR) Silver Jubilee Symposium, Nazirakhat, Tepesia, Sonapur, Kamrup, Assam, 21-22 April 2016

Centre of Plasma Physics- Institute for Plasma Research (CPP-IPR) celebrated its silver jubilee with a symposium titled, "CPP-IPR Silver Jubilee Symposium". The decorous two day program was held at Don Bosco Institute, Guwahati. On 21st April 2016, the program started with the welcome address by the Centre Director, Prof. K. S. Goswami. The program continued with the felicitation of Prof. S. Bujarbarua, founder director, CPP and Prof. P. K. Kaw, former Director, IPR, for their monumental contribution towards the institute. Prof. Bujarbarua elaborated the commissioning of CPP and merging it with IPR. Prof. Kaw praised and motivated the constant effort of the researchers of the institute towards solving world class problems. The meeting was graced by the presence of many dignitaries including, Prof. J. N. Goswami, Prof. B. N. Goswami, Prof. Y. C. Saxena, Prof. A. C. Das, Prof. Jayanti Chutia, Prof. H. Bailung, Prof. K. D. krori, Fr. Joseph (Pro-VC Assam Don Bosco university) etc. The special attraction of the symposium was a student interaction with Prof. J. N. Goswami, Prof. B. N. Goswami, Prof. A. C. Das and Prof. Asoke Kumar Sen (Assam University). The session was coordinated by Prof. Y. C. Saxena. In the afternoon the delegates and students were taken to CPP-IPR for the laboratory visit. On, 22nd April, 2016, technical lectures were delivered by Dr. Subrata Pradhan, Prof. Amita Das, Dr. Jaydeep Ghosh, Dr. Mainak Bandopadhyay, Dr. Ujjal Barua and Prof. M. P. Bora (Gauhati University). Dr. Pradhan spoke about the recent developments of SST-1 and Prof. Amita Das touched upon the physics and engineering challenges in magnetic fusion. Dr. M. Kakati presented the recent commissioning of the CIMPLE-PSI device. In the session after lunch, posters from various institutions were presented.

One-Day Workshop on Thermal Plasma and its Industrial Applications, FCIPT, IPR, Gandhinagar, 29 April 2016

A one day workshop on Thermal Plasma and its Industrial Applications was organized by FCIPT on 29th April 2016. The aim of this workshop was to sensitize industries about how thermal plasmas can be used for industries in the field of waste management, nano-material production, ceramic/ mineral processing etc. The workshop was attended by around 50 participants from various industries. Participants were excited to see Plasma Pyrolysis, Nano-Powder Production and Plasma Torch during laboratory visit.

International Yoga Day Celebration @ IPR, Gandhinagar, 21 June 2016

As per the directives received from Ministry of AYUSH, Govt. of India, IPR celebrated the International Yoga Day on 21st June 2016 in the lawns of the main campus. The theme of the programme was "Yoga for Harmony and Peace". A Yoga demonstration session of around forty five minutes was organized in which students, faculty and administrative staff took part enthusiastically. Under the guidance of three invited experts, various Yoga postures and asanas were performed. Yoga session started with a little prayer followed by Sookshma Vyayam, Vajrasana, Tadasana, Vrikshashana, Surya Namaskar, Nadi Shodhan Pranayama and Bhramaree Pranayama. IPR Staff members participated in these session were very satisfied as the Yoga session was quite a relaxing and refreshing experience for them. After a light refreshment, an interactive talk on "Benefits of Yoga for stress management and good health" was arranged in the packed seminar hall in which the Yoga experts explained as to how the Yoga helps in releasing the stress and can be useful for the better living

46th National Safety Week, IPR, Gandhinagar, 4-10 March 2017

The 46th National Safety Week was celebrated at IPR during 4-10 March 2017. The institute organized various competitions in this week to create safety awareness among the employees. Competitions include Slogan in Hindi & English, Cartoon Making, Quiz and Essay Writing in Hindi & English based on decided topics for the employees of IPR, FCIPT & ITER-India. Encouraging response was received from the employees for various competitions. A hands-on demonstration for using fire extinguisher was conducted for the employees as well as security staff at IPR, FCIPT and IPR Extension labs as a part of the Safety Week. A demonstration of self-contained breathing apparatus (SCBA) was also conducted for the employees, specially for those who work with cryogenic fluids. The concluding session was organized on 10th March 2017. Mr. Devendra Modi welcomed the gathering and Mr. Rajiv Sharma made a presentation on "Experience with Cryogenic Safety, Problems and Solutions". This was followed by a talk by Dr. Chenna Reddy who expressed his thoughts on safety at work. The safety pledge was then administered to the staff by Shri. P K Atrey. This was followed by a safety quiz conducted by Shri Bharat Doshi. IPR Director then delivered the keynote address and gave away the prizes to the winners of various competitions organized during the safety Week. The vote of thanks was delivered by Shri Sunil Kumar, Chairman, Safety Committee.

National Conference on Emerging Trends in Vacuum Electronic Devices and Applications (VEDA), IPR, Gandhinagar, 16-18 March 2017

The National Conference on Emerging Trends in Vacuum Electronic Devices and Applications (VEDA) was hosted by IPR in collaboration with the Vacuum Electronics & Applications Society, Bengaluru during 16-18 March 2017. The event was inaugurated by Dr. Shashank Chaturvedi, Director IPR, Dr. Sushil Raina, President VEDA Society and Dr. Sudhir Kamath (Director, MTRDC), who also delivered the keynote address. The meeting had six plenary and sixteen invited talks by leading experts in the fields of vacuum devices and high power microwaves. The meeting also had oral presentations as well as a poster session. Around100 participants from various R&D institutions and Universities took part in this event.

E.8 MoU SIGNED

E.8.1 NATIONAL MoU SIGNED

IPR-St. Xavier's Teaching Collaboration

As part of the ongoing teaching collaboration with St. Xavier College (Ahmedabad), Dr. Mukesh Ranjan from FCIPT was invited to deliver a talk on latest trends in plasma based nanotechnology activities. Talk was mainly attended by students and the faculties of St. Xavier College. The talk was arranged to motivate the young students for pursuing the career in research and possible opportunities to work at FCIPT/IPR. This is part of the MoU signed between IPR and St. Xavier's college Ahmedabad.

E.8.2 INTERNATIONAL MoU SIGNED

MoU between IPR & IEK-4

The Institute of Energy and Climate Research - Plasma Physics (IEK-4), Forschungszentrum Juelich GmbH (FZJ), Germany and the Institute for Plasma Research (IPR), recognizing the mutual benefits obtainable in the field of Nuclear Fusion from the research cooperation on fusion science and technology between the two Institutes, have signed a Memorandum of Understanding (MoU) for academic and research cooperation. This MoU, which comes under the umbrella agreement between Government of India and The Institute of Energy and Climate Research - Plasma Physics (IEK-4), Forschungszentrum Juelich GMBH, Gemany in the field of fusion energy research, was signed on 28th April, 2016 by the Directors of IPR and IEK-4. Under this five year MoU (renewable), cooperative and joint research activities will be initiated on areas of fusion science and technology, such as fusion material development, plasma material interaction studies, tungsten – plasma spectroscopy and related technology, and on the plasma and fusion experimental programs of both Institutes. There would also be exchange of researchers and PhD students between the two institutes with the intent of learning, training, lecturing, conducting seminars and engaging in workshops and research.

E.9. TECHNOLOGY TRANSFERS

1. Transfer of 'Atmospheric Pressure Plasma Jet Technology (APPJ)' on non-exclusive basis to M/s Aditya High Vacuum Pvt. Ltd., Ahmedabad

The atmospheric pressure plasma jet technology for bio-medical applications was transferred by IPR to Ahmedabad based company, M/s Aditya High Vacuum Pvt. Ltd. on non-exclusive basis. The technology knowhow and license agreement was signed on 23-June-2016 at IPR, Bhat, Gandhinagar in the presence of Director IPR. The company plans to commercialize the atmospheric pressure plasma jet to various organizations in the field of bio-medical applications.

2. Transfer of 'Nanopowder production technology' on non-exclusive basis to M/s Plasma & Vacuum Techniques, Ahmedabad

The 'Nanopowder production technology' for production of metal oxide nano particles was transferred on non-exclusive basis to M/s Plasma & Vacuum Techniques, an Ahmedabad based firm working exclusively on plasma and vacuum technologies. The agreement was signed on 8th July 2017 at IPR, Bhat Gandhinagar in the presence of Director, IPR. The company intends to design, manufacture and supply nano powder production systems to user industries involved in production of Nano powders.

Shri A. Varadarajulu from IPR (Left) & Dr. N. Venkat-ramani from Aditya High Vacuum exchanging the tech-nology transfer document

3.Transfer of 'Plasma Pyrolysis Technology for organic (non-biomedical waste)' on non-exclusive basis to M/s Bhakti Energy, Rajkot

The plasma pyrolysis technology for non-biomedical waste was transferred on non-exclusive basis to M/s Bhakti Energy, Rajkot on 29th August 2016 at IPR, Bhat Gandhinagar. The company is into the field of renewable energy and intends to develop, supply and install plasma pyrolysis based waste disposal systems with or without energy recovery possibilities

4. Transfer of 'Atmospheric Pressure Inline Plasma Treatment Technology for textiles' on non-exclusive basis to M/s Arshad Electronics Pvt. Ltd., Mumbai

IPR had developed and patented atmospheric pressure inline plasma treatment system which can be used for textile and film processing. The said technology was transferred on non-exclusive basis to M/s Arshad Electronics Pvt. Ltd., Mumbai on 9-Nov-2016 at IPR, Bhat, Gandhinagar in the presence of Director IPR.

Exchange of technology transfer agreement between Chairman SPC, IPR (left) and Proprietor, Bhakti Energy (right) in the presence of Director, IPR (Middle)

5. Transfer of 'Plasma Pyrolysis Technology for organic (non-biomedical waste)' on non-exclusive basis to M/s G P Green Energy Systems Pvt. Ltd., Kolkata

The plasma pyrolysis technology was transferred to M/s G P Green Energy Systems Pvt. Ltd., a Kolkata based firm engaged in the field of manufacturing gasification systems for energy recovery. The agreement was signed on 7-Dec-2016 at IPR, Bhat Gandhiangar in presence of Director IPR. The company plans to explore plasma technology for next generation waste disposal needs to destroy complex molecules which are not disposable through conventional gasification systems.

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Exchange of technology transfer agreement between Proprietor, M/s Arshad Electronics (left) and Dr. Chenna Reddy in presence of Director IPR (Middle).