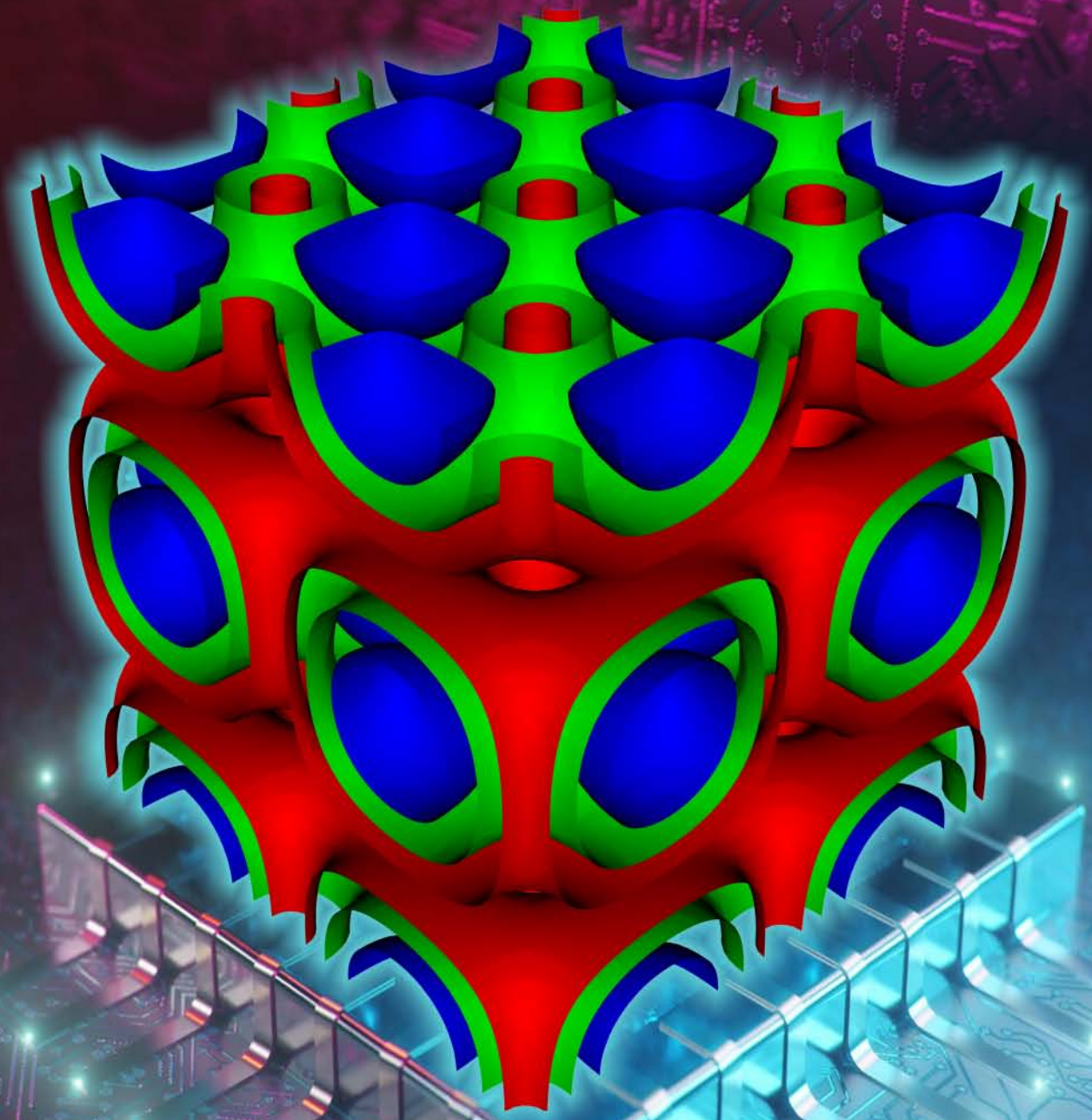
वार्षिक प्रतिवेदन
2019 - 2020

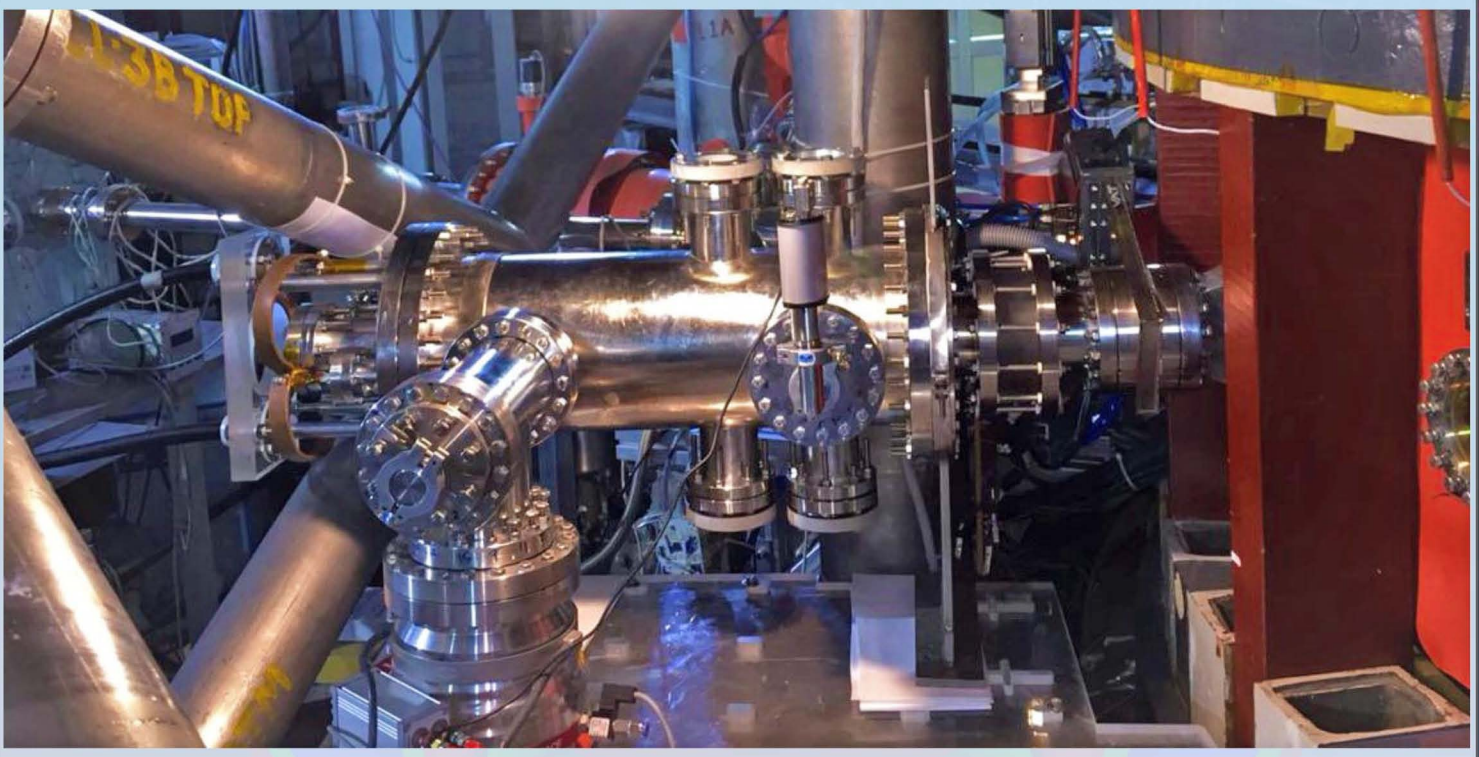
ANNUAL REPORT
2019 - 2020



प्लाज़्मा अनुसंधान संस्थान

INSTITUTE FOR **PLASMA RESEARCH**

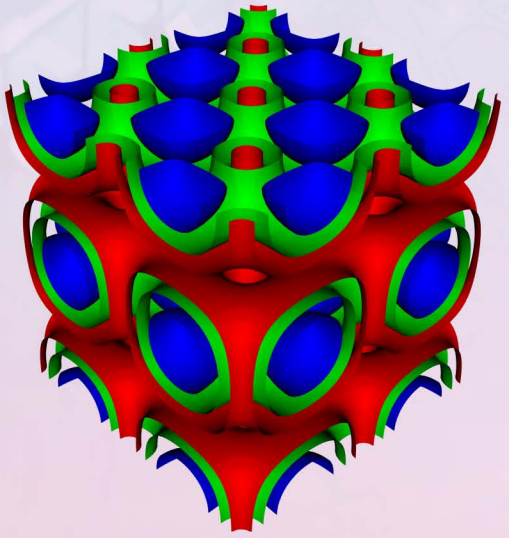
Bhat, Gandhinagar - 382428.



आदित्य अपग्रेड पर लगाया गया इंडक्टिव पेलेट इंजेक्टर (आईपीआई)
Inductive Pellet Injector (IPI) mounted on ADITYA-U

आईपीआर में एसएसटी-1 का मुआयना करते हुए अध्यक्ष, पऊआ एवं सचिव, पऊवि श्री के. एन. व्यास
Chairman, AEC & Secretary, DAE Shri K. N. Vyas visiting SST-1 at IPR

आईपीआर के एचपीसी क्लस्टर ANTYA पर सिमुलेशन प्रदर्शन द्वारा प्राप्त आवर्ती टेलर-ग्रीन (टीजी) प्रवाह
Recurring Taylor-Green (TG) Flow obtained by performing a simulation on IPR HPC cluster ANTYA



ANNUAL REPORT
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Institute for **Plasma Research**

Bhat, Gandhinagar 382428

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EXECUTIVE SUMMARY

Nuclear Fusion programme

Tokamaks are susceptible to rapid destruction of plasma in a process called a "disruption" – this is a major concern in reactor-scale devices like ITER, due to potential machine damage. A gradual release of the stored energy through radiation is desirable. For the first time in the world, an electromagnetic high-speed pellet injector has been deployed on the Aditya-U tokamak. The injected lithium titanate and lithium carbonate pellets reach the hot plasma core in a few milliseconds and radiate away their thermal energy, causing a rapid decrease in plasma current, temperature and density. This has been a collaborative effort between IPR and BARC Visakhapatnam. Better wall conditioning and lithiumization of Aditya-U has resulted in repeatable discharges with plasma current of ~150 kA and pulse length of ~330 ms.

In the Steady-State Superconducting Tokamak (SST-1), the experimental campaign has been extended to a record 15 days with 300 plasma shots, with plasma pulse durations upto 650 milliseconds, 30% higher than the best achieved ever before, and better reproducibility of plasma parameters. This became possible due to improvement of the initial magnetic field null inside the vacuum vessel, permitting higher gas fill pressures, in turn allowing plasma creation with a limited pulse of electron cyclotron heating at 42 GHz. The improved plasma density also permitted long-duration current drive using injected power at 3.7 GHz, which was not hitherto possible due to a low-quality plasma near the wave launcher. Also for the first time in SST-1, the three frequency ranges used for plasma heating (tens of MHz, few GHz, tens of GHz) were applied simultaneously. Improved cryo-insulation has permitted production of liquid Helium from the cryo-plant in addition to coil cooling, which will now allow cooling of current leads.

An important part of India's in-kind contribution to the ITER project is the cryostat, a 3800 tonne, 30 m diameter and 30 m high world's largest vacuum vessel. The sub-assembly of the Cryostat Base Section, weighing 1250 tons, was successfully completed and handed over to ITER Organization. This involved fabrication meeting strict tolerances, a first at this scale and magnitude. A handover ceremony was held on 23 July 2019, where India was represented by Dr. Anil Kakodkar and the Indian ambassador in France. In another achievement, the SPIDER test facility in Padua, Italy, produced the first SPIDER hydrogen beam using a 96 kV, 75 A Acceleration Grid Power Supply which was developed in India and supplied as in-kind contribution to ITER. The major part of the cooling water piping network and equipment (chillers, pumps, electrical panels etc.) has been delivered by ITER-India. Key ITER auxiliary systems (cryogenic plants, power converters, etc.) receive cooling water from this system. Substantial progress has also been made in the deliveries related to vacuum vessel in-wall shielding and the multi-process transfer lines for the cryogenic system.

There has been good progress in the indigenous development of fusion technologies. IPR's High Heat Flux Test Facility (HHFTF) has been used to perform heat load testing upto 2.5 MW/m2 on an indigenously-developed water-cooled Back-Plate of a Positive Ion Neutral Beam Injector (PINI). In an important step towards development of an indigenous cryoplant, an industry-scale air compressor has been successfully

converted to a helium compressor and has been operated in a closed loop continuously for 24 hrs with a helium flow rate of 60 g/s & delivery pressure of 14.5 bar. Fusion machines require coupling of high levels of microwave power (few GHz, hundreds of kilowatts) into a plasma in an ultra-high vacuum (UHV) system. This requires a "window" that is compatible with an UHV environment on one side and 3 bar pressure on the other. Such windows have hitherto been imported. An RF Pill Box type vacuum window has been indigenously designed & developed to operate at 3.7 GHz for 125 kW for a duration of 1 second. The major challenge was to establish & optimize the vacuum brazing of metal (copper) to ceramic (alumina), including the brazing set-up, its fixtures, precision machining & brazing cycle. It also required vacuum brazing of three dissimilar materials (copper, SS and alumina) in a single vacuum brazing cycle at high temperature.

A new High Performance Computing (HPC) facility named ANTYA has been commissioned at IPR and is operational on 24x7 basis. This has a theoretical peak performance of ~1 Petaflop and sustained performance ~0.65 Petaflop. Extensive scaling stud¬ies of open-source codes (LAMMPS and PLUTO) have been completed using full-machine capabilities. The scaling up to 10,000 cores has been demonstrated for these highly scalable open-source codes. In-house developed codes, as well as collaboration-based codes, have been successfully installed to run in a distributed environment on ANTYA. The intense computation needed for simulating various plasma/fusion systems for fundamental studies as well as Societal Applications like design of plasma pyrolysis-based waste disposal systems, is being greatly facilitated because of ANTYA. Indeed, it is allowing full-scale studies which were simply not possible earlier.

There has been significant progress in developing Societal and Industrial applications of plasmas. IPR has designed & developed an inline plasma-based polymer surface activation system to improve the performance of multilayer geo-membranes for lining landfills. Plasma treatment is expected to improve adhesion between High Density Polyethylene (HDFE) layers, thereby increasing the lifetime in the presence of water, and eliminating emission of polluting gases. This system is now under evaluation at CIPET. An indigenously-developed prototype Helicon plasma thruster system has been operated at 10 milliNewton thrust, with an input RF power level of 1500 W. A water-repellent Super-hydrophobic teflon surface has been produced by low energy ion beam irradiation. Such surfaces can be used for several applications, such as self-cleaning, anti-scratch, anti-icing, anti-corrosion and fog harvesting. Collaborations are underway with several medical research institutions to explore the use of plasma-jets, developed at IPR, for cancer treatment, based on in-vitro as well as in-vivo studies. Development of multilayer (TiN, TiAlN) coatings on zirconium alloy tubes, which are used in nuclear power reactors, are being explored to reduce water-side corrosion by the coolant water.

DIRECTOR,
IPR.

ANNUAL REPORT

APRIL 2019 TO MARCH 2020

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 Plasma Based Technologies & Applications

IPR has a long-standing, focused programme for developing plasma technologies for a variety of societal applications, such as waste management, medical/health, agriculture, textile, industrial, space and defence. These are time-bound projects with clear deliverables involving partnerships with a variety of end-users including industry. Technology has also been transferred to industry in several areas. Progress in these areas is described in the following section.

A.1.1 Plasma Surface Engineering Applications

Water Repellent Super hydrophobic PTFE Surface Produced by Low Energy Ion Beam Irradiation : Super hydrophobic surfaces are of great interest due to their superior water-repellent applications, such as self-cleaning, anti-scratch, anti-icing, anti-corrosion and fog harvesting. Super hydrophobicity is achieved by having a large contact angle ($\theta > 150°$) with low surface energy. Surface properties are modified either by surface structuring or by changing surface chemistry. Teflon and Teflon-like coatings have several applications in automobiles, non-stick cookware, and medical applications due to high heat resistance, excellent electrical insulation and biocompatibility. As PTFE is hydrophobic in nature, many investigations have been carried out to alter its wettability by modifying the surface structures. In our recently published study in Nature Scientific Report, we have found remarkable changes in wettability (increase in hydrophobicity) of PTFE after just a few seconds of Ar+ ion beam irradiation at energies as low as 300 eV. We have also found that PTFE surface become superhydrophobic under lower energy (300 eV-800 eV) Ar+ ion beam irradiation. Also, with the help of oblique incidence irradiation, the surface can become superhydrophobic at much lower fluences and energies without any additional gas and high energy ion beams. From a technological view point, this technique would be helpful for developing superhydrophobic bulk PTFE sheets with small duration irradiation; also, parts of the surface can be made superhydrophobic by using masking or ion beam writing.

In-vitro and In-vivo studies using Plasma Jet for oral cancer cells: IPR is collaborating with ACTREC to study the

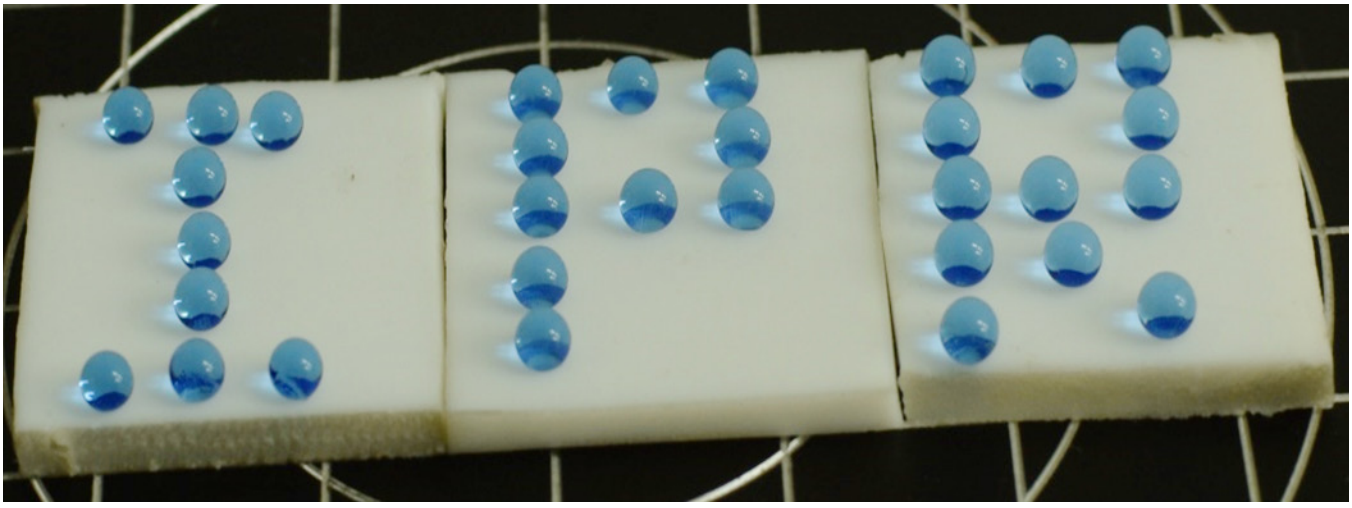


Figure A.1.1 Photograph of the Hyprophobic PTFE surface produced

interaction of plasma jet with oral cancer cells. Initially, the plasma jet parameters were optimized for in-vitro condition in terms of voltage and duration of treatments. In this study, plasma jet treatment was done on oral cancer, breast cancer and HEK293 cell lines using biological assays. On the basis of the in-vitro findings, preliminary in-vivo studies were initiated on tumors generated in hamster buccal pouch (HBP) model. Further studies to understand the mechanism of interaction are in progress.

Development of multilayer (TiN, TiAlN) coating on zirconium alloy tube. We are exploring the possibility of developing multilayer coatings of TiN and TiAlN coatings on zirconium based alloy tubes, which are used in nuclear power reactors. The coatings have been performed by cylindrical magnetron sputtering technique by modifying an existing system. Water cooled Titanium (Ti) and Aluminium (Al) cylindrical targets along with substrate rotation assembly were incorporated in the vacuum system. Preliminary experiments for the deposition of TiN and TiAlN as individual and multilayers were carried out. The process has been optimized for the deposition of TiN and TiAlN on the outer side of cylindrical stainless steel tubes. Similar coatings on zirconium alloy tubes will be developed and corrosion studies will be performed in the future.

A.1.2 Atmospheric Plasma Applications

Development and supply of inline atmospheric pressure air plasma system for surface modification of HDPE film in Geo-membrane application: An atmospheric pressure air plasma system for the inline surface modification of HDPE (High Density Polyethylene) film has been developed by APD (Atmospheric Pressure Plasma Division), IPR and commissioned at CIPET (Central Institute for Plastic and Engineering), Ahmedabad in March 2020. This system comprises of 6 pairs of electrodes and generates a uniform glow discharge plasma in air over a width of 1.5 meter. The objective of this project is to develop a Geo-membrane with improved characteristics of strength and leaching. The plasma surface modification of HDPE film induces nano-scale surface roughness and increases its surface energy, which in turn can improve adhesion among different layers of HDPE used in Geo-membrane. Detailed experiments for developing Geo-membrane from plasma modified HDPE films will be conducted by CIPET.

Figure A.1.2 Air-plasma treatment system installed at CIPET

Development of Basic Plasma Physics experimental setups for CEBS-DAE, Mumbai University: A compact Ion-Acoustic and Langmuir Probe system was developed, installed and commissioned at the Centre for Basic Sciences, a DAE centre established at Mumbai University campus. The system has been designed keeping in mind the growing popularity of plasma sciences and will enable M.Sc. Physics students to gain first hand practical experience in experimental plasma physics. It will also motivate them to pursue plasma physics as a career. Earlier, a system demonstrating Paschen breakdown was developed and installed in the same laboratory and it evoked much excitement among students. The new system consists of a vacuum chamber, power supplies, di-

Figure A.1.3 Ion-Acoustic Wave and Langmuir Probe System installed at UM-DAE CEBS

agnostic probes, filament cage and exciter grid. The vacuum chamber is fully reconfigurable and can support both low and high pressure experiments. The Langmuir probe along with ramp generator power supply facilitates the characterization of plasma both at low and high pressures. The optical probe allows one to insert a fiber optic cable, camera and laser beam inside the chamber to carry out more detailed studies on the plasma.

Project on Surface Modification of Silicone Catheter for Prevention of Bacterial Adhesion: Under a project on "surface modification of silicone catheters for prevention of bacterial adhesion as well as biofilm formation", a set of preliminary experiments have been conducted. It has been observed that plasma surface activation process results in physico-chemical changes on the silicone catheter surface which comprises of attachment of oxygen containing functional groups and generation of nano-scale roughness. Because of this surface, free energy increases significantly. In 6 days of aging study, polar part of the total surface energy decays and reaches the value comparable to the control sample whereas dispersive part does not change much in aging duration. therby establishing that plasma induced physico-chemical changes cause reduction of bacterial adhesion and growth on the catheter surface. Figures A.1.4 a and b show scanning electron microscope images of untreated silicone catheter surface and figures 4.1.4 c and d show images of plasma treated ones. Both these samples were subjected to microbiological testing at Division of Biological and Life Sciences, Ahmedabad University. These are preliminary results and a detailed study

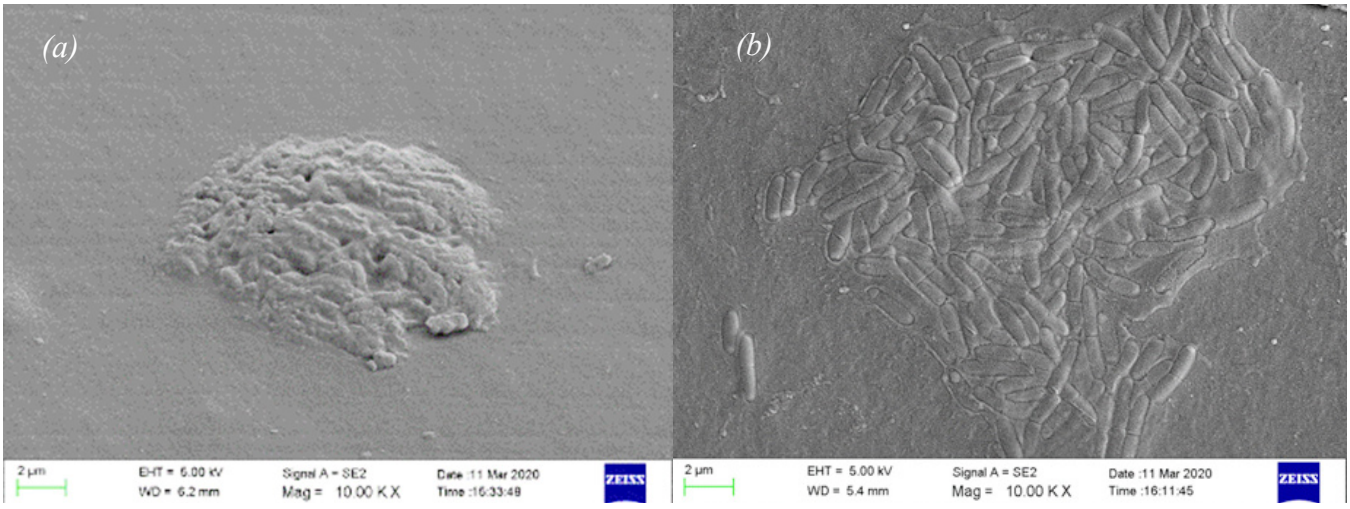
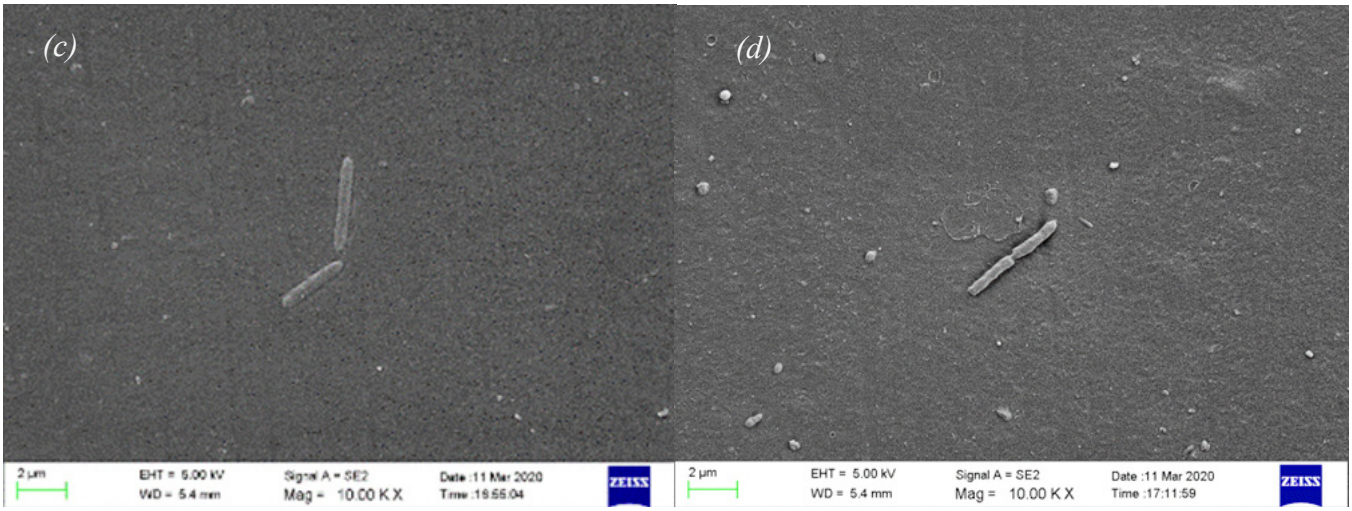


Figure A.1.4 Biofilm formation (a) growth of bacterial cells (b)on untreated silicone catheter surface (c) Plasma treated silicone catheter surface with (d) very less bacterial adhesion and growth



is underway.

A.1.3 Plasma Thrusters

Helicon Plasma Thrusters: Helicon plasma thrusters hold the promise of higher specific impulse and long lifetime as compared to other types of thrusters for long-duration, low-thrust applications in space. Building on IPR's basic research experience with helicon-wave driven plasmas, a lab-scale helicon plasma thruster system has been designed, fabricated and operationalised at IPR. A thrust of 10 mN has been achieved with 1500 W RF power, corresponding to a Specific Impulse and Thrust efficiency of 250-500 seconds and 6% respectively. Further optimisation and thrust increase is expected in the coming months

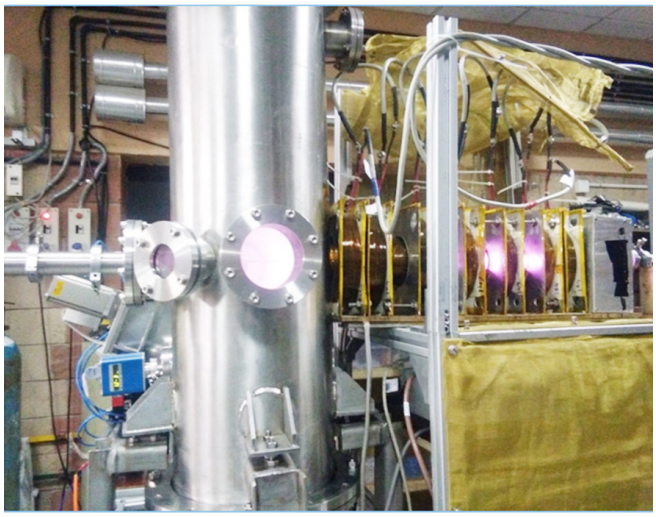
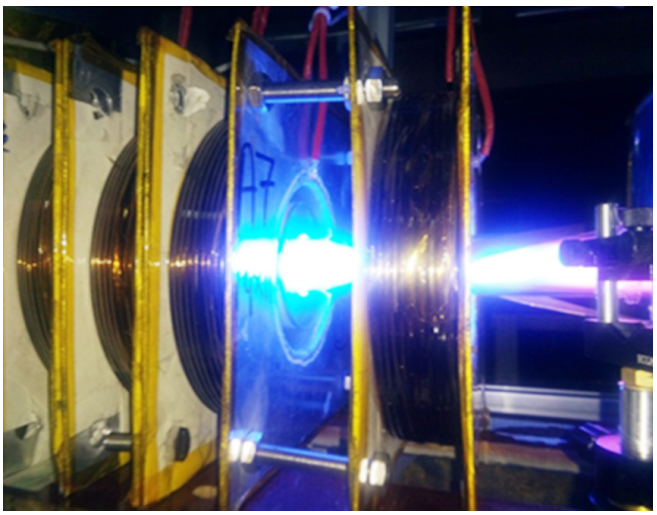
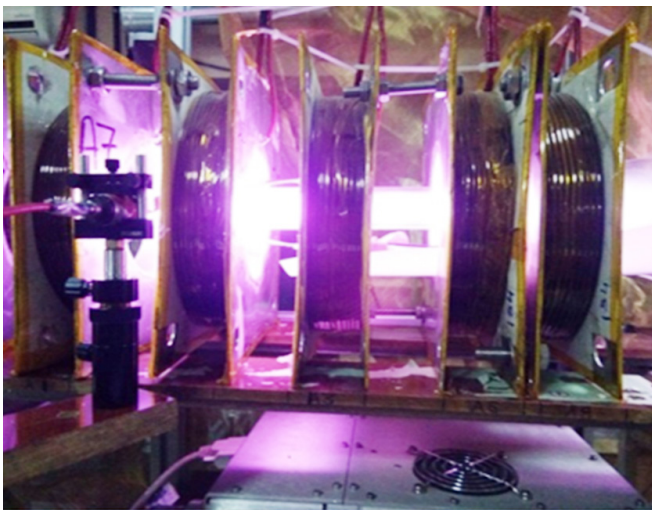


Figure A.1.5 Helicon Plasma Thruster experiments in Operation





A.1.4 External Projects

A table with brief details about the external projects has been given below:

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A) Projects Completed				
Sr. no	Organisation	Description	Deliverables	Status
1)	Anand Agricultural University, Anand	Design and installation of vacuum system for plasma treatment of seeds.	A vacuum system integrated with atmospheric pressure plasma power supply.	System delivered and installed in AAU lab, Anand.
2)	Institute of Pharmacy, Nirma University	Supply of Plasma Jet system	Plasma Jet system	System delivered to Institute of Pharmacy, Nirma University
3)	Saurashtra University, Rajkot	Plasma experimental setup for lab	Supply & installation of plasma experimental system.	System installed & demonstrated in Dec 2019.
4)	DST. & CSMCRI Bhavnagar	Feasibility study for safe disposal of industrial spent solvents & chemical waste using thermal plasma technology	Feasibility study report with energy recovery data.	Experiments on plasma gasification of solvent waste using IPR's plasma pyrolysis system installed at CSMCRI were completed.
5)	DST. & MANTRA, Surat	Environment friendly plasma system for in-line treatment of textile at moderate speed	Design and development of system, and its delivery to MANTRA, Surat.	System installed at MANTRA, Surat
6)	Heavy Water Plant, Manuguru	Calibration of Optical pyrometers	Calibration	Work completed and report submitted to HWP.
B) Projects Started				
Sr. no	Organisation	Description	Deliverables	Status
01	U R Rao Satellite Center-ISRO	Up-gradation of SPIX-II project to SPIX-III	Reports on study of interaction between space plasma and solar panels	Procurement of components for upgrading SPIX-II facility to SPIX-III is underway.
02	Vikram Sarabhai Space Centre (VSSC)- ISRO	Plasma erosion characterization of anode liner material	Test reports of plasma erosion characterization	First technical report submitted to VSSC. Procurement of components to upgrade the existing facility is underway.
03	Natural Storage Solutions Private Limited (NSSPL), Gujarat	Feasibility study of application of Plasma activated water & plasma jet for removal of fungus from lemon surface	Feasibility study report	Experiments with Plasma activated water and plasma jet were conducted. Initial results found promising.
04	Indian Space Research Organization	Synthesis and characterization of Boron Nitride nanostructures	1.Boron Nitride nano powder (~500 gm) to VSSC-ISRO 2. Report on synthesis and characterization of Boron Nitride nano powder	Boron Nitride nano powder (~500 gm) to VSSC-ISRO

A.2 Fundamental Plasma Physics

Plasma is being created and characterized in various conditions so as to explore its fundamental properties which can be later used for applications. Here it is being studied in very small scale laboratory experiments as well as in moderately bigger size like Large Volume Plasma Device

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A.2.1 Basic Experiments

A.2.1 Basic Experiments

Basic Experiments in Toroidal Assembly (BETA)

Observation of Toroidal Acoustic Mode in a Current-Less Toroidal Plasma: The existence of a Toroidal Acoustic Mode (TAM) in a nearly collision-less, magnetized current-less toroidal plasma has been demonstrated experimentally. The mode is found to be a discrete, global, axisymmetric mode with measured frequency nearly three times that of $\sqrt{2}C_s/(2\pi R)$, where $C_s=(T_e/M_i)^{1/2}$, Te is the local electron temperature, and M_i is the ion mass. The observed frequency is found to be independent of the radial location. The mode is found to be driven by the nonlinear interaction of a finite frequency acoustic-like mode with itself. The TAM is a discrete, global mode and is found to exhibit (m=1, n=0) symmetry in density fluctuations and (m≥0, n=0) symmetry in potential fluctuations, where m and n are the poloidal and toroidal mode numbers, respectively. It is found that the TAM mode interacts with the background fluctuations. The observed frequency of both the TAM mode and the driver mode is found to scale linearly with $1/\sqrt{M}$), where M_i is the ion mass, but with their slopes different by a factor of 2. This mode is found to have characteristics similar to Geodesic Acoustic Modes often found in Tokamaks.

Large Volume Plasma Device (LVPD)

Electron Temperature Gradient Turbulence Induced Energy Flux: The Large Volume Plasma Device (LVPD) has successfully demonstrated excitation of the Electron Temperature Gradient (ETG) driven turbulence in the finite plasma beta (β~0.06−0.4) condition, where the threshold condition for ETG turbulence, the ratio of density scale length to the temperature scale length, greater than 2/3 is satisfied. The observed mode follows wave vector scaling and frequency ordering as $k_\perp\rho_e \leq 1 << k_\perp\rho_i$, $\Omega_i < \omega << \Omega_e$, where $k_\perp$ is the perpendicular wave vector, ρ_e, ρ_i are Larmor radii of the electron and ion, respectively, and Ω_i, Ω_e, ω are the ion, electron gyro frequencies and the mode frequency, respectively. Simultaneous measurement of fluctuations in electron temperature, ~(10−30)%, plasma density ~(5−12)%, and potential ~(1−10)% are obtained. A strong negative correlation with correlation coefficients of~−0.8 and ~−0.9 are observed between the density and potential and temperature and potential fluctuations, respectively. These correlated density, temperature, and potential fluctuations lead to the generation of turbulent heat flux. The measured heat flux is compared with the theoretically estimated heat flux from ETG model equations. The experimental result shows that the net heat flux is directed radially outward.

Observation of Electromagnetic Fluctuation induced Particle Transport in ETG Dominated Large Laboratory Plasma: The large volume plasma device (LVPD), a cylindrically shaped, linear plasma device of dimension (Φ = 2 m, L = 3 m) has been used to successfully demonstrate the excitation of electron temperature gradient (ETG) turbulence. The ob-

served ETG turbulence shows significant power for rotational modes of frequencies 25 to 90 kilo-radians per second for corresponding wavenumbers ~ (0.1 – 0.2)/(electron larmor radius). The observed frequency and wave number matches well with theoretical estimates corresponding to Whistler-ETG mode. We investigated electromagnetic (EM) fluctuations induced plasma transport in high beta (~0.01 - 0.4) ETG mode suitable plasma in LVPD. The radial EM electron (ion) flux are found to be resulting primarily from the correlation between fluctuations of parallel electron current and radial magnetic field. The EM particle flux is observed to be much smaller than the electrostatic particle flux. The EM flux is small, but finite, contrary to the conventional slab ETG model. A theoretical model has been developed for the EM particle flux in straight homogeneous magnetic field geometry. The estimates from the model are seen to compare well with the experimental observations. Sluggish parallel ion response is identified as the key mechanism for generation of small but finite EM flux.

Radial Variation of Electron Temperature Gradient in a Double Plasma Laboratory Device: Radial control of the electron temperature gradient is demonstrated in a double plasma device (figure A.2.1) by making use of segmented grid biasing. The plasma produced in the source region is allowed to diffuse into the target region through a single grid as well as through the cassette of multiple-grid assembly, under different grid bias conditions. Both electron heating and cooling are observed radially at one location in the target region when a single grid is used. The electrons are cooled down to a temperature of 3.3 eV from 5.1 eV when the grid bias is raised from −25 to 0 V. Similarly, during heating, the electron temperature increases from 4.8 to 7.3 eV when the grid bias is varied between 0 and +20 V. Two different transparencies of grids, 45% transparency (mess-size, m = 0.8 mm~λ_{De}) and 75% transparency (mess-size, m=2.4 mm>λ_{De}), are

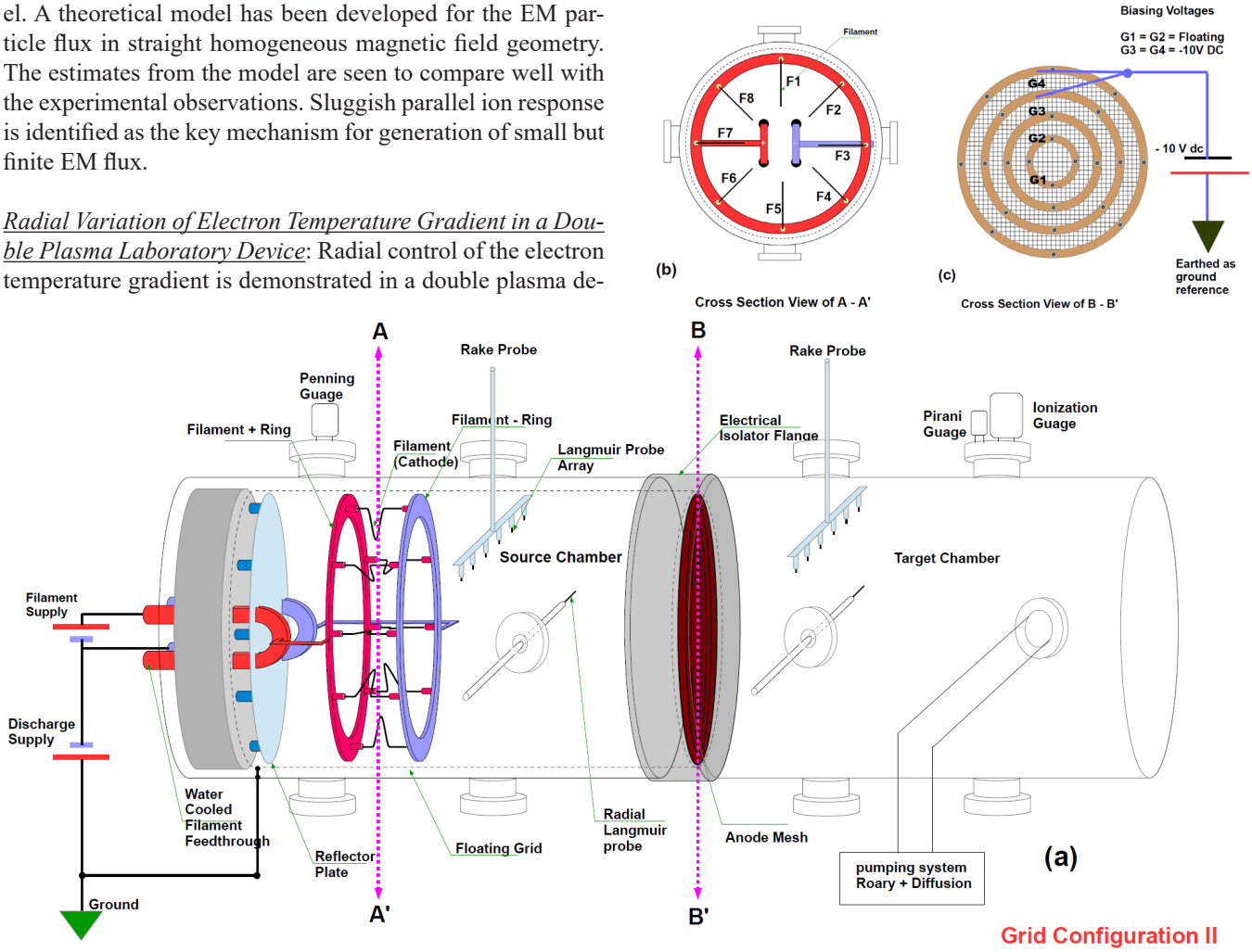

Figure A.2.1.a The schematic of the double plasma device (DPD) showing source and target chambers isolated by a Perspex ring 'I'. The cross-sectional view of the filament (A-A') and multi-grid arrangement (B-B') are shown in 'b' and 'c' respectively

used, where the value of $\lambda_{De} \approx 0.8$ mm. The obtained electron energy distribution function suggests that a grid with less transparency is more effective in cooling the electrons because of insignificant energetic electron–neutral collisions in the target region as a sheath in the close vicinity of grid allows only the high energetic electrons to pass through it. The higher transparent grid, on the other hand, produces electron heating as it exerts a negligible influence on the free flow of accelerated high energy electrons to target plasma due to insignificant thermalization. We expanded this concept and, for novelty, applied it to a radially segmented grid assembly of electrically isolated grids, for effectively charging different plasma regions with differently various potentials for exerting a radial control on electron temperature. The results obtained show that a significantly sharp electron temperature gradient is obtained with a typical gradient scale length of $L_{Te} \sim 10$ cm in the target plasma region. The outcome of this study may be useful both in plasma processing applications and for studying plasma turbulence in unmagnetized plasmas

Non-Neutral Plasma Device

Extension of diocotron mode period: Evolution of launched diocotron mode frequency of trapped toroidal electron plasma extending 40 second has been observed in Small aspect ratio partial toroidal experiment named SMARTEX-C (SMall Aspect Ratio Toroidal Electron plasma eXperiment – in 'C'). Exponential decay rate of stored charge for 100 - 300 Gauss range is observed to be independent of B-field at filament injection energy of 250 eV. Contamination of electron plasma by newly added electrons due to ionization of background neutral gas has to be lowered. Radial profile of floating potential of electron plasma using High impedance Langmuir probe diagnostics was attempted. To indirectly estimate the electron plasma temperature, gas puff of definite quantity of different gases has been investigated by launching diocotron mode at different instance of time. Effect of heavy gas molecules like N_2 and Argon as a function of gas pressure and interaction time with plasma has been investigated in detail. Diocotron launch technique was characterized for wave launch parameters to infer the data with better accuracy.

Developmental and technical work: Experimental setup is prepared to puff definite quantity of gas at desired instance of time in SMARTEX-C. Several concepts of TF coil were explored, out of which air cooled, 24 turn Cu bus-bar based picture frame TF coil has been designed. COMSOL based modeling of B-field, its ripple, and force for stress analysis of joints has been carried out. Non-Evaporable Getter (NEG) Pump was regenerated externally using Tungsten filament heating and temperature of the NEG cartridge was monitored using IR camera. On the mouth of the SMARTEX-C pumping system the base pressure of 2×10^{-10} mbar was obtained and in the trapping region vacuum of $6\text{-}8\times10^{-10}$ mbar was obtained. Charge collection/dump experiments were carried out, but it was found that dumps were not perfectly destroying the plasma owing to plausible finite resistance in the path. 4-channel I to V converter circuit has been implemented on the experimental system. Query based searchable data-base of experimental parameters of SMARTEX-C plasma shots has been prepared and installed on NNP-server. Test set-up for imaging diagnostics has been designed, fabricated and installation in progress.

Dusty Plasma Experiments(DPEx)

Experimental Investigation of Test Particle Induced Micro-Structural Changes in a Finite Two-Dimensional Complex Plasma Crystal: The microstructural changes induced in a two dimensional complex plasma crystal by the movement of a single extra particle existing below it are investigated experimentally using a DC glow discharge device. The finite monolayer crystal consisting of mono-dispersive melamine formaldehyde particles is created in the background of an Argon plasma. The crystal formation is frequently found to be accompanied by the presence of one or more slightly heavier particles suspended a little below the monolayer. The interplay of one such test particle with the crystal is investigated for two distinct cases—(i) when the particle remains confined (trapped) in the space below the crystal and (ii) when it interacts for a short time with the crystal and then moves out of the vicinity. The trapped particle orbit induces permanent structural changes in the crystal in the form of micro-cracks, and these changes are identified using a variety of diagnostic analyses. The cracks can be enhanced by energizing the test particle with an incident laser. The passing particle, on the other hand, induces only transient changes in the crystal from which it is able to recover and return to its initial state in a clear demonstration of the viscoelastic property of a strongly coupled system.

Effect of size and shape of a moving charged object on the propagation characteristics of precursor solitons: Experimental observations show the modifications in the propagation characteristics of precursor solitons due to the different shapes and sizes of the object over which the dust fluid flows. The experiments have been performed in a P shaped Dusty Plasma Experimental device where dusty plasma is created in

a DC glow discharge Argon plasma using kaolin particles. A floating copper wire installed radially on the cathode acts as a charged object in the plasma environment. The flow on the dust fluid is initiated by suddenly lowering the potential of the charged object from grounded potential to close to floating potential. The size (height and width) of the potential hill is varied by drawing current from the wire through a variable resistance. With a decrease in the height of the potential hill, the amplitude, velocity, and number of excited precursor solitons are found to decrease, whereas the widths of solitons are seen to increase. It is found that below a threshold value, these solitary waves are not excited, and the dust fluid simply flows over the hill. To examine the effect due to the shape of the potential profiles, the wire is replaced by a triangular object. Only trailing wakes are seen to be excited when the dust fluid faces the linearly increasing slope of the potential profile, whereas both solitons and wakes get excited when the object is placed with the sharp edge facing the flow. All the experimental findings qualitatively agree with numerical solutions obtained with different source terms in the forced-Korteweg–de Vries model equation.

Multi-Cusp Plasma Device

Characterization of Argon Plasma in a Variable Multi-Pole Line Cusp Magnetic Field Configuration: A detailed characterization of argon plasma confined by a multi-pole line cusp magnetic field (MMF) over a large cylindrical volume (1 m axial length and 40 cm diameter) has been done. Various magnetic field configurations with various magnet current scenarios have been obtained from the magnetic field simulation in the vacuum. From the experimental results, it is been observed that for such a field configuration the confinement of the primary electrons increases and leak width (plasma escaping through the cusp) of plasma decreases with increasing the magnetic field. As a result the mean density, particle confinement time and the stability of the plasma increase with increasing magnetic field values. In addition to this, the radial uniformity of the plasma density across the magnetic field is found to be explicitly depending on the magnetic field values of MMF. Moreover, the nature of turbulence in a quiescent argon plasma has been identified.

Evidence for neutrals carrying ion-acoustic wave momentum in a partially ionized plasma: An experimental study of Ion Acoustic (IA) wave propagation is performed to investigate the effect of neutral density for Argon plasma in an unmagnetized linear plasma device. The neutral density is varied by changing the neutral pressure, which, in turn, allows the

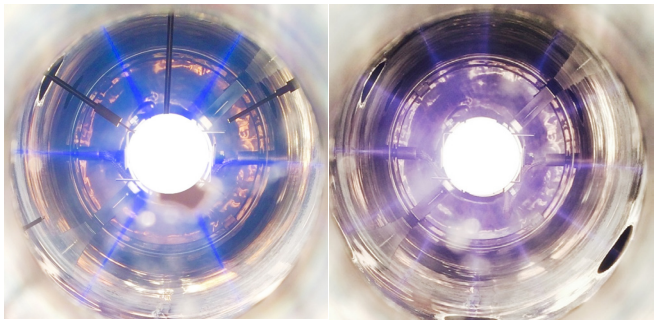

Figure A.2.2 (a) Twelve Pole Six Magnets and (b) Six Pole Six Magnets configurations of the Multi-Cusp Plasma Device.

change in ion-neutral, and the electron-neutral collision mean free path. The collisions of plasma species with neutrals are found to modify the IA wave characteristics such as the wave amplitude, the velocity, and the propagation length. Unlike the earlier reported work where neutrals tend to heavily damp the IA wave, the present study suggests that the ion-neutral collisions support the wave to propagate for longer distances as the neutral pressure increases. This happens when the ion-neutral collisional mean free path is comparable to the wavelength of the wave. A simple analytical model is derived to qualitatively support the experimental findings. This study was done on a Twelve Pole Six Magnets (TPSM) configuration (Figure A.2.2a) which has been found to have better confinement properties than the Six Pole Six Magnets (SPSM) configuration (Figure A.2.2b). Both of these configurations can be obtained in the Multi-Cusp Plasma device by passing appropriate currents in the electromagnets.

Magnetized Linear Plasma Device

Spatial Temperature Profile in a Magnetized Capacitively Coupled Discharge: A floating emissive probe has been used to obtain the spatial electron temperature (T_e) profile in a 13.56 MHz parallel plate capacitive coupled plasma. The effect of an external transverse magnetic field and pressure on the electron temperature profile has been studied. In the un-magnetized case, the bulk region of the plasma has a uniform T_e. Upon application of the magnetic field, the T_e profile becomes non-uniform and skewed. With increase in pressure, there is an overall reduction in electron temperature. The regions adjacent to the electrodes witnessed a higher temperature than the bulk for both cases. The emissive probe results have also been compared with particle-in-cell simulation results for the unmagnetized case. The experimentally obtained T_e is twice the value obtained using PIC results. However the

trends of both experimental and PIC results are in fairly good agreement and serves to validate the usefulness of the emissive probes in RF discharges.

Positive Ion Impediment across Magnetic Field in a Partially Magnetized Plasma Column: The radial characterization of a partially magnetized plasma column created by a hot cathode filament has been done. It is found that in the absence of a magnetic field, plasma potential and density profiles follow the Boltzmann distribution. However when a magnetic field is introduced, a clear divergence from Boltzmann distribution is seen as the plasma density becomes more pronounced in the center whereas a corresponding minima is observed in plasma potential. This radial potential profile impedes the radial diffusion of positive ions towards the grounded sidewalls. A phenomenological model based on short-circuiting effect is developed, which fairly explains this contrasting behavior.

Influence of Cold Hollow Cathode Geometry on the Radial Characteristics of Downstream Magnetized Plasma Column: The effect of cathode geometry on the radial characteristics of a downstream plasma column has been studied for a cold cathode type of hollow cathode (HC) system. It is observed that when an axial magnetic field is applied to a cylindrical cathode, the downstream plasma exhibits an off-centered peak in the plasma density. However, as the magnetic field increases, the discharge extinguishes rapidly above a critical value, due to the suppression in secondary electron emission from the cylindrical cathode surface. On the other hand, by replacing the hollow cylinder with a cone-shaped cathode an oblique sheath is formed with respect to the axial magnetic field. This configuration helps in sustaining the discharge at twice the magnetic field than in the cylindrical case. It is also found that the downstream plasma exhibits a peak plasma density at the center for the case of the conical cathode. A phenomenological model explaining the above experimental observations for each HC setup has been developed which helps to understand the phenomena qualitatively.

Understanding Langmuir Probe Characteristics of a Magnetized Plasma Column in Partial Contact with Grounded Probe Reference: An experimental investigation has been carried out on Langmuir probe measurements in a magnetized plasma column which exhibits two-temperature electron populations. It is a known fact that probe I(U) traces follow the usual exponential law if the measurements are performed with a reference electrode in good contact with plasma; which is usually a grounded discharge electrode. However in the present case, as the grounded probe reference is not a part of the discharge circuit the resulting I(U) analysis is not straightforward. It is found that owing to the high impedance between bulk plasma and probe reference, the probe measurement results in lower values of electron saturation current as compared to the ideal scenario. For an appropriate correction, a simple analysis technique has been proposed to interpret probe I(U) traces resulting from such magnetoplasma devices, where reference to the probe is in partial/poor contact with the bulk plasma. This correction is found to be satisfactory.

Effect of Magnetization on Impedance Characteristics of a Capacitive Discharge using Push-Pull Driven Cylindrical Electrodes: The impedance characteristics of a 13.56-MHz capacitively driven, symmetric magnetized discharge, created in argon and helium using an array of cylindrical electrodes, has been done. It is found that the discharge produced in argon is largely capacitive, while it tends to become inductive as the axial magnetic field strength increases. However, an opposing trend is seen in the case of helium discharge. On the other hand, the effective resistance is seen to continuously decrease for both helium as well as argon. The effect of increasing the radio frequency (RF) power levels is seen to have a marginal effect in the plasma density formed between the discharge electrodes, whereas the density rise is quite significant with the increase in the magnetic field. This behavior has been attributed to power mode transition from ion to electron heating inside the discharge.

Inferring Plasma Parameters from the Sheath Characteristics of a DC Biased Hairpin Probe: The cylindrical sheath around a hairpin resonator probe has been varied by applying a dc potential to the hairpin to infer different plasma parameters in an argon and oxygen discharge. As the sheath width increases due to negative bias, the resonance frequency of the hairpin correspondingly shifts towards a lower value. An analytical model based on fluid approximation has been developed to estimate the sheath width variation as a function of the applied voltage on the probe. The analytical result is compared with the well-known capacitance model that assumes a conjugate dielectric region around the hairpin consisting of a pair of cylindrical sheaths and the plasma. Using this method, a wide range of plasma parameters, including the electron temperature, plasma potential, and electronegativity parameter have been obtained in an electronegative oxygen discharge. This method has been found advantageous over the conventional floating hairpin resonator probe.

Transverse magnetic field effects on spatial electron temperature distribution in a 13.56 MHz parallel plate capacitive discharge: The effect of a transverse magnetic field on spatial electron temperature Te distribution along the line joining the center of capacitively driven rectangular discharge plates, operated at 13.56 MHz in a push-pull configuration, has been studied. It is found that the electron temperature distribution is almost uniform at low operating pressure (1 Pa). However, as the background pressure increases, the electron temperature tends to peak near the discharge plates. The overall magnitude in T_e is also found to increase throughout the volume on account of increasing the background pressure. This experimental observation has been qualitatively depicted by COMSOL Multiphysics® fluid simulation. The reason for observing higher electron temperature peaks near the discharge plates has been explained on the basis of stochastic electron heating due to the rapidly moving RF sheaths.

Positive ion speed at the plasma–sheath boundary of a negative ion-emitting electrode: One-dimensional fluid model has been developed for a planar sheath in front of a negative ion-emitting electrode surface immersed in a collision-less, non-magnetized, electronegative plasma. It was found that the positive ion speed at the plasma–sheath boundary (PSB) increases linearly with negative ion emission from the electrode but attains a saturation value as soon as a virtual cathode is formed near the electrode surface. The effect of negative ion emission on the pre-sheath region shows that the potential drop increases across the pre-sheath in accordance with the rise in positive ion speed at the PSB. The sheath width obtained using the present model shows a similar trend as the Child-Langmuir law, but its magnitude is found to be consistently higher compared with a non-emitting electrode.

The Role of Apex Angle of a Cone-Shaped Hollow Cathode on Plasma Parameters: An analytical model based on particle and energy conservation equations has been developed to determine the plasma parameters inside conical and cylindrical hollow cathodes. Using this model, the effective plasma size and its dependence on the apex angle of the cathode has been formulated. The study shows that the plasma density falls monotonically, while electron temperature rises as the apex angle of the cone increases. This is caused due to a contraction in the effective plasma size inside the conical cathode. The plasma parameters obtained from the experimental measurements inside conical and cylindrical cathodes are found to be in qualitative agreement with the model.

Helicon Plasma for Negative Ion source

Quantification of Atomic Hydrogen Anion Density in a Permanent Magnet Based Helicon Ion Source (HELEN) by Using Pulsed Ring Down Spectroscopy: A permanent magnet-based helicon plasma source (HELEN) has been characterized as a negative ion source. A non-invasive diagnostic technique based on cavity ring down spectroscopy (CRDS) is developed to measure the line-integrated negative hydrogen ion (H^-) density in HELEN. Experimental negative hydrogen ion density has been measured for different magnetic field, pressure, and RF (13.56 MHz) power configurations. It is observed that in high power range (800–850 W),

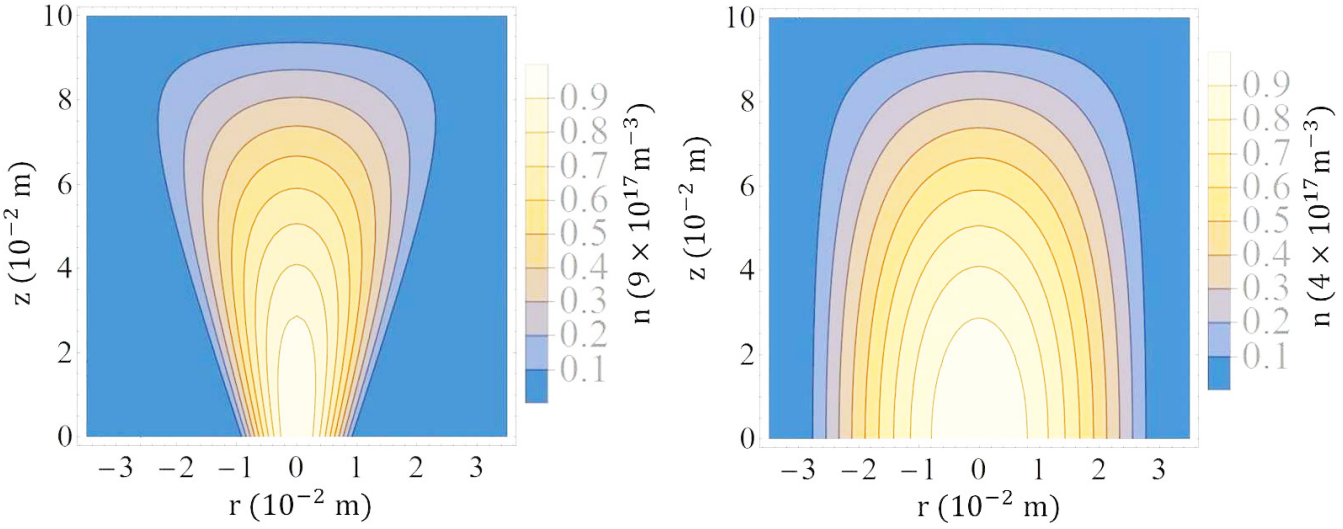

Figure A.2.3 Simulated plasma density (a) conical and (b) cylindrical hollow cathode shapes

the source is operating in helicon wave heating mode with a background plasma density of ~10^{18} m^{-3} and electron temperature of ~2 eV. Negative hydrogen ion density is measured by CRDS method and also by optical emission spectroscopic technique. The measured negative ion density is in the range of ~10^{16} m^{-3} under volume mode operational condition even without any use of standard magnetic filter or cesium seeding in the downstream region. The influence of pressure variation (pressure range from 4×10^{-3} mbar to 4×10^{-2} mbar) on negative ion density production is not significant, except for a particular axial magnetic field configuration (55 G) and at 8×10^{-3} mbar pressure, where ~34% hike is observed.

Discharge Properties of Helicon Oxygen Plasma in the Source and Expansion Chambers: A study of a helicon discharge has been performed with O_2 gas, operating at 13.56 MHz frequency and powers between 0–1500 W and pressure between 3×10^{-3} and 8×10^{-3} mbar. Measurements of plasma parameters were made in the plasma production chamber as well as in the downstream expansion chamber. In the source chamber, transition from E to H and finally to W mode appears by increasing the input radio frequency (RF) power. To the best of our knowledge, this is the first detailed report of Helicon mode transition in Oxygen discharge. Mode transition is further confirmed by studying the radial density profile and by external matching circuit parameters measurement. Comparison of Langmuir probe I-V measurements and electron energy distribution function (EEDF) in source and expansion chambers confirms formation of negative ions. Negative ion fraction has been measured in the expansion

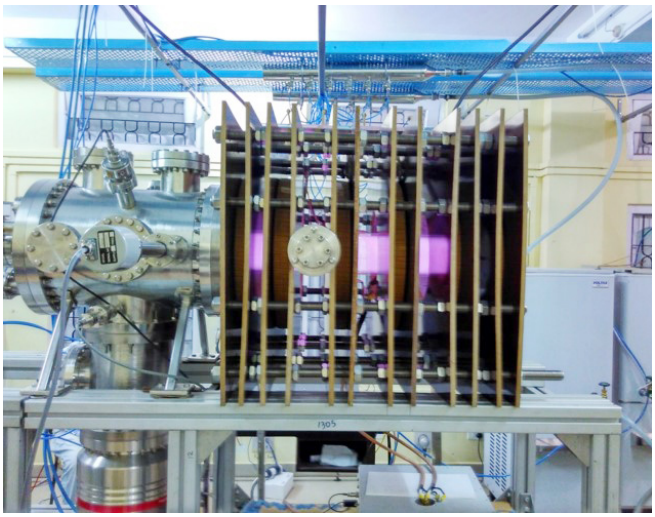

Figure A.2.4 Oxygen Plasma produced by Helical Discharge

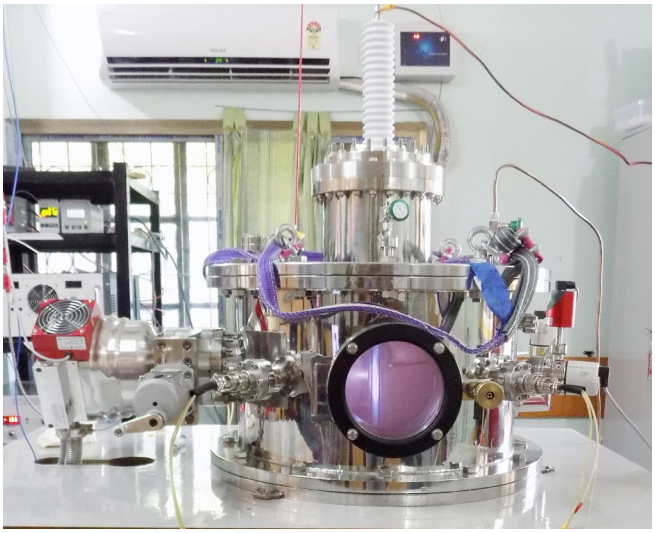

Figure A.2.5 Production of plasma discharge in the cylindrical IECF device.

chamber by using two-probe method and densities of charged particles (electrons, positive and negative ions) have been calculated using standard Langmuir probe theory and quasi-neutrality condition.

Inertial Electrostatic Confinement Fusion (IECF) Device

Studies on Virtual Electrode and Ion Sheath Characteristics in a Cylindrical IECF Device: An experiment on the formation of virtual electrode and ion sheath characteristics has been carried out in a hot cathode discharge plasma produced inside a cylindrical inertial electrostatic confinement fusion device. The plasma parameters such as electron temperature and plasma density are evaluated by using a Langmuir probe. Transition from a single potential well to multiple potential wells, i.e., virtual electrodes inside the cathode grid, is observed when the bias voltage applied to the cathode is increased from –1000 to –5000 V. An emissive probe has been used for the measurement of plasma potential due to its greater accuracy than the conventional Langmuir probe. Ion sheath potential structures and pre-sheath characteristics for different cathode potentials investigated using the emissive probe are found to be consistent with the Debye sheath model.

Other Devices

Effect of Inhomogeneous Magnetic Field on Plasma Generation in a Low Magnetic Field Helicon Discharge: A method has been found to produce plasma efficiently by a helicon

wave in a non-uniform magnetic field near the antenna center. Experiments are carried out with different non-uniformities of the magnetic field near the antenna keeping the magnetic field at the center of the antenna <100 G. Coupling efficiencies are studied by measuring the antenna current with and without plasma. Plasma production efficiencies are also estimated in all the different magnetic field topologies. It has been observed that the coupling efficiency increases with the magnetic field non-uniformity. Observation of the beat wave in the axial variation of the axial wave magnetic field suggests the presence of different radial wave modes. Measurements of the axial wavenumber along with the estimation of the radial wavenumber suggest wave propagation near the resonance cone causing more absorption. It is found that the density obtained by introducing a non-uniform magnetic field results in a higher density than the conventional helicon. Finally, the wavelength is measured for the non-uniform magnetic field near the antenna when the magnetic field is kept at 25 G and 50 G at the antenna center. For the 25 G case, the measured axial wavelength is found to be twice the length of the antenna. This suggests that the half wavelength antenna excites the full wavelength helicon wave. However, in the 50 G case, the measured wavelength is shown to be approximately equal to the antenna length.

Whistler Wave Propagation and Interplay between Electron Inertia and Larmor Radius Effects: The influence of Larmor radius effects on the propagation of whistler waves is investigated experimentally in laboratory plasma. The waves are excited using a loop antenna of diameter less than the electron skin depth, the natural scale length in this regime. In an earlier experiment, it was shown that such waves assume an elongated shape with perpendicular dimensions of the order of skin depth. In the present work, we show that wave propagation is significantly modified when the external guiding magnetic field is decreased. The wave spreads in the perpendicular direction in spite of starting of as an elongated whistler due to electron inertia effects. In the near region, the antenna field becomes dominant even forming null points, with the physical processes taking shape and wave still being guided by the net background magnetic field. However, the feeble external magnetic field in the region away from the antenna is unable to guide the wave any further and the wave

Figure A.2.6 The experimental device to study the Whistler waves.

spreads. In spite of a large current pulse, the wave remains linear ($\Delta B/B_0 \leq 1$). The observed results are attributed to the interplay between electron inertia and finite Larmor radius effects and are explained in terms of a modified physical model.

Comparative Study of Discharge Characteristics and Associated Film Growth for Post-Cathode and Inverted Cylindrical Magnetron Sputtering: In this study, an experimental investigation of a DC cylindrical magnetron discharge for argon gas in post-cathode (i.e. direct) and hollow-cathode (i.e. inverted) configurations was carried out. The discharge properties at different externally applied magnetic fields and operating pressures were measured and compared for both the configurations. The discharge current (I)–voltage (V) characteristics obey $I \propto V_{n,}$ where the value of n is in the range of 3–8. The discharge current increases linearly with the magnetic field in the post-cathode configuration, whereas it saturates at higher magnetic fields in the case of inverted configuration. Measurement of plasma potential indicated a considerable anode fall in the inverted magnetron configuration, whereas a negligible anode fall and strong cathode fall were observed in the case of post-cathode configuration. The plasma density and electron temperature, measured using a double Langmuir probe, were observed to be higher in the inverted magnetron configuration. The plasma density was found to be maximum at around 3–4 cm away from the respective inner electrode in both the configurations. A clear change in surface morphology of copper thin film was observed in the case of inverted magnetron configuration, which might be due to the extra ionization near the anode owing to the anode fall.

Zero Bias Emission Current in Laser Heated Emissive Probe and Proper Choice of Probe-Tip Material: Emissive probes are considered as one of the best diagnostic tools for the direct measurement of plasma potential in low temperature plasma systems. Laser-heated emissive probes (LHEPs), due to their higher lifetime, are becoming more popular than their current-heated conventional counterparts. Graphite due to its higher absorption coefficient at CO_2 laser wavelength and LaB_6 due to its lower work function are commonly used as the probe materials for laser heated probes. Experiments with a probe-tip made of a graphite material have revealed that the emission processes other than thermionic emission also occur on heating the material with the laser, which can affect the plasma potential measurements and change the I-V characteristics of the LHEP. This additional emission due to the laser irradiation on the graphite-tip explains the measurements of lower values of plasma potentials and also describes the observation of an increase in electron saturation current with the increase in thermionic emission current due to heating. The possible mechanisms of this negatively charged-emission other than the thermionic emission from the graphite-tip have been thoroughly characterized in the absence of plasma. The above mentioned additional emission is not observed in the probe-tip made up of LaB_6, and hence a good comparison of I-V characteristics could be established with a conventional filament emissive probe.

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A.3 Tokamak Plasma Experiments

Experiments on the two tokamaks, ADITYA-U and SST-1, continued to make steady progress. The highlights of experiments on ADITYA-U include realization of plasma parameters close to the design values, deployment of a novel electromagnetic high-speed pellet injectors for the first time, experimental studies related to runaway electron generation and losses, toroidal rotation studies and modulation of drift tearing MHD modes. Continued technology improvements on SST-1 yielded, for the first time, a record 15 days of plasma operation with maximum ohmic pulse current durations of 650 ms, a good 200 ms improvement over the one obtained last year. The following sub-sections of this section provide details of the above.

A.3.1 Aditya Tokamak

Aditya-U operations have been mainly focused on realizing plasma parameters close to the design parameters of circular plasmas in limiter configuration and also the preparation for initiation of shaped-plasma operation. Emphasis has been given to novel experiments on runaway electrons (REs) and disruption control in the Aditya-U. Furthermore, experiments on radiative-improved modes using Ne, Ar gas injection, modulation of MHD modes and edge turbulence using periodic fuel gas-puffs, density dependence of plasma toroidal rotation reversal, and 42 GHz ECR assisted low loop voltage start-up and heating experiments, have been carried out.

Discharge Parameters Improvement in Aditya-U: During the past year, repeated cycles of vacuum vessel baking up to 135° C, followed by extensive wall conditioning using novel pulsed-GDC (glow discharge cleaning) along with lithium coating resulted in a lower base vacuum of ~ 6 x 10^{-9} m-Torr and substantial improvement of discharge parameters. The novel pulsed-GDC reduces the wall loading of hydrogen

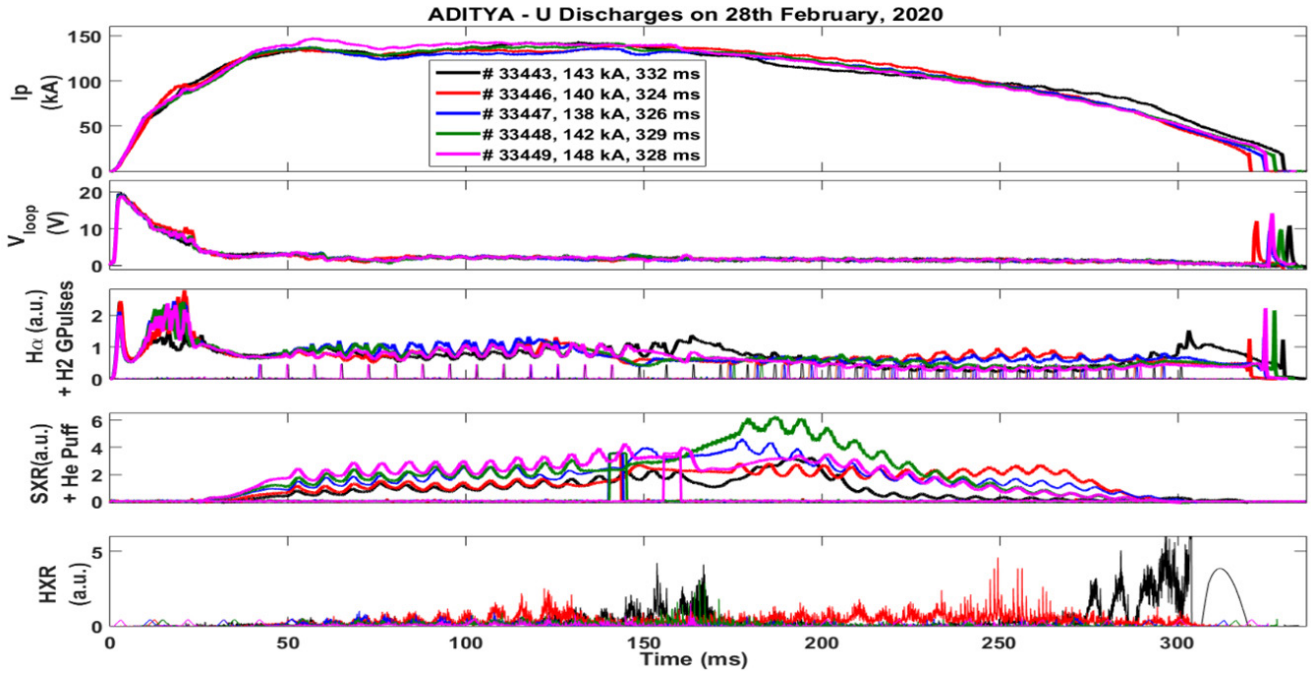

Figure A.3.1.1 Discharge performance improvement in Aditya-Upgrade Tokamak Operations.

to obtain better density control. Use of negative convertor operation along with real time horizontal plasma position control stretched the hydrogen-plasma pulse length beyond 330 ms in repeated discharges of I_p ~ 150 kA as shown in Figure A.3.1.1 without any pre-ionization for the first time. Various Lithium wall conditioning techniques have been developed, such as (a) Heated Lithium rods insertion in H_2-GDC (b) Lithium fueling by developed evaporator system (c) Combination of Lithium fueling and H_2-GDC (d) Combination of Ar-H_2 mixture GDC followed by Lithium fueling and H_2-GDC, for improving the Lithium coating. The results of different techniques have been compared in order to obtain the optimum technique for Lithiumization. A major vessel opening has been carried out for installation of ICRH antenna and other diagnostics in November and the plasma operations resumed from February-2020. Furthermore, deuterium gas puff experiments have been carried out in preparation for full deuterium discharges, in which the discharges are initiated in Hydrogen and Deuterium gas is puffed during the flat-top region of the plasma current to maintain density of the plasma. Preliminary experiments related to plasma shaping by charging the divertor coils during plasma current plateau, confinement improvement with ion cyclotron resonance (ICRH) assisted auxiliary heating and deuterium injection is ongoing.

Experiments in Aditya Upgrade tokamak

Electromagnetic Pellet Injection in Aditya-U Tokamak: Tokamak fusion devices are susceptible to rapid destruction of plasma in a process called a "disruption" – this is a major concern in reactor-scale devices like ITER, due to potential damage to the vacuum vessel & magnets. For the first time ever, an electromagnetic high-speed pellet injector has been deployed on the Aditya-U tokamak. The injected lithium titanate and lithium carbonate pellets reached the hot plasma core in a few milliseconds and radiated away its thermal energy, causing a rapid quench of plasma current. This experiment has been a collaborative effort between IPR and BARC, Visakhapatnam. The electromagnetic injector system has been developed and installed by the Computational Analysis Division, BARC, Vizag. An international patent application is being drafted on the same. For the first time, Aditya-U has experimentally demonstrated the use of electromagnetic pellet injection for firing the pellets into the tokamak plasmas for disruption mitigation studies. This is a significant development towards disruption control that can accomplish the critical need of disruption mitigation in future tokamaks including ITER. In these experiments, a projectile containing a radiative payload, weighing ~ 50 - 200 mg, is accelerated towards the core of the plasma with velocities of ~ 200-220 m/s using a linear coil gun accelerator as shown in the figure A.1.3.1.2. The projectile can deposit micron-sized dust deep into the plasma core and radiate away the stored energy in the plasma within a few milliseconds. Lithium titanate (Li_2TiO_3) and Lithium carbonate (Li_2CO_3) particles of sizes 50 – 80μm are used in the experiments. As a preparation for these experiments, standard reference discharges of I_p ~120 kA of 100 -120 ms duration have been established. Later, lithium titanate (Li_2TiO_3) impurity particles pellet has been injected

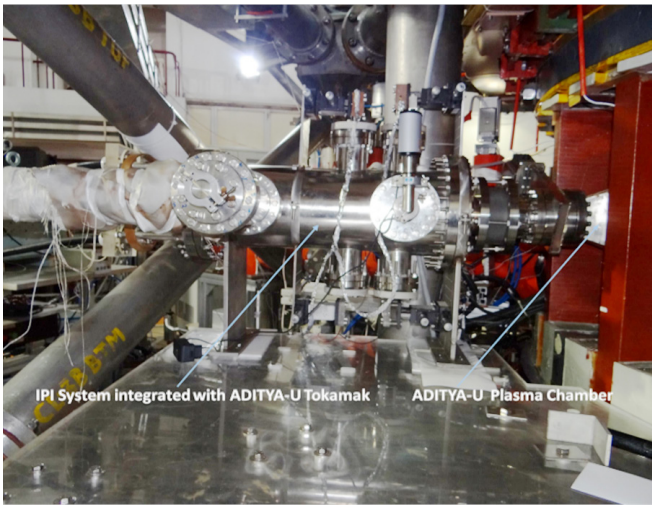

Figure A.3.1.2 – Electromagnet Pellet Injector integrated to the Aditya-U tokamak

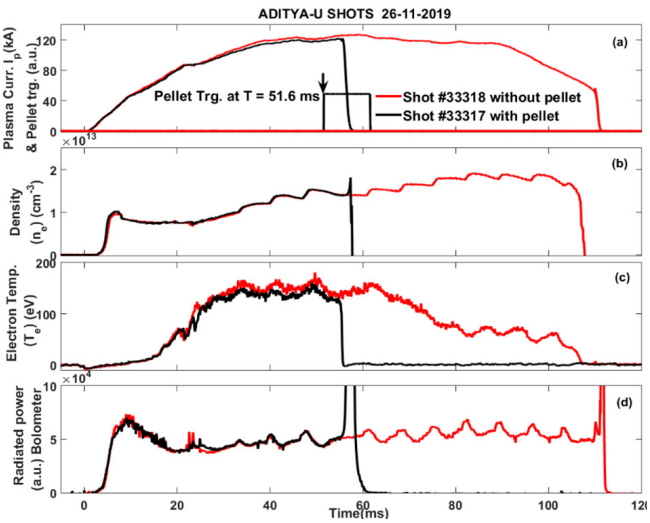

Figure A.3.1.3 Time evolution, (a) plasma current and pellet trigger pulse (b) electron density (c) electron temperature & (d) total radiated power with pellet (#33317, black) and without pellet (#33318, red)

into the plasma during the plasma current flat-top at ~ 51.6 ms. The impurity particles reached the core plasma within ~ 1.25 ms and causes fast termination of plasma current. The time evolution of two consecutive discharges, black curve (#33317) with particle injection and red curve (#33318) without pellet injection are shown in Figure A.3.1.3, representing the radiative dissipation of the plasma stored energy in the discharge in which particles are injected. The chord averaged electron density and electron temperature, terminates very rapidly (Figure A.3.1.3 (b) and (c) respectively), due to the increased plasma radiation (d) after the impurity particles are injected.

Runaway Electron (RE) generation and mitigation: Since RE dynamics remain as one of frontline areas of fusion research, several experiments have been carried out on RE generation and losses. Experimental observation indicate a possible role of turbulent fluctuations at the plasma edge and SOL regions in RE loss. Controlled experiments using periodic gas puffs have shown that the turbulent fluctuations present in the edge region play a role in the RE loss rate. When multiple gas-puff pulses are applied during the plasma current flat-top, the temporal evolution of HXR intensity also modulates in amplitude exhibiting prominent peaks with a full width at half maxima (FWHM) ~ 2 ms, following each gas puff along with fluctuations. The suppression and recovery of the HXR intensity strongly coincides with the suppression and recovery of turbulent edge fluctuations in all the studied discharges, which indicates a significant role of edge fluctuations on REs as shown in Figure A.3.1.4. This observation of correlated effect of electrostatic fluctuation on RE transport throws light on new mechanism of RE loss and may be exploited to design novel RE mitigation methods. Exploring further the RE formation mechanisms, controlled RE generation experiments have been carried out by lowering the plasma density and adjusting the vertical magnetic field. A fast visible imaging video camera, used for 2D tangential viewing, captured images which showed features of the RE beam formation with high spatial and temporal resolution as shown in Figure A.3.1.4 a. These results indicate the role of vertical fields in RE beam confinement, which can be modified in order to mitigate the disruption-generated REs in tokamaks. RE confinement is also observed to be modified during Supersonic Molecular Beam Injection (SMBI) experiments and the results indicate trapping of REs in large MHD islands formed due to SMBI.

Toroidal rotation studies: The toroidal plasma rotation velocity on Aditya-U has been measured using passive charge exchange line emission spectroscopy of C^{5+} spectral line at 529 nm. The line has been monitored using a space-resolved visible spectroscopy diagnostic consisting of a 1 m multi-track spectrometer coupled with a charge coupled device (CCD) detector. During operations, the plasma current is in the clockwise direction as viewed from the top of the machine. In typical ohmically heated limiter discharges with central chord-averaged electron density ~$2.5\times10^{19}m^{-3}$, the maximum toroidal rotation velocity at the plasma core is found to be ~20 km s^{-1} in the counter-current direction. Reversal of plasma toroidal rotation to the co-current direction is observed for high electron density discharges with a central chord-averaged density of ~$5\times10^{19}m^{-3}$. Interestingly, in the discharges with a central chord-averaged electron density of ~$2.5\times10^{19}m^{-3}$, where neon gas is injected at the plasma current flat-top, the toroidal rotation reversal has been observed after the gas puff. The maximum toroidal rotation velocity obtained after inversion is – 24 km/s in counter-current direction of plasma current and ion temperature of ~ 150 eV in the core. Most interestingly the direction of toroidal core plasma

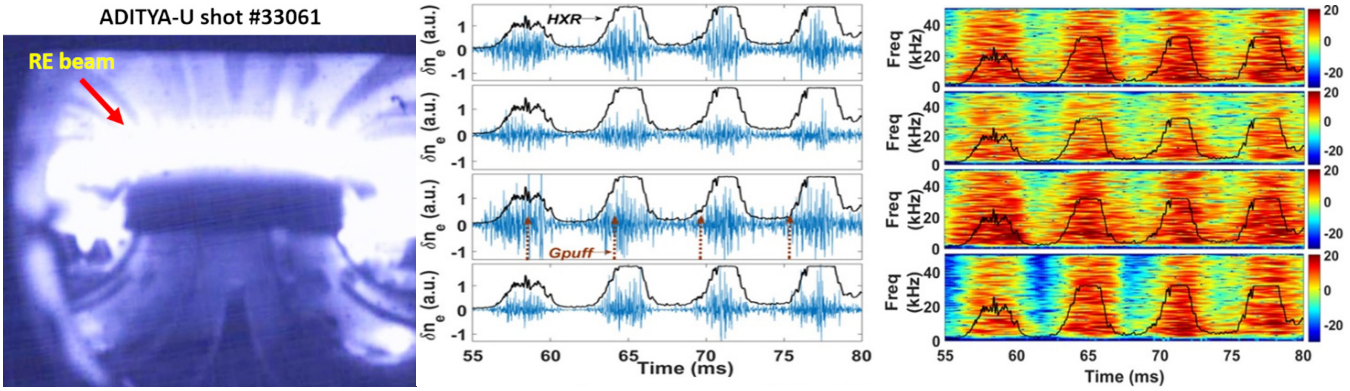

Figure A.3.1.4 (a) Two-dimensional tangential view of Aditya-U plasma with RE beams, (b) Correlation of Hard X-Ray with density fluctuations during gas-puff

rotation reverses from Counter-current to Co-current direction during and after the application of neon gas puff. The reversal of toroidal rotation may be related to the transition of discharges from linear Ohmic confinement to saturated Ohmic confinement in Aditya-U, since the Ne puffing is known to improve confinement through radiative processes.

Modulation of Drift-tearing MHD modes: Short gas puffs, injecting approximately ~10^{17}–10^{18} molecules of fuel gas (hydrogen) at one toroidal location, are found to concomitantly decrease the drift-tearing mode rotation frequency and the mode amplitude during the period of injection and then recover back to its initial values when the gas pulse is over. This leads to a periodic modulation of the rotation frequency and amplitude of the drift-tearing modes that is correlated with the periodicity of the gas pulse injection. The underlying mechanism for this change in the mode characteristic appears to be related to gas puff induced change in the radial profile of the plasma pressure in the edge region that brings about a reduction in the diamagnetic drift frequency. Detailed experimental measurements and BOUT++ code simulations support such a reduction in diamagnetic drift frequency. The results reveal a close interaction between the edge dynamics and core MHD phenomena in a tokamak that could help us better understand the rotation dynamics and amplitude pulsations of magnetic islands.

Electron Cyclotron Resonance Heating (ECRH) System

ECRH assisted breakdown: 42 GHz ECRH-assisted low-loop voltage plasma start-up and heating experiments have been carried out on Aditya-U. In these experiments, the Tokamak is operated at a toroidal magnetic field of 1.26-1.4 T and ECRH power in fundamental O-mode is launched from the low field side of the tokamak. The ECRH power and duration for breakdown have been varied from 75-150 kW and from 50-100 ms. In order to achieve pre-ionization, the ECRH input is started ~25 ms before the loop voltage. In Aditya-U tokamak, normal plasma discharges are achieved with a peak loop-voltage of ~20 V. With EC-assisted discharges, the peak loop voltage is reduced by 30-35 % to ~13V and successful normal plasma discharges are achieved at low-loop voltage.

ECR heating: Plasma heating experiments have also been carried out in Aditya-U using 42 GHz ECRH system. The typical plasma current is in the range of 100-115 kA and the discharge duration ~250 ms. EC power is launched at the flat-top of plasma current around 50 ms after start of loop voltage. The increase in soft X-ray signal indicates plasma heating. In various experiments, EC power is varied from 150 kW to 250 kW and the EC pulse duration is also varied from 50 ms to 150 ms. The heating effect is observed as the volume soft X-ray (SXR) signal gradually increased with EC-power. ECRH experiments will continue at higher magnetic fields.

A.3.2 Steadystate Superconducting Tokamak - 1 (SST-1)

Status and Operation

A good magnetic field null configuration inside the torus is a prerequisite for producing stable plasma start-up. Simulation studies suggested some modifications in one of the external correction coils of the central solenoid. Based on this study, additional 4 turns were wound in the existing correction coil (TR-4) and subsequently, the measured error field showed a significant improvement in the magnetic null configuration. This has been proven in two experimental campaigns conducted in the SST-1 tokamak: the April 2019 campaign was conducted with the objective of demonstrating the characteristics of plasma breakdown and start-up, particularly to see the effect of improved magnetic field null. Plasma experiments were carried out at a toroidal field of 1.5T, assisted by ECR pre-ionization, Ohmic and Lower Hybrid current drive. The major highlights were:

1) Improved cryo-insulation and optimal operation of the cryo plant led to the production of 50-60 liters/hour of Liquid Helium (LHe) along with cooling of TF and PF3 coils.
2) The TF coils were kept in a charged state, producing 1.5 Tesla field, for 8 hours with reliable operation of the Cryoplant system over 9 days.
3) For the first time in SST-1, all 3 modes of RF heating: ICRH, LHCD and ECRH, were injected into plasma in a single shot.
4) For the first time in SST-1, a plasma discharge was produced with the TF coils charged, simultaneously with the PF3 coils-set in the superconducting state.
5) Long-duration plasma discharges (~645ms) were obtained by using both the single long-pulse LHCD and multiple short-pulse LHCD.

Another campaign was conducted in September 2019 with an objective to scan the operating parameters for Ohmic current drive and optimize for best operational conditions. The major highlights were:
• Keeping the TF coils as well as PF-3 coils in the supercon-

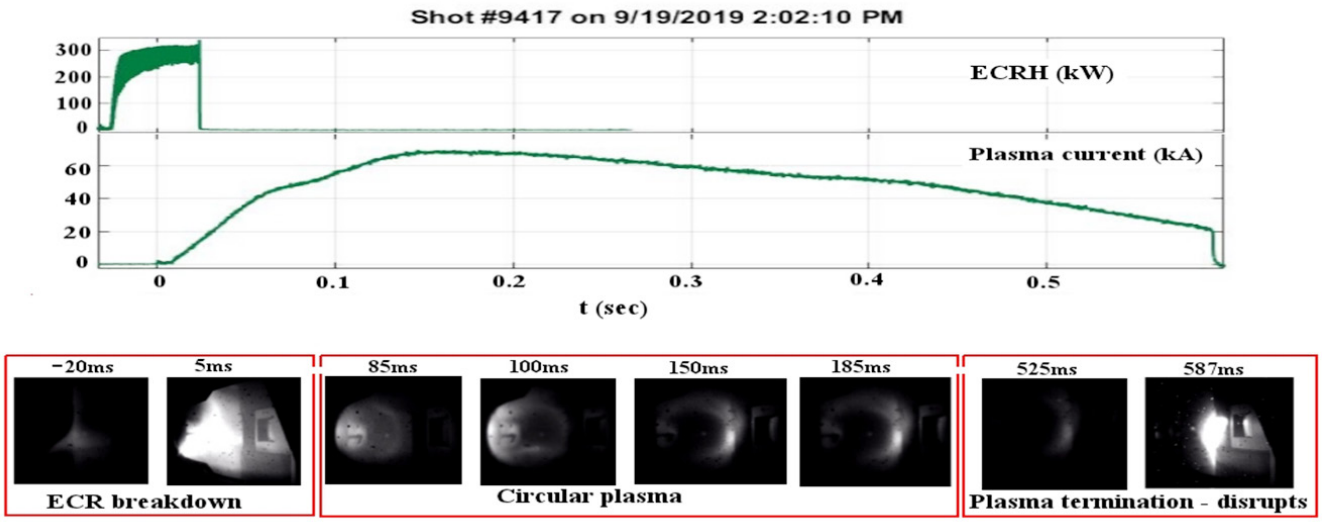

Figure A.3.2.1 SST-1 plasma with ~600 ms duration, higher than 450ms got before. This has been possible because of Lower Hybrid Current Drive along with many other optimizations done on the machine and its operation

ducting state, liquid helium was simultaneously produced at a rate of 40 l/h.

• For the first time, a record 15 days of plasma operation was carried out in SST-1 with the maximum Ohmic plasma current of duration 650ms, substantially higher than the 450 millisecond limit obtained in the 24th campaign.

• Multiple gas puff patterns at various times during the plasma discharge were tried to study their effect on suppression of Hard X-rays. The gas puffs indeed helped to suppress Hard X-Rays, resulted in enhanced plasma density, which was observed in many diagnostics, including the soft X-ray (SXR) signal

• Sawtooth oscillation is an important signature of successful plasma discharges in a tokamak. It is periodic relaxation of the core plasma density and temperature. This activity was also observed in some of the discharges in this campaign.

From October 2019 onwards, the SST-1 machine has been opened for short-term upgradation. It includes installation of (i) pair of PF-3 current leads required for moderately-shaped plasma, (ii) RF spiral antenna assembly for alternate pre-ionization and startup experiments and (iii) diagnostics like Thomson Scattering, Langmuir probes, Magnetic probes array, X-ray and Bolometer, etc. The next plasma experimental campaign is planned in June 2020.

Optimization of cryoplant operation for SST-1

During August-September 2019, optimal utilization of the SST-1 cryogenic plant has resulted in the following achievements:
1) A flat-top toroidal field current lasting for ~20,000 seconds was demonstrated using vapor-cooled current leads. This allowed a more than two-week long "window" for plasma experiments, a record for SST-1.
2) Simultaneous cool-down of the TF coils, PF coils and Case have been successfully demonstrated down to temperatures of 15-16 K.
3) For more than 24 hours, the PF-3 coil pair were kept at 7-8 K temperature, simultaneously with keeping TF coils in the superconducting state.

Current Feeder System (CFS) for SST-1 PF coils

In order to power the superconducting TF and PF#3 coils in SST-1 Tokamak, three pairs of 10 kA rated current leads are required. This will allow, for the first-time, shaped plasma operation in SST-1. The current feeder system (CFS) acts as a bridge between these SC magnets at 5 K and power supply kept at room temperature. So far in SST-1, only TF coils current leads (CL) were installed. Integration work for 2 pairs of CLs and associated SC bus bars is in progress.

This includes the following major steps:

i) Testing of CLs: Before integration, all four current leads are tested and qualified for helium leak tightness and resistance measurements. Availability of space/access is a major constraint. Electrical insulation of CLs is also a big challenge due to high inductive voltages.

ii) Vapor Cooled Current Lead for PF#3 Coils inside CFS Chamber: This involves fabrication of 4 numbers of SC bus-bars low-resistance joints between CL and coil, after ensuring proper alignment. These bus bars are made of Nb-Ti/Cu based CICC (Cable in-conduit conductor).

iii) Cryo-cooling: To cool the bus bars of PF#3 coils, the pressurized helium cryogenic circuit is rerouted and qualified for helium leak tightness. Similarly, to cool the Current Leads, a liquid helium (LHe) supply circuit has been envisaged and will be implemented shortly. Most of the low temperature surfaces will be covered by superinsulation MLI (Multi-Layer Insulation). Required temperature sensors, voltage taps, pressure drop transducers and flow meters will be deployed.

Ion Cyclotron Resonance Heating (ICRH) system

The 4th stage of SST-1 ICRH generator has been tested and has delivered 588 kW for a pulse duration of 0.1sec at 24.8 MHz. The 3rd stage power supply needs a fast protection system which acts within 10 μsec and also limits the fault energy within 10 Joules, to prevent damage to the Tetrode tube. A suitable 15kV, 30A solid state switch has been indigenously developed for open-circuiting the HVDC power supply. A new 1.5 MW cw ICRH source is being coupled to SST-1. As a first step, it has been tested for pulsed operation of the type required for SST-1 .

Lower Hybrid Current Drive (LHCD) System

Recent experiments show significant improvements in the operating pressure, thereby enhancing the efficiency of LHCD as it is now possible to launch the LHCD after a delay of several 100s of milliseconds of the ECRH pulse. Even multiple pulses of LHCD could help to drive the current. In the April 2019 campaign, long-duration plasma discharges (~645ms) were obtained by using both the single long-pulse LHCD and multiple short-pulse LHCD. It has been reported from other tokamaks (for e.g. Japanese tokamak TRIAM) that by modifying the loop voltage, one can get improved Lower Hybrid absorption. Efforts are underway on SST-1 to test the same in the forthcoming campaigns.

Data acquisition & control

Commercial SCADA packages are costly and are charged on per license basis. Also, they have a recurring cost of maintenance & upgrade. We have initiated the use of open source SCADA package for the following: Experimental Physics Industrial Control System (EPICS) and Control System Studio (CSS) to monitor and control SST-1 subsystems; cryogenics, vacuum and magnet. With the use of these tools, it has been possible to monitor SST-1 cooldown status over the intranet at anytime from anywhere with a single browser click. This has also lead to central archiving of data from these distributed subsystems. Deployment of these tools on other IPR projects is in process.

Thomson Scattering Diagnostic system

A Vertical Thomson Scattering system has been aligned and calibrated (spatial and wavelength) using Rotational Raman scattering from Nitrogen gas. An Nd:YAG Laser system and laser beam clustering has been arranged inside the Laboratory while the Imaging system which collects the scattered photons has been installed on the machine. An indigenously developed 5 channel Filter polychromator for spectral dispersion and detection of Thomson Scattered Photons has also been integrated.

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A.4 Fusion & Related Technologies

Under the purview of continuous progress related to fusion science and technologies , many technologies are being developed. A brief about the technologies developed under various heads are given here.

A.4.1 Magnet Technologies

Fabrication and testing of compact HTS solenoid coil: High temperature superconductors (HTS) are promising candidates for next generation high field compact magnets, since they do not require cryogenic cooling at 4 K. Coil winding, inter-pancake and terminal joints are challenging technologies required for the fabrication of HTS tape based high-field magnets. As a first step, IPR has fabricated a small bore (~50 mm) double pancake, liquid nitrogen bath-cooled, HTS solenoid coil with 24 turns and a height of 21 mm. This has produced a pulsed magnetic field of 1.1 Tesla with a current pulse of duration 0.72 millisec, and a DC magnetic field of 0.06 Tesla at 110 A current. Figure A.4.1.1 shows the HTS coil assembly used to measured magnetic fields. The next step will be to develop higher-field and larger bore HTS coils for practical applications -- these activities are covered in a new DPR titled “Fusion Technologies” that has been cleared by PAC and is awaiting DAE sanction.

Indigenous Development of Hybrid Nb3Sn and NbTi CICC joint: Systems with superconducting magnets often require joints between different kinds of superconducting materials. For the first time in India, IPR has developed a hybrid overlap joint of length 120 mm, for connecting Nb_3Sn and NbTi Cable-in-Conduit-Conductor (CICC). This is a thermally sta-

Figure A.4.1.1 HTS coil assembly

Figure A.4.1.2 Hybrid Joint integrated with the test insert

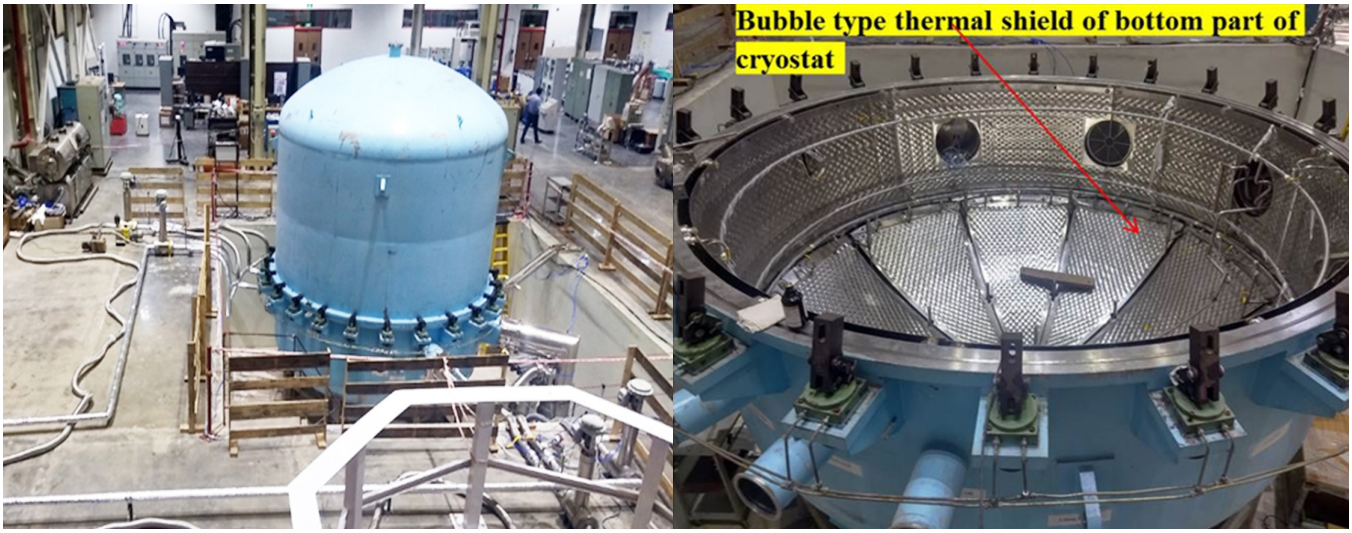

Figure A.4.1.3. (a) Integrated Magnet Test Facility (MTF) *(b)Thermal shields of bottom part of cryostat of the MTF*

ble joint operating at 4.5 K and currents upto 10 kA. This joint is of practical importance because it can be integrated in the limited space available near Nb_3Sn CICC-based superconducting magnets

Integrated Magnet Test Facility:An integrated magnet test facility (MTF) has been installed & commissioned at IPR. This facility is meant for testing high temperature (80-4.5 Kelvin) as well as low temperature (~4.5 Kelvin) superconducting magnets for fusion & other applications. It consists of a large Cryostat weighing 21 Tons and having a volume of 83 m^3, along with a liquid nitrogen thermal shield. It is capable of housing superconducting magnets with a maximum size of 5 m height and 4 m diameter. The vacuum and cool down performance of the thermal shields of this cryostat have been found to be satisfactory.

A.4.2 High Temperature Technologies

i) A new copper-alloy test mock-up of 400 mm length has been specially developed for conducting experimental studies on Critical Heat Flux(CHF) for One-Sided Heating using the High Heat Flux Test Facility (HHFTF). Critical Heat Flux for quasi-steady heat flux condition is observed during the experiments. Subsequent experiments with transient heat flux indicate that CHF for fast rising transient heat-flux is lower than the quasi-steady heat flux.

i) HHFTF has been used to perform heat removal testing on the Back-Plate of Positive Ion Neutral Beam Injector (PINI). Electron Beam of HHFTF was operated at full power of 200 kW at 45 kV acceleration voltage for ~450 s to generate a steady-state heat flux of 2.5 MW/m^2 on the entire surface of the back-plate. Infra-Red Mapping of the surface of back-plate is performed to generate 2D temperature profile during High Heat Flux testing.

iii) A Tungsten-coated target (450 mm long, 30 mm wide) with copper-alloy substrate, developed by ARCI, has been successfully tested for its performance at 500 C surface temperature ($3MW/m^2$ heat flux) for 1000 thermal cycles using HHFTF. Tungsten coated sample is also successfully tested during thermal fatigue tests performed using the Gleeble system for 1000 cycles from 100 to 500°C.

iv) Brazed Tungsten Mono-block fabrication technique developments/improvements for divertor targets are continued. Improved machining techniques resulted in achieving better concentricity of machined hole in tungsten and casted copper within +/- 100 microns as per ultrasound investigations. In the attempts made to braze copper-alloy tube with copper-casted tungsten mono-block tile using horizontal assembly, brazing is achieved with minor defects.

v) Vacuum Brazing has been performed for development of Straight Section and Y-Section Wave-Guides.

A.4.3 Fusion Blanket Technologies

Thermal-hydraulics and structural analyses of LLCB TBM set: Indian Lead-Lithium cooled Ceramic Breeder (LLCB)

Test Blanket Module (TBM) is one of the tritium breeding Fusion blanket concepts. First wall (FW) is a plasma facing component of the TBM designed to withstand high heat flux from plasma. FW is cooled by high pressure, high temperature helium gas flowing through coolant channels. The detailed thermal–hydraulics of FW has been performed based on the heat flux and neutronic heat generation. using ANSYS CFX. The distribution of flow in different flow circuits of FW from manifolds has been performed and the flow distribution is found to be uniform in all the circuits. Thermal-hydraulic analysis of helium flow inside the FW channels has been done and then the manifolds to estimate temperature, pressure drop and heat transfer coefficient have been documented. TBM shield is located behind TBM to provide shielding from high energy neutrons to magnets and other components behind the TBM set. Water flows in parallel channels inside TBM Shield, provides the function of neutron moderator as well as coolant to remove heat deposited by the neutrons in the structure. Flow rate in parallel channels of shield has been regulated using orifice of different diameter. CFD Flow analysis inside shield has been performed to validate the distribution of flow inside the parallel channels. Based on velocities obtained, the heat transfer coefficients have been evaluated and thermal analysis of TBM shield has been performed considering thermal load from neutronic heat generation. The results obtained from thermal–hydraulic analysis of FW, manifolds and TBM shield have been used for thermo-structural analysis of LLCB TBM set based on load combinations as per ITER load specifications. RCC-MR 2007 code has been used for the structural assessment and prevention of ptype and s-type damages. The temperature and stresses are found to be within the acceptable limits and safety margins with some proposed modifications.

Performance Assessment of the Helium Cooled First Wall Mock-Up in HELOKA Facility: The Lead-Lithium Ceramic Breeder (LLCB) Test Blanket Module (TBM) being developed by India for testing in ITER adopts various well developed design engineering and manufacturing technologies. The First Wall (FW), which is directly exposed to the incident heat flux, is designed for high pressure helium flow, high operating temperature (up to 100 bar and 550 °C) and considerable thermal stress and electromagnetic disruption loads. In order to check the thermal performance of the FW and ensure its structural integrity, a mock-up of the FW fabricated in India was tested in HELOKA test facility at KIT, Germany. Both normal and accidental operating conditions were investigated under ITER-like surface heat fluxes. Based on these results the thermal performance of the FW were validated.

3D Modelling of Loop Layout, Pipe Stress Analysis and Structural Responses of High-Pressure High-Temperature Experimental Helium Cooling Loop (EHCL): An Experimental Helium Cooling Loop (EHCL) is being developed as a part of R&D activities in fusion blanket technologies. This system is designed to test various nuclear fusion blanket mock-ups. The primary loop is designed to remove 75 kW heat load on the Test Section Module (TSM). This system is a high-pressure high-temperature loop which produces significant deflections and thermal expansions in the piping network, which leads to the reaction forces and moments. During the earthquake, an additional high acceleration acts (in all directions) on the piping system which again enhances the pipe deflections. EHCL equipment arrangement, loop layout, methodology and results of pipe stress analysis have been studied. EHCL equipment are connected through DN 50 schedule 80 major pipes and associated valves. The high temperature piping network is analyzed for sustained and occasional load responses to ensure the integrity of the system. The process piping code ASME B31.3 is referred for pipe stress analysis. The calculated stresses are in acceptable limit. The least available stress margin is ~29% and the corresponding displacements are of 9.8 mm, 19.72 mm and 21.76 mm in x, y and z directions respectively are observed in the heater outlet to TSM inlet line. The obtained results of reaction forces and moment forces would be utilized as an input for the selection of pipe. supports. The results of pipe stress analysis would be used in further loop optimization.

Automation and Interlock System Design for BP-Li Liquid-Metal Purification Experimental Facility: In nuclear fusion domain, eutectic lead-lithium (Pb-Li) is of critical importance as a tritium breeder, neutron multiplier as well as a high-temperature coolant for nuclear power plants. To achieve intended plant efficiency through operation of such high-temperature fluid systems, it is necessary to control composition characteristics of operating fluid. In contrast, at elevated temperatures and higher velocities lying within operational region of interest, Pb-Li plays role of an active corrodent for structural materials, exhibiting selective leaching towards certain elements like Ni, Cr, Mn etc. Such elemental impurities alongwith oxides tend to precipitate in cooler sections of the system, thereby restricting flow of coolant resulting in overall performance degradation. To maintain the purity of Pb-Li, online removal of impurities is essential. In this regard, an online Pb-Li purification facility is under fabrication. Performance evaluation of this facility will be assessed over long duration operations at relevant process conditions. To operate the facility with minimum human-intervention

and downtime, a PXI-express platform based data-acquisition and control system is designed using LabVIEW environment for continuous monitoring and control of process parameters. Investment protection for critical loop components is addressed using software based interlock modules. The details about the developed data-acquisition system, definitions for control and interlocks logics, alarm management, remote operation of loop components and salient integrated features for a user-convenient long-duration automated operation of the facility are documented. Detailed design and validated performances for cover gas pressure control system and timer-based latched configuration liquid-metal drain interlock are also studied.

Development of an Optimised Magnetic Field Source for Flowmeter Applications: Sensitivity of a magnetic flowmeter relies on many factors like magnetic field strength, gap between electrodes, material properties, magnet temperature etc. For a given measuring conditions, a strong magnetic field source can produce highest sensitivity for the flowmeter. An economic design of magnetic field source would be to produce the strongest magnetic field from a given amount of magnetic material. For this purpose, various magnet configurations are analyzed using FEM and the flowmeter sensitivity using such magnet configurations are compared. It is observed that magnets arranged in a Halbach fashion produce the highest sensitivity for the flowmeter using a given amount of magnetic material. The major challenge for the development of such a magnetic field source is its fabrication from its constituent magnets, combatting their huge attractive/repulsive forces (~2500 N for our case). Therefore, a specific mechanical tool has been designed for assembling the magnetic field source and a robust assembly technique has been devised using numerical computations. The designed magnetic field source produces a peak magnetic field of 0.78 T in the pole cross section of 50 mm × 50 mm.

A Neutronic Experiment to Support the Design of an Indian TBM Shield Module for ITER: A shield module is associated with an Indian Test Blanket Module (TBM) in ITER to limit the radiation doses in port inter-space areas. The shield module is made of stainless steel plates and water channels. It is identified as an important component for radiation protection because of its radiation exposure control functionality. The radiation protection classification leads to more assurance of the component design. In order to validate and verify the design of the shield module, a neutronic laboratory-scale experiment is designed and executed. The experiment is planned by considering the irradiation under a neutron source of 14 MeV and yields of 10^{10} n s^{-1} . The reference neutron spectrum of the ITER TBM shield module has been achieved through optimization of the neutron source spectrum by a combination of steel and lead materials. The neutron spectrum and flux are measured using a multiple foil activation technique and neutron dose-rate meter LB 6411 (He-3 proton recoil counter with polyethylene), respectively. The neutronic design simulation is assessed using MCNP5 and FENDL 2.1 crosssection data.

A.4.4 Remote Handling & Robotics Technology

In-Vessel Inspection System (IVIS): The IVIS system is capable of in-service visual inspection inside SST-1 like chamber under ultra-high vacuum in between the plasma shots. All major components of the In-Vessel Inspection system (IVIS) and storage vacuum chamber (SVC) are being fabricated and integrated at vendor site. Various IVIS components such as vacuum compatible motors, gearboxes, encoders and gate valves have been received at IPR and various tests such as outgassing, load testing under vacuum, motion control, etc. are ongoing. A prototype rotary joint with hybrid bearings has been developed and tested. A test chamber for IVIS testing and qualification is under fabrication. The complete IVIS system is envisaged to be delivered soon.

Virtual Reality facility development: IPR is developing an immersive 3-sided interactive VR facility – orders have been placed for different sub-systems. The VR facility will have capabilities of complete immersive visualization of any system like tokamak, in-vessel components using 3D CAD models, real time interactions with haptic arm, etc. IPR has already developed various VR applications for tokamak RH, visualizations etc, that can be directly incorporated with the VR facility upon completion.

A.4.5 Neutral Beam Technologies

Indigenous development of critical technology for fusion plasma heating system: High power Neutral Beam Injection (NBI) systems are used world wide for fusion reactor plasmas. The heart of an NBI system is the ion source and one of its critical components is a water-cooled Back Plate (BP). The BP, used for mounting several critical components, must also handle a high heat load of 2 MW/m^2 from the plasma. This implies considerable technical challenges in fabrication. Following considerable R&D, such a BP has been fabricated for the first time in India and successfully tested on IPR's

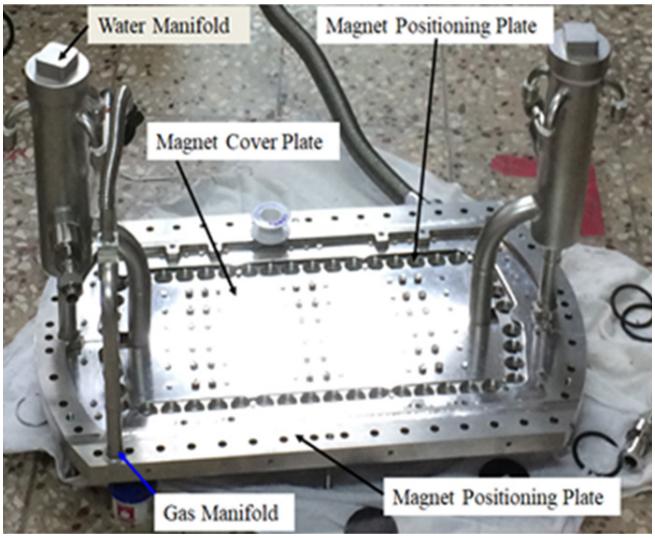

Figure A.4.5.1 Water cooled back plate for NBI source

High Heat Flux Test Facility (HHFTF) upto 2.5 MW/m^2. Hence this critical component can now be manufactured in India at a lower cost.

Performance Evaluation of Various Diagnostics Developed for a Negative Ion Based Neutral Beam Injector Program: The characteristics of a negative hydrogen ion (H-) source and its neutralization efficiency determine the performance of a negative ion based neutral beam injector (NNBI). Therefore, for the safe operation of an NNBI system, it is necessary to monitor the performance of the ion source and its beam through a systematic characterization process. A judicious selection of different diagnostics based on electrical, optical and thermal types and including calorimetric techniques are required. In this regard, a number of diagnostics are being developed under the NNBI R&D program in the Indian Test Facility (INTF). These diagnostics are versatile in nature in terms of their working principles and independent prototype experimental efforts have been carried out to establish them and prepare them for operational use. Electrical probes (EP), optical emission spectroscopy and cavity ring down spectroscopy (CRDS) are mainly envisaged for ion source plasma characterization. Additionally, standard electrical measurements in RF and DC power supply circuits are already in regular use in the operational experimental setups, ROBIN and HELEN-I, for monitoring the power supplies. Doppler shift spectroscopy (DSS) and optical emission tomography (TOMO) are being developed for beam characterization in terms of divergence, stripping and beam profile. Some of these are characterized on separate prototype experiments and are already integrated and have been tested in the available operational plasma experimental setups: ROBIN and HELEN-I. The DSS system, with multiple lines of sight (LOS) (blue-shifted and red-shifted), is integrated in the ROBIN setup and CRDS is arranged in HELEN-I. The TOMO technique is used to find the beam power density profile from the hydrogen beam emitted Balmer line intensity. The optical brightness profile of a neutral beam due to beam emission radiation is proportional to the beam power density. In this regard, a tomography code based on maximum entropy is developed to reconstruct the 2D optical emissivity profile of the INTF beam by inverting the LOS integral of the brightness of the beam. The code has been validated with the simulated INTF beam power density profile, in terms of the mathematical functions representing it.

A.4.6 Large Volume Cryoplant Systems

Indigenous helium compressor for cryoplant application; One of the major components in a cryoplant is a helium compressor, which is normally imported. As a significant step towards indigenisation, an industry-scale air compressor has been successfully converted to a helium compressor. This has been operated successfully in a closed loop continuously for 24 hrs with a helium flow rate of 60 g/s & delivery pressure of 14.5 bar, with oil impurities in the compressed helium below 100 PPB (parts per billion) and a local leak rate ~10^{-5} mbar ltr/sec. *The cost of such a compressor is several times lower than that of imported ones.*

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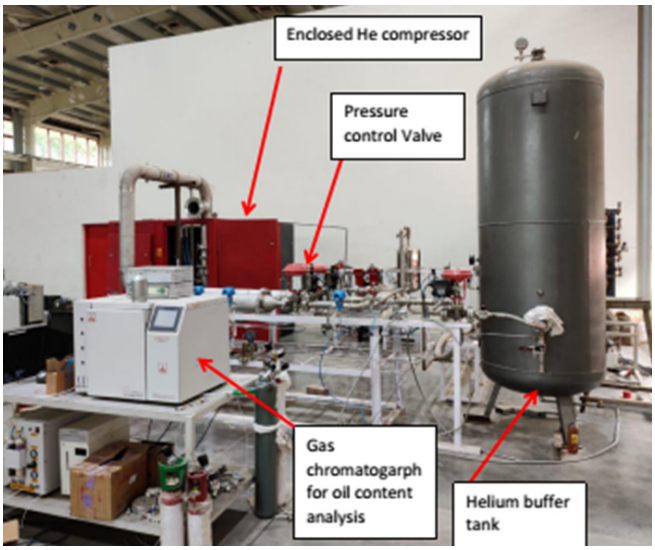

Figure A.4.6.1 Helium compressor converted from air compressor

A.5 Theoretical, modeling and Computational Plasma Physics

The Institute has a vibrant programme involving theoretical analysis and computer simulations for plasma systems. This covers basic research as well as plasma applications. Continuing with its long-standing focus on high performnce computing facilities, IPR has now set up a 1 Petaflop HPC facility.:

A.5.1 High-Performance Computing (HPC, 1 Peta flops) System

IPR has established a High Performance Computing (HPC) facility having a theoretical peak performance of 1 Petaflop (PF). This HPC system named ANTYA (meaning 10^{15} in Sanskrit), having more than 10,000 cores, can perform 10^{15} Floating-point Operations Per Second (FLOPS). The installation, testing, and commissioning of ANTYA were completed successfully in July 2019. ANTYA is being used by the R&D community of the Institute, exploiting the power of parallel computing for solving complex tasks. Extensive scaling studies of open-source codes (LAMMPS and PLUTO) have been completed using full-machine capabilities. The scaling up to 10,000 cores has been demonstrated for these highly scalable open-source codes. In-house developed codes, as well as collaboration based codes, have been successfully installed to run in a distributed environment on ANTYA. Heavily used commercial engineering applications have also been ported successfully on ANTYA.

Scaling Studies of Codes Performed on ANTYA CPU and GPU nodes separately: LAMMPS (Large-scale Atomic/ Molecular Massively Parallel Simulator) and PLUTO are open-source General Public License (GPL) codes used for Molecular Dynamics (MD) and Computational Astrophysics simulations respectively by IPR Researchers. On ANTYA, LAMMPS has been installed for both MPI version (LAMMPS CPU) and GPU version (LAMMPS GPU). Figure A.5.1.1a shows the LAMMPS scaling study performed in ANTYA for a crystal equilibration with about 2 billion atoms via lenard-jones type potential. For LAMMPS GPU only scaling study shown in figure A.5.1.1b, 10.5 million

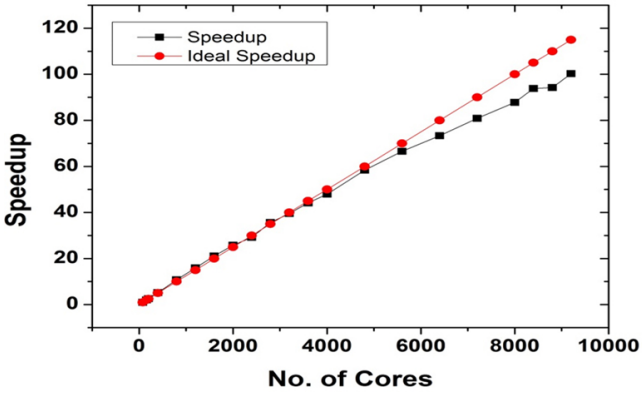

Figure A.5.1.1a Actual Speedup obtained vs. Ideal Speedup for LAMMPS CPU on ANTYA CPU nodes for more than 2 billion atoms.

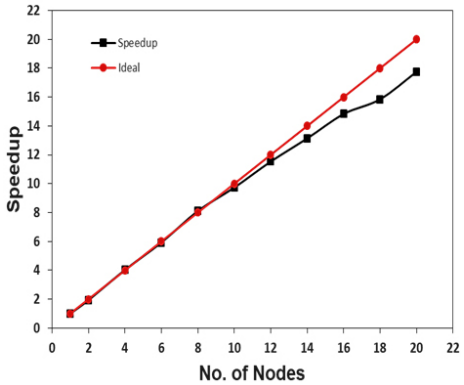

Figure A.5.1.1b Actual Speedup obtained vs. Ideal Speedup for LAMMPS GPU on ANTYA GPU nodes for 10.5 million atoms.

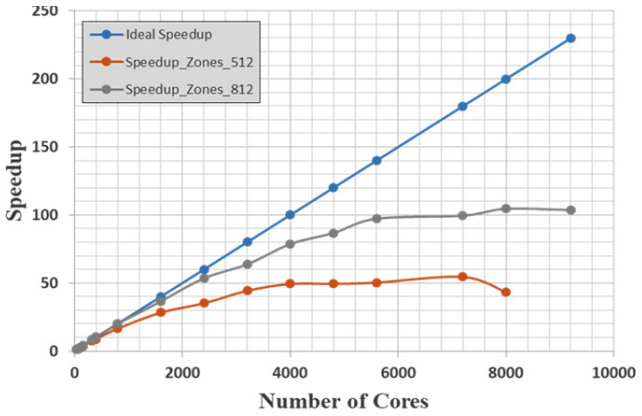

Figure A.5.1.1c: Speedup comparison of 512/812 grid size problems with the ideal speedup for PLUTO

atoms have been selected based on the GPU memory limit. For PLUTO scaling study, an RMHD blast problem considered where the average Mach number is to be estimated using RMHD equations. Two sets of 3-D calculations were performed, on 512 and 812 grid sizes. Figure A.5.1.1c shows the speedup comparison of these two problems with the ideal speedup. Speedup obtained in the 812 grid size problem is better than the 512 grid problem. A total of 230 nodes has been used for performing the scaling runs. Further several other open-source codes like OpenFOAM, NAMD, Darknet-YOLO, Bout++, etc. with data analysis and visualization applications like VisIt, ParaView have been installed and tested on ANTYA. The table list the codes (indigenous/scientific and commercial) which have been ported to ANTYA and are in regular use.

In-house developed/Collaboration Codes		
Code Name	**Description**	**Code Type (CPU/GPU)**
GMHD3D	A parallel 3-D compressible viscous resistive MHD code, using the pseudospectral method with multiple time solvers developed at IPR.	GPU
EPPIC	A new suite of 1D-3V-MCC and 2D-3V-MCC codes called Expanding Plasma PIC or EP-PIC solvers have been developed in-house to study the physics of plasma in an expanding magnetic field.	CPU and GPU
PEC2PIC PEC3PIC	Parallelized Electrostatic Cartesian 2-D / 3-D Particle-In-Cell is a 2-D/3-D, electrostatic, PIC code developed in-house.	CPU
GTS	Gyrokinetic Tokamak Simulation code is a full-geometry, massively parallel δf PIC code developed at PPPL (δf - perturbative). This code is being used by IPR Research Scholars under an academic agreement with code developers, PPPL.	CPU
CPD	Charged Particle Dynamics (CPD) is 3-D relativistic, electromagnetic, particle-in-cell code.	CPU
MPMD-2D & 3D	Upgraded Multi-GPU MPMD code has been installed in ANTYA.	CPU and GPU
Osiris4.0	A 3-D, relativistic, object-oriented PIC code for modeling plasma-based accelerators. This code is being used by IPR Research Scholars under an academic agreement with UCLA.	CPU

Applications with Commercial Licenses		
Code Name	**Description**	**Version and Type (CPU/GPU)**
ANSYS	HPC Users can submit the jobs in ANTYA from their (client) machines through Remote Solver Manager (RSM) using the available ANSYS HPC licenses.	R2-2019, CPU and GPU
COMSOL	COMSOL has been installed on ANTYA and client machines can be used to remotely submit the jobs on ANTYA using available commercial HPC licenses.	5.4, CPU and GPU
CST	A high-performance 3D EM analysis software installed and tested for both CPU and GPU runs using available commercial HPC licenses.	2019, CPU and GPU
MATLAB	It has been installed and tested for the available licenses on ANTYA.	2016, CPU and GPU
IDL	It has been installed and tested on ANTYA.	8.7, CPU

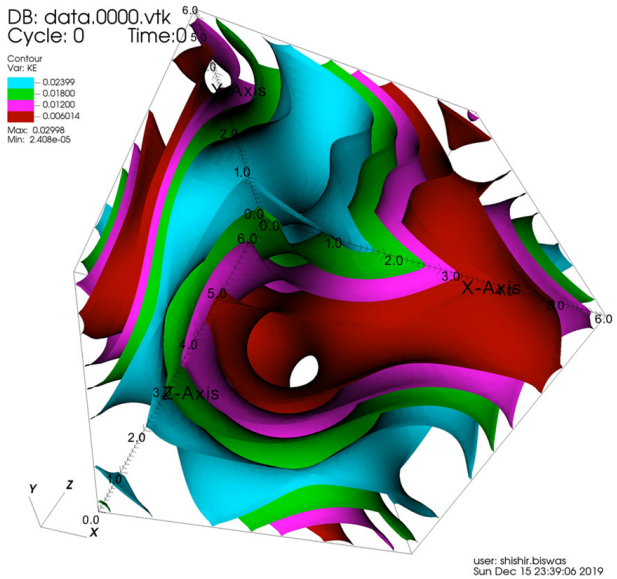

Figure A.5.1.2a: Recurrent and Non-Recurrent Flow Simulation with PLUTO Code

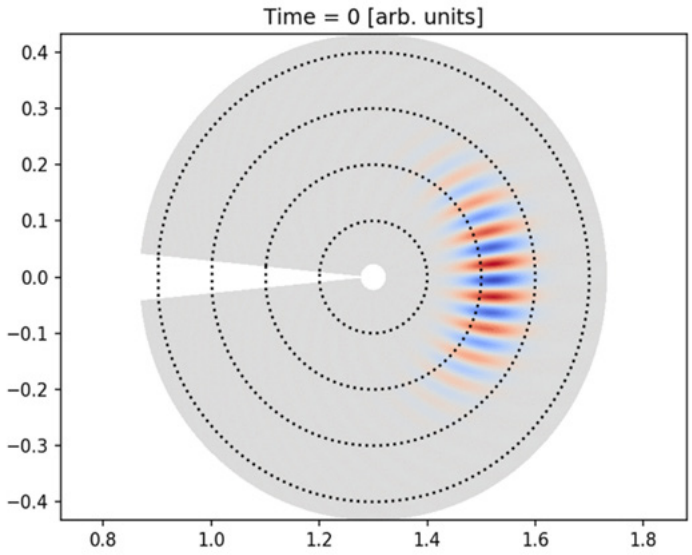

Figure A.5.1.2b Effect of Flow-Shear on ITG Instability in a Tokamak using Bout++

Recent results of simulations performed on ANTYA

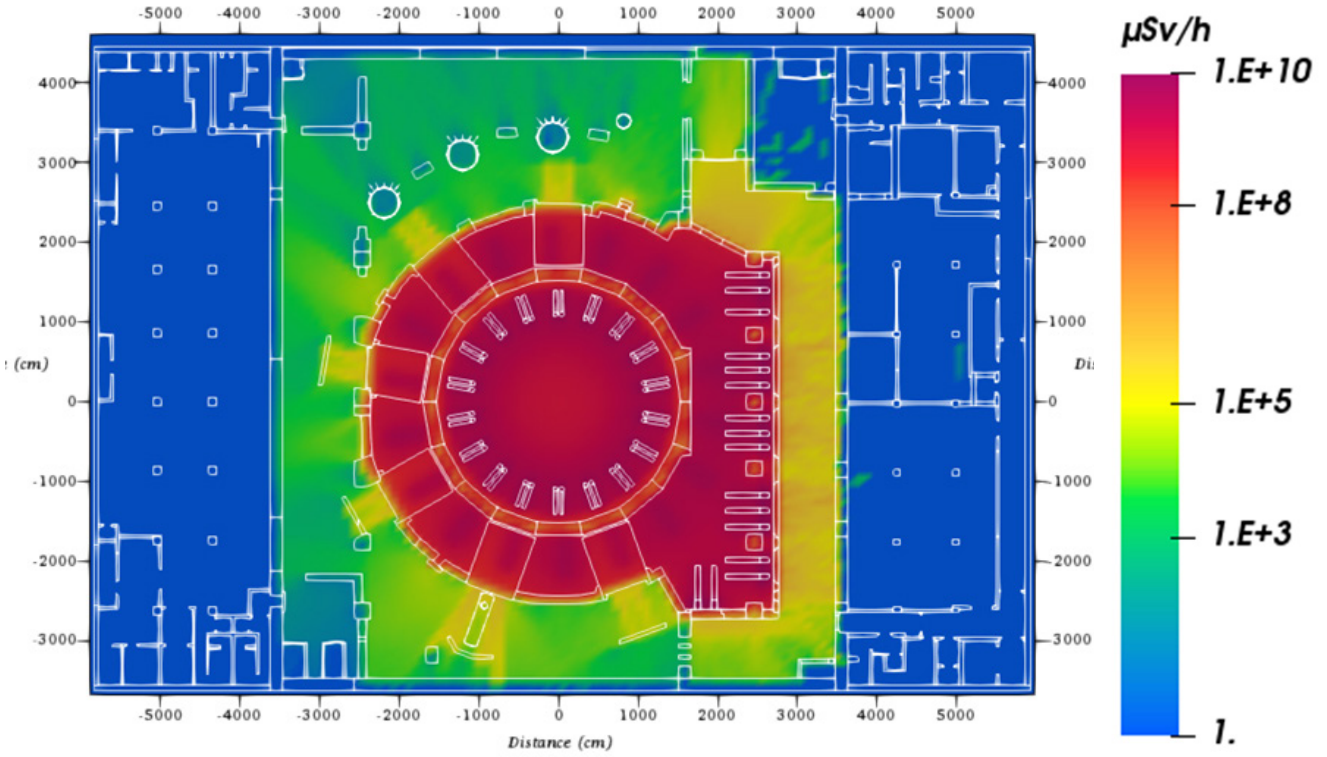

Figure A.5.1.2c Biological Dose Rate Map in Tokamak Complex (Modeling of highly complex radiation sources in ITER environment is performed under Task Agreement C74TD22FI between ITER and IN-DA)

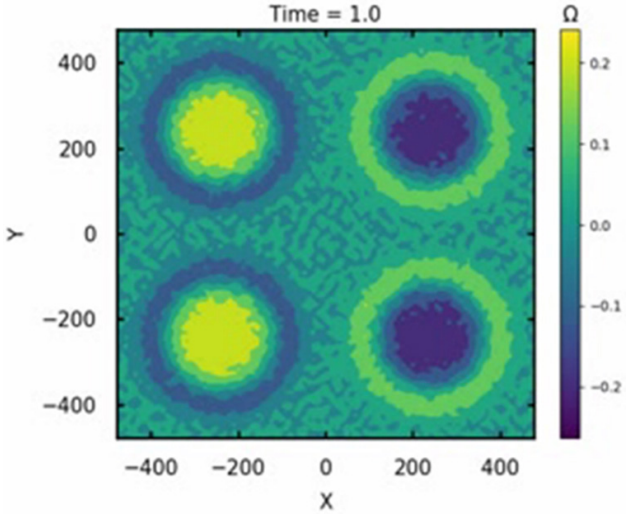

Figure A.5.1.2d Large Scale MD Simulation with 1 Million Particles using Upgraded Multi-GPU MPMD code

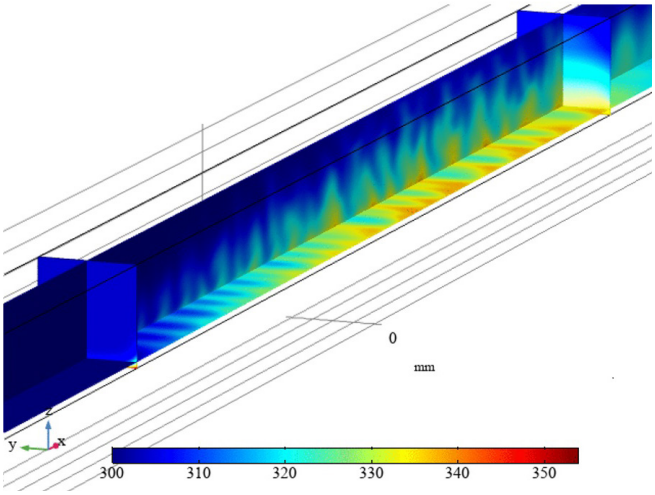

Figure A.5.1.2e Magneto hydrodynamic Flow in Liquid Breeder Blankets Using COMSOL

Recent results of simulations performed on ANTYA

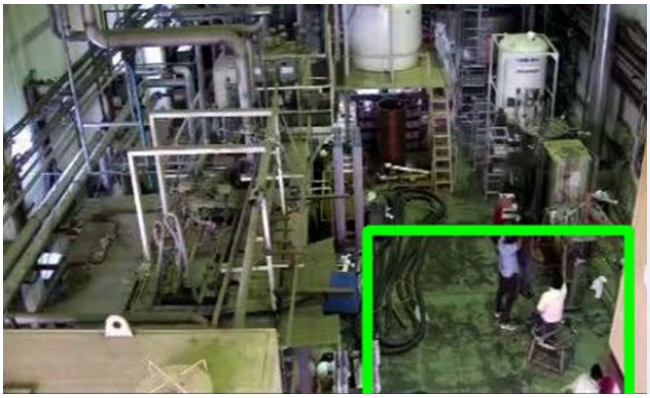

Figure A.5.1.2f Artificial Intelligence-based CCTV Intrusion detection model trained on ANTYA

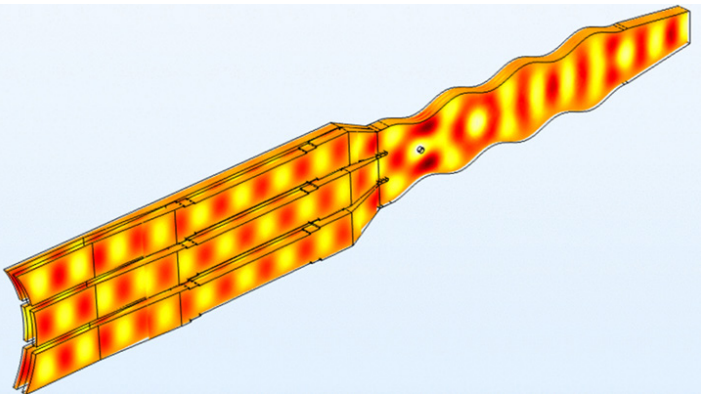

Figure A.5.1.2g E-field profile of the Passive Active Multi-junction (PAM) launcher using CST for Aditya-U Tokamak

Figure A.5.1.2h Plasma Pyrolysis Reactor Design using ANSYS- Fluid Temperature (K) on Midplane of the 200 kg/hr Plasma Pyrolysis Reactor with Time.

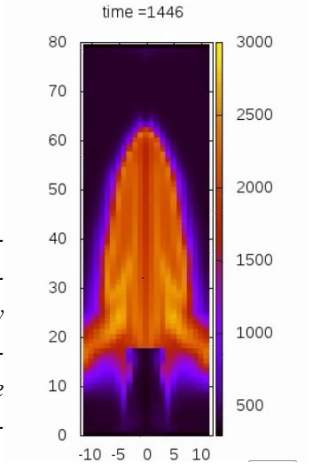

Figure A.5.1.2i Simulation of Plasma Fuel System using Conchas-spray code A high power (typically 100 KW) plasma arc is set up in a cylindrical tube and a coal-air mixture is allowed to pass through this arc.-

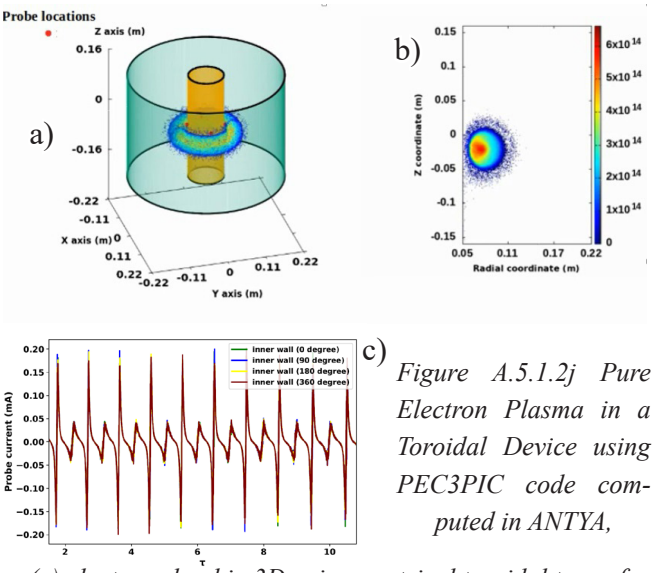

Figure A.5.1.2j Pure Electron Plasma in a Toroidal Device using PEC3PIC code computed in ANTYA, (a) electron cloud in 3D axisymmetrical toroidal trap of SMARTEX-C geometry, (b) the 2D projection of the electron cloud density on r-z plane ,(c) the inner wall probe current

A.5.2 Nonlinear Plasma Theory & Simulation

Coherent Nonlinear Oscillations in Magneto-hydrodynamic Plasma: Single fluid magneto-hydrodynamic (MHD) equations have been studied through direct numerical simulations using pseudo-spectral methods in two as well as three spatial dimensions. At Alfven resonance, a reversible periodic exchange of energy between kinetic and magnetic variables is observed. The oscillations are identified as nonlinear dispersion-less Alfven waves that have been predicted earlier on theoretical grounds but not observed in large scale numerical simulations. A systematic study of their occurrence for various initial conditions and a range of Alfven velocities is carried out. An analysis based on a finite mode representation of the incompressible single fluid MHD equations in two spatial dimensions reproduces the essential features of these oscillations.

Collective Dynamics of Globally Delay-Coupled Complex Ginzburg-Landau Oscillators: The effect of time-delayed coupling on the collective behavior of a population of globally coupled complex Ginzburg-Landau oscillators is investigated. A detailed numerical study is carried out to study the impact of time delay on various collective states that include synchronous states, multi-cluster states, chaos, amplitude-mediated chimeras, and incoherent states. It is found that time delay can bring about significant changes in the dynamical properties of these states including their regions of existence and stability. In general, an increase in time delay is seen to lower the threshold value of the coupling strength for the occurrence of such states and to shift the existence domain toward more negative values of the linear dispersion parameter. Further insights into the numerical findings are provided, wherever possible, by exact equilibrium and stability analysis of these states in the presence of time delay

Simulation of the Internal Kink Mode in Visco-Resistive Regimes: ***The numerical simulation results of the nonlinear evolution of the (1,1) internal kink mode in the presence of various kinds of equilibrium plasma flows***. The present studies are carried out in the framework of a two fluid model to extend our past investigations done with a reduced magneto-hydrodynamic (RMHD) model. Two-fluid effects are found to significantly influence the mode dynamics in a number of different ways. In the linear regime diamagnetic effects in combination with flows provide a synergistic stabilizing influence that also carries over to the nonlinear regime. In addition one observes novel symmetry breaking phenomena in the linear growth rates as well as in the nonlinear saturated states of the mode. Our study also explores the influence of strong viscosity on the mode evolution and finds interesting modifications in the real frequency of the mode in the linear regime.

Solitary and Shock Wave in Magnetized Collisional Pair-Ion Plasmas: The effect of ion–ion collision on the dynamics of nonlinear magneto-sonic wave in a magnetized pair-ion plasma consisting of positive and negative ions has been studied. The external magnetic field is situated perpendicular to the wave propagation. Two fluid model is used to describe the dynamics of positive and negative ions. Lagrangian transformation technique is used to carry out the linear and nonlinear analysis. Linear analysis yields the dispersion relation of magneto-sonic wave in pair-ion plasmas. In small amplitude limit, Korteweg-de Vries Burgers' (KdVB) equation has defined the nonlinear propagations of magneto-sonic wave. Ion–ion collisions are the source of dissipation in the system and also the origin of the Burgers' term in KdVB equation. This Burgers' term in KdVB equation is the source of the shock structures in pair-ion plasmas. Analytical and numerical analysis reveals that the wave exhibits the solitary wave in absence of collisions. In presence of collisions, the wave exhibits both oscillatory and monotonic shock structures depending on the balance between dispersion and dissipation of the system. For weak dissipation, as compared to dispersion, oscillatory shock structure is formed and in reverse case, nonlinear wave exhibits monotonic shock wave.

Stationary Langmuir structures in a relativistic current carrying cold plasma: Nonlinear stationary structures formed in a cold plasma with immobile ions in the presence of a relativistic electron current beam have been investigated analytically in the collisionless limit. These are cold plasma version of the relativistic Berstein-Greene-Kruskal (BGK) waves. The structure profile is governed by the ratio of maximum electrostatic field energy density to the kinetic energy density of the electron beam (κ). It is found that, in the linear limit (κ<<1), the density, electric field, and velocity vary harmonically in space, whereas for large values κ, the fluid variables exhibit an-harmonic behavior

A.5.3 Tokamak & Fusion Reactor Studies

Numerical Simulation of the Effect of Pellet Injection on ELMs: Numerical simulation studies of the dynamical behavior of edge localized modes (ELMs) are done under the influence of repetitive injection of pellets. In our nonlinear 2-fluid model the ELMs are excited by introducing a particle source in the confinement region and a particle sink in the edge region. The injection of pellets is simulated by periodically raising the edge density in a pulsed manner. We find that when the edge density is raised to twice the normal edge density with a duty cycle (on time-off time) of 1:2, the ELMs are generated on an average at a faster rate and with reduced amplitudes. These changes lead to significant improvements in the plasma beta indicative of an improvement in the energy confinement due to pellet injection. Concurrently, the plasma density and temperature profiles also get significantly modified. A comparative study is made of the nature of ELM dynamics for different magnitudes of edge density enhancements. The relative impact on ELMs from resonant magnetic perturbations compared to pellet injection in terms of changes in the plasma temperature, density, location of the ELMs and the nonlinear spectral transfer of energies are also thought through..

Displacement Damage Study in Tungsten and Iron for Fusion Neutron Irradiation: Displacement damage in tungsten and iron are studied using the TALYS-1.8 code and molecular dynamics simulations. The TALYS-1.8 code is used to predict the energy spectra of recoils. The MD simulations of self-recoils of up to 200 keV damage energies are carried out to predict the number of Frenkel pairs in iron and tungsten using the LAMMPS code. Time evolution of vacancies and interstitials are studied. The results of MD simulations are used to calibrate the constant parameters of the Arc-dpa method. The displacement damage cross section of tungsten and iron are calculated for the neutron irradiation of up to 15 MeV energy with the NRT and Arc-dpa approaches. The dpa (Arc-dpa) value at the first wall location of EU DEMO reaches 1.19 dpa/FPY and 0.93 dpa/FPY in iron and tungsten, respectively. Similarly, dpa values in iron and tungsten are also predicted at different neutron effluence using the NRT and Arc-dpa mechanism.

Kinetic Particle simulation in a global toroidal geometry: The gyrokinetic toroidal code has been upgraded for global simulations by coupling the core and scrape-off layer regions across the separatrix with field-aligned particle-grid interpolations. A fully kinetic particle pusher for high frequency waves (ion cyclotron frequency and beyond) and a guiding center pusher for low frequency waves have been implemented using cylindrical coordinates in a global toroidal geometry. The two integrators correctly capture the particle orbits and agree well with each other, conserving energy and canonical angular momentum. As a verification and application of this new capability, ion guiding center simulations have been carried out to study ion orbit losses at the edge of the DIII-D tokamak for single null magnetic separatrix discharges. The ion loss conditions are examined as a function of the pitch angle for cases without and with a radial electric field. The simulations show good agreement with past theoretical results and with the experimentally observed feature in which high energy ions flow out along the ion drift orbits and then hit the divertor plates. A measure of the ion direct orbit loss fraction shows that the loss fraction increases with the ion energy for DIII-D in the initial velocity space. Finally, as a further verification of the capability of the new code, self-consistent simulations of zonal flows in the core region of the DIII-D tokamak were carried out. All DIII-D simulations were performed in the absence of turbulence

A.5.4. Fundamental Plasma Studies

Electric Field Filamentation and Higher Harmonic Generation in Very High Frequency Capacitive Discharges: The effects of the discharge voltage on the formation and nature of electric field transients in a symmetric, collision-less, very high frequency, capacitively coupled plasma are studied using a self-consistent particle-in-cell (PIC) simulation code. At a driving frequency of 60 MHz and 5 mTorr of argon gas pressure, the discharge voltage is varied from 10V to 150V for a fixed discharge gap. It is observed that an increase in the discharge voltage causes filamentation in the electric field transients and to create multiple higher harmonics in the bulk plasma. Correspondingly, higher harmonics, up to 7th har-

monic, in the discharge current are also observed. The power in the higher harmonics increases with a rise in the discharge voltage. The plasma density continues to increase with the discharge voltage but in a nonlinear manner, whereas, the bulk electron temperature decreases. Meanwhile, the electron energy distribution function evolves from a Maxwellian at lower discharge voltages to a bi-Maxwellian at higher discharge voltages.

Coupling of Drift Wave with Dust Acoustic Wave: A drift wave is a prominent mode of a magnetized plasma of inhomogeneous density. It plays an important role in the transport of particles, energy, and momentum perpendicular to the ambient magnetic field. The frequency of this mode is governed by the inhomogeneity scale length and is much lower than the typical homogeneous plasma modes involving ions and electrons. In this work, the possibility of coupling of this particular mode with the low frequency modes of a dusty plasma medium is considered. The drift wave has been found to saturate at Large ky (perpendicular wavenumber) in a magnetized plasma with weakly correlated dust species mainly due to the shielding by polarization drift of ions. However, when dust particles are strongly correlated, the drift wave converts into a transverse shear wave at large ky.

Compressibility Effects on Quasi-stationary Vortex and Transient Hole Patterns Through Vortex Merger: The effect of compressibility in the process of vortex merging is discussed. In past, in the incompressible limit, it has been observed that the merging of a collection of intense point-like vortices arranged uniformly outside a circular vortex, can lead to quasi-stationary vortex patch and transient hole pattern inside the patch via nonlinear merger process leading to 'vortex crystals'. Weak compressibility is seen to introduce a natural acoustic scale to the problem. We find that the natural mode is independent of the number of point-like vortices and the amplitude scales linearly with compressibility. Further, it is identified that after a merger, the system exhibits oscillation at a natural frequency together with its harmonics and beats with its own harmonics. The power of the frequency is found to scale as M^{-2}, where M is the Mach number. Also the vortex crystals formed are found to 'melt' faster as compressibility is increased from M = 0 to 0.5.

Influence of Select Discharge Parameters on Electric Field Transients Triggered in Collision-less Very High Frequency Capacitive Discharges: Self-consistent particle-in-cell simulations are carried out to investigate the effect of discharge voltage, driving frequency, and the extent of the electrode gap on the formation of electric field transients. The shape of the electron energy distribution function into the bulk plasma and the nature of the mode transition in plasma density are presented for the driving frequency range of 27.12 MHz to 80 MHz. The present results, taken in conjunction with our previous study that only looked at the driving frequency dependence in collision-less capacitive Argon discharges, provide a comprehensive and detailed account of the dynamics of such discharges over a multi-parameter operational space.

Plasma flow equilibria in 2D cylindrically symmetric expanding magnetic field: A steady-state plasma flow exiting through an expanding magnetic field is studied by means of 2D particle in cell numerical simulations. The effects of change in the localized plasma source region dimension and the associated plasma transit length in an upstream, uniform-magnetic- field region were examined, simulating cases with different axial lengths of the dielectric plasma source region, distinct from the location of physical expansion. Axial potential profiles at various radial locations show development of a stepwise axial potential drop, producing plasma (ion) acceleration in the corresponding regions. For a narrow source region with a long pre-expansion flow region, non-monotonic potential variation is recovered where ion phase-space scatters show the trapped region and signatures of chaotic ion trajectories and possible pre-expansion ion heating. Considering a relevance of the studied flow equilibria to the thrust generation schemes for space propulsion, a formal estimate of thrust values associated with the plasma outflow is also done for the cases simulated.

Multiple Steady State Co-Rotating Dust Vortices in Streaming Plasma: The 2D vorticity–stream function hydrodynamic model is applied to dust clouds electrostatically confined in an unbounded and streaming plasma. The vortex flow structure of the volumetrically driven dust cloud is analyzed systematically for different aspect ratios (ARs) of the bounded dust domain, exploring linear and nonlinear regimes of flow for a range of the kinematic viscosity. These results show the interplay between inertial and diffusive transport processes involving structural changes in dust vortex flow that develops asymmetry and shows a regular sequence of structural bifurcations at threshold kinematic viscosity corresponding to a change in the AR value by nearly an integer. Agreement with many experimental observations is recovered, where the generation of newer self-similar multiple co-rotating vortices is observed. The exclusive dependence of subsequent structural transitions on the flow domain AR is analyzed based on the properties of numerical solutions. These nonlinear solutions

allow understanding of the underlying nonlinear characteristics of self-similar co-rotating vortices in experiments and their behavioral similarities with various relevant complex driven–dissipative natural systems.

Dynamics of a Toroidal Pure Electron Plasma using 3D PIC Simulations: Nonlinear dynamics of toroidally confined, initially cold, collisionless pure electron plasma has been numerically simulated in a tight aspect ratio, axisymmetric device, confined using a toroidal magnetic field, using a 3D3V particle-in-cell code PEC3PIC. A set of three numerical experiments are conducted by loading the toroidal electron cloud at varying radial distances from the central axis at the vertical midplane, and a comparative analysis of the progression of cloud dynamics and particle transport in the three experiments is carried out. In each experiment, the cloud is seen to initiate toroidal Diocotron oscillations with the following interesting features: (i) initial nonlinear reshaping and density peaking, (ii) elliptical orbital path in the poloidal cross section along with chirp or rotational frequency dynamics and the increase and decrease in the peak density of the filled electron cloud, (iii) cross-field transport and particle loss, and (iv) the measured wall probe signals showing close similarity to experimental signals. It is demonstrated that relatively better confinement of electrons in the toroidal configuration is achieved by loading the initial plasma at the vertical midplane, close to the inner wall of the chamber, supporting the mean-field theoretical predictions. For all cases, the density distribution profiles in the (r, θ)and (r, z) planes of the cylindrical coordinate system (r, θ, z) have consistent peaked density central profiles. The time dependency of the dominant frequencies of the dynamics, obtained from wall probe data using Hilbert–Huang transformation and windowed Fourier transformation, suggests toroidicity induced low poloidal number m (~1 - 12)coupling and dynamical chirping.

Negative Entropy-Production Rate in Rayleigh-Benard Convection in Two-Dimensional Yukawa Liquids: The steady-state fluctuation theorem (SSFT) gives the relative probability of occurrence of events violating the second law of thermodynamics in a system with a small number of degrees of freedom. Using two-dimensional complex plasma as a working medium, wherein particle level observation of instantaneous velocities and positions has become experimentally possible, we perform “first-principles” molecular-dynamics simulations using the Yukawa potential in the presence of external gravity and an external temperature gradient leading to the onset and formation of Rayleigh-Bénard convection cells. In such a far-from-equilibrium steady state, the SSFT is put to the test. It is demonstrated that the SSFT is satisfied without any additional fit parameter for observation time τ , comparable to or greater than the relevant microscopic timescale associated with the system under observation.

Lane Formation in Driven Pair-Ion Plasmas: Lane formation dynamics of driven 2D pair-ion plasmas is investigated in underdamped cases. Extensive Brownian dynamics simulation is performed to study the behavior of the system in the presence of both constant and time-varying external electric fields. Lanes are found to form when like particles move along or opposite to the applied field direction. The lane order parameter has been implemented to detect phase transition. For the constant external field case, investigations are performed at different field strengths, to analyze the phase transition from a disordered to a lane state. It is observed that in this case, the electric field strength must exceed a critical value above which lanes are formed distinctly. For the case of the oscillating electric field, the frequency of the external oscillating field is found to control the lane formation phenomenon. It is observed that if the frequency of the external field exceeds a critical value, the system exhibits a transition back to the disordered state. A simple method for calculating the critical field strength provides quantitative agreement between the calculated and simulated values of the critical field strength for the case of the constant external electric field. The calculated value of the critical frequency agrees qualitatively with our simulation results for the oscillating external electric field case.

Effect of transverse beam size on the wakefields and driver beam dynamics in plasma wakefield acceleration schemes: Wakefields driven by a relativistic electron beam in a cold homogeneous plasma are studied using 2D fluid simulation techniques. It has been shown that in the limit when the transverse size of a rigid beam is greater than the longitudinal extension, the wake wave acquires a purely electrostatic form, and the simulation results show a good agreement with the 1D results published before. In the other limit when the transverse dimensions are equal to or smaller than the longitudinal extension, the wake waves are electromagnetic in nature, and 2D effects play a crucial role. Furthermore, a linear theoretical analysis of 2D wakefields for a rigid bi-parabolic beam has also been carried out and compared with the simulations. It has also been shown that the transformer ratio, which is a key parameter that measures the efficiency in the process of acceleration, becomes higher for a 2D system (i.e., for a beam having a smaller transverse extension compared to the longitudinal length) than the 1D system (i.e., for a beam having a larger transverse extension compared to the longitudi-

nal length). Furthermore, including the self-consistent evolution of the driver beam in the simulation, we have seen that the beam propagating inside the plasma undergoes transverse pinching, which occurs much earlier than the longitudinal modification. Due to the presence of transverse dimensions in the system, the 1D rigidity limit given before in literature gets modified. We have also demonstrated the modified rigidity limit for the driver beam in a 2D beam–plasma system.

Stationary Langmuir structures in a relativistic current carrying cold plasma: Nonlinear stationary structures formed in a cold plasma with immobile ions in the presence of a relativistic electron current beam have been investigated analytically in the collisionless limit. The structure profile is governed by the ratio of maximum electrostatic field energy density to the kinetic energy density of the electron beam, i.e., $\kappa = E_m / (4\pi n_0 m_0 v_0^2)^{1/2}$, where E_m is the maximum electric field associated with the nonlinear structure and v_0 is the electron beam velocity. It is found that, in the linear limit i.e. $\kappa << \sqrt{2\gamma_0/(1+\gamma_0)}$) the fluid variables, viz., density, electric field, and velocity vary harmonically in space where γ_0 is the Lorentz factor associated with beam velocity (v_0), In the range $0 < \kappa \leq \kappa_c (=\sqrt{2\gamma_0/(1+\gamma_0)})$ the fluid variables exhibit an-harmonic behavior. For values of $\kappa_c < \kappa < +\infty$, the electric field shows finite discontinuities at specific spatial locations indicating the formation of negatively charged planes at these locations

Phase transition and emergence of active temperature in an active Brownian system in underdamped background: We explore the role of inertia in the properties of active Brownian particles (ABPs) immersed in an underdamped background in two dimensions using Langevin dynamics computer simulation. Similar to an equilibrium two-dimensional passive interacting particle system, the system of ABPs transits from a liquid phase to a solid phase with the change in the coupling parameter, which is the ratio of interaction potential energy and thermal energy of the background solvent. Important qualitative and quantitative differences are found in the liquid-solid phase transition with increasing strength of activity as compared to those found in the conventional overdamped background limit. In the underdamped background, inherent activity is found to lead to a temperature, called the active temperature and defined by average velocity fluctuations of the ABPs, that is different from the fixed background solvent temperature. A new scaling law for active temperature as a function of activity strength is found near the liquid-solid boundary. Active temperature, which behaves similar to the thermodynamic equilibrium temperature, is also found to depend upon the interaction strength between the active particles and the strength of the background dissipation. With an increase in background dissipation, the difference between active temperature and the background solvent temperature decreases and the difference is found to eventually vanish in the overdamped limit, demonstrating the correctness of the calculation.

Driven electrostatic phase space vortices in a 1D weakly dissipative Vlasov-Poisson system: The effect of collisions on driven electrostatic phase space vortices is analyzed by means of Eulerian simulation for two different collision models. It was demonstrated recently that in the absence of collisions, at late times, steady state phase space vortices manifest to form a plateau in the resonant region of the particle velocity distribution function, due to trapping of particles supporting multiextrema giant phase space vortices (PSVs). In the presence of collisions, over long time, this multiextrema plateau are found to smooth out, since collisions drive the velocity distribution toward Maxwellian, irrespective of how weak the collisions are as long as they are non-zero. In these conditions, kinetic processes and collisionality are found to be in competition, and the evolution of the plasma is found, therefore, to be a result of nontrivial combination of these two effects. An attempt has been made by means of numerical simulations to study the effect of weak collisionality on the electrostatic driven phase space vortices with two types of collision operators: (1) Bhatnagar–Gross–Krook (Krook) collision operator, where the colliding particles can be treated as isolated pairs and, (2) Fokker–Planck (FP) type collision operator (Zakharov–Karpman) in one dimension, where many weak collisions lead to particle diffusion in velocity space. It is shown that depending on the collision model used, the nature of smoothing in velocity space of giant PSVs results in qualitatively very different phase space structures. However, irrespective of the collision model used, excess density fractions over 10% are retained.

A.5.5. Laser-Plasma Interaction

Beyond the Conventional Collisional Absorption of Laser Light in Under-Dense Plasma: A Particle-In-Cell Simulation Study: Collisional absorption of laser light in an underdense plasma is studied by particle-in-cell (PIC) simulation with Monte Carlo binary Coulomb collisions between charge particles. For a given plasma thickness of a few times the wavelength of 800 nm laser, fractional absorption (α) of the laser light due to Coulomb collisions (mainly between electrons and ions) is calculated at different electron temperature T_e with a total velocity $v = (v_{th}^2 + v_0^2/2)1/2$ dependent Coulomb logarithm ln (v), where v_{th} and v_0 are thermal and ponderomotive velocity of an electron. In the low-tempera-

ture regime (T_e 15 eV), it is found that α increases with increasing laser intensity I_0 up to a maximum corresponding to an intensity Ic, and then it drops (approximately) obeying the conventional scaling of α ~ I−3/20 when $I_0 > I_c$. Such a non-conventional increase of α with I_0 in the low intensity regime was demonstrated earlier in experiments, and recently explained by classical and quantum. Here, for the first time, we found this nonconventional collisional laser absorption by PIC simulation, thus bridging the gap between models, simulations, and experimental findings. Moreover, electron energy distributions naturally emanating during the laser interaction (in PIC simulations) are found to be anisotropic and non-Maxwellian in nature, leading to some deviations from the earlier analytical predictions.

Excitation of Kdv Magnetosonic Solitons in Plasma in the Presence of an External Magnetic Field: A new mechanism for direct laser energy coupling to heavier ion species in the presence of an external magnetic field has been illustrated. It has been shown that at higher amplitude, the ion disturbances form magneto-sonic solitons. A 2D particle-in-cell simulation for an incident laser beam normal to an over-dense plasma target in the presence of an external magnetic field has been carried out for this purpose. The external magnetic field is chosen such that the heavier ions remain unmagnetized but the lighter electron species get magnetized at the laser frequency. For conventional lasers of ~1 μm wavelengths, the magnetic field requirement satisfying the aforementioned condition turns out to be of the order of several hundreds of kilo Tesla. This requirement goes down by one order if pulsed CO_2 lasers with wavelengths of ~10 μm are employed. At present, magnetic fields of several kilo Tesla have already been generated in the laboratory. Keeping this in view, the simulations have been carried out for the pulsed CO_2 laser parameters. It is shown that the ion heating is enhanced considerably in the presence of an external magnetic field. Furthermore, it is shown that at a higher intensity of the laser, the ion disturbances acquire higher amplitude to excite Korteweg–de Vries magnetosonic solitons. The solitons, as expected, propagate stably for several thousands of ion plasma periods. However, subsequently, they are seen to develop transverse modulations which grow with time.

Asymmetric electron cloud from laser-driven cluster nanoplasma: A nano-cluster ionized by a femto-second pulse of wavelength larger than the cluster size sets up an electron cloud that oscillates with respect to the ion cloud. In experiments, a linearly polarized pump pulse sets up the dipole and the polarization of the probe pulse that comes after a prescribed time is varied, and the differential changes in the measured absorption gives a direct measure of the asymmetry and ellipticity in the permittivity. We perform fully relativistic two-dimensional electro-magnetic particle-in-cell simulations and our results show that orthogonally polarized pump-probe pulses absorb about 18% less compared to the parallel case at the peak of the linear plasma resonance which corroborate experiments at TIFR.

Relativistic Self-Focussing and Self-guiding of laser pulse: Propagation of laser pulse in plasma is determined by the critical power P_c. When the power of laser pulse exceeds this threshold value P_c, it expels the electron in its path which leads to modulation in the electron density. The electron density modulation in turn modifies the refractive index of the plasma in such a way that relativistic self-focussing and self-guiding is made possible. Very often this parameter regime for laser and plasma density is ignored for generation of monoenergetic electron beam via laser wakefield acceleration. However, recent experiments, have demonstrated production of monoenergetic, 35 MeV electron bunch using 3 TW pulse (a_0=1) and high density $5.8\times10^{19}cm^{-3}$ plasma. OSIRIS PIC simulations have been carried out in this parameter regime to decipher the role of various physical mechanisms (specifically direct laser acceleration) responsible for production of the surprisingly narrow energy electron bunch.

Ideal MHD simulation of laser generated plasma plume: Numerical simulation using three dimensional ideal magnetohydrodynamics equations have been carried out to study the evolution of pulsed laser generated plasma plume flowing in a direction perpendicular to the applied external magnetic field (0.13 T). Gross features like formation of cavity and collapse of cavity into a jet beam as observed in experiments are well reproduced in the simulation. Simulation shows that initially when the dynamic beta of plasma is high, the plasma expansion is unimpeded and the magnetic field is advected with the flow. The plasma expansion leads to compression and bending of the external magnetic field lines at the plasma plume boundary. The increased magnetic pressure at the boundary of plasma plume decelerates the plume expansion and gives rise to a reverse shock in the expanding flow. This leads to formation a cavity surrounded by a shell of shocked plasma. The radial expansion is then halted when the plasma pressure and the magnetic pressure becomes comparable. Finally, the cavity collapses into a jet like flow.

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CHAPTER B

Activities of ITER-India

Since last reporting ITER-India has made significant progress in the development and delivery of the 9 packages which are a part of India's commitment to ITER IO. These include the cryostat, the cooling water system, the in-wall shields, the cryolines and cryodistribution boxes, 9+1(spare) RF sources for the ion cyclotron heating (ICRH) package, 2 gyrotrons and related assemblies for the electron cyclotron heating (ECRH) package, the diagnostic neutral beam (DNB) line, the power supplies related to the ICRH, ECRH and the DNB and some part of diagnostics.

In parallel, construction and commissioning activities are moving fast at ITER site. Several contractors are working at present for the completion of civil works, piping network and plant-systems. Activities inside the Tokamak complex have commenced. Installation of piping, equipment and other systems/components have started. Installation of Cryostat Base section is planned by middle of May, 2020. The ITER Council met in November 2019 to review the affairs of the project, and 68.7% physical progress has been reported by end of January 2020 related to the completion of activities required for the first plasma. For the full project the progress is 54.5%. *Credits received for Indian in-kind deliveries now stands at 95361 IUA (ITER Units of Account).*

The following sections provide a brief overview of the progress made by ITER India towards ensuring the deliverables to IO and related to various packages:

B.1 Cyrostat

Significant efforts have been made towards ensuring that the progress related to 29.3 metres tall and 28.6 metres wide 4000 tons cryostat is in-line with ITER-IO's work schedule. The cryostat assembly consists of a base section, lower cylinder, upper cylinder and a top lid. Each of this section is an assembly of several sectors. This approach has been chosen considering the manufacturing in India and subsequent transport to IO. One of the important achievement in July 2019 was the completion and handover to ITER organisation of the base section and lower cylinder of the cryostat. The Indian delegation for this important event was led by Dr. Anil Kakodkar, former chairman of the atomic energy commission. In addition to Dr. Kakodkar the ceremony was addressed by Dr. Bernard Bigot, director general ITER Organisation and attended by Mr. Vijay Mohan Kwatra, Indian ambassador to France and several colleagues from ITER organisation and ITER India. The base section has now moved to the assembly hall, prior to its installation in the tokamak pit. Further, in

Figure B.1 Cryostat base section hand-over ceremony at ITER, July 2019. Dr. Anil Kakodkar addressing the gathering

Figure B.2 Manufacturing of Top Lid segments nearing completion at Hazira, India

continuation to the works performed in previous years, the sectors related to upper cylinder manufactured at L&T were delivered to the cryostat workshop located at IO site for final assembly and acceptance tests during this year and handed over to IO. The top lid manufacturing is nearing completion at L&T. The activities of this year have ensured 80% completion of the cryostat package with the desired quality and standards.

B.2 Cooling Water system

The ITER cooling water system incorporates multiple closed heat transfer loops plus an open-loop heat rejection system (HRS). Heat generated during operation is transferred through the Tokamak cooling water system (TCWS) to the intermediate component cooling water system (CCWS), and to the HRS, which finally rejects the heat to the environment. Chilled Water System (CHWS) provides chilled water to HVAC systems and few components. CCWS capable of handling 1000 MW power with a flow rate of 5700 kg/s per loop, CHWS, and HRS capable of handling 500 MW are under the Indian scope. The total piping length for these systems is 18 kms with a total weight of 1100 Tons. Excellent progress made during this year has ensured completion of 95% of the commitment. The deliveries to ITER site include E-house (22m L x 8m W x 4 m H) in four modules along with the accessories, 9 numbers of plate type heat exchangers each with a 70 MW capacity, 18 and 7 numbers of metallic and non-metallic bellows respectively, 6 numbers of air release cum vacuum breaker valves, 6 number of strainers and 4 numbers of water polishing units to control conductivity and the dissolved oxygen content in water. The deliveries also include 21 heat exchangers, 24 horizontal and 12 vertical pumps, 2 of the 4 chemical dosing systems, electrical, instrumentation and control units and piping spools of various diameters. Site

Figure B.3 Base Section Moved from Cryostat workshop to assembly Hall building. Installtion in the tokamak pit and welding activities to commence soon

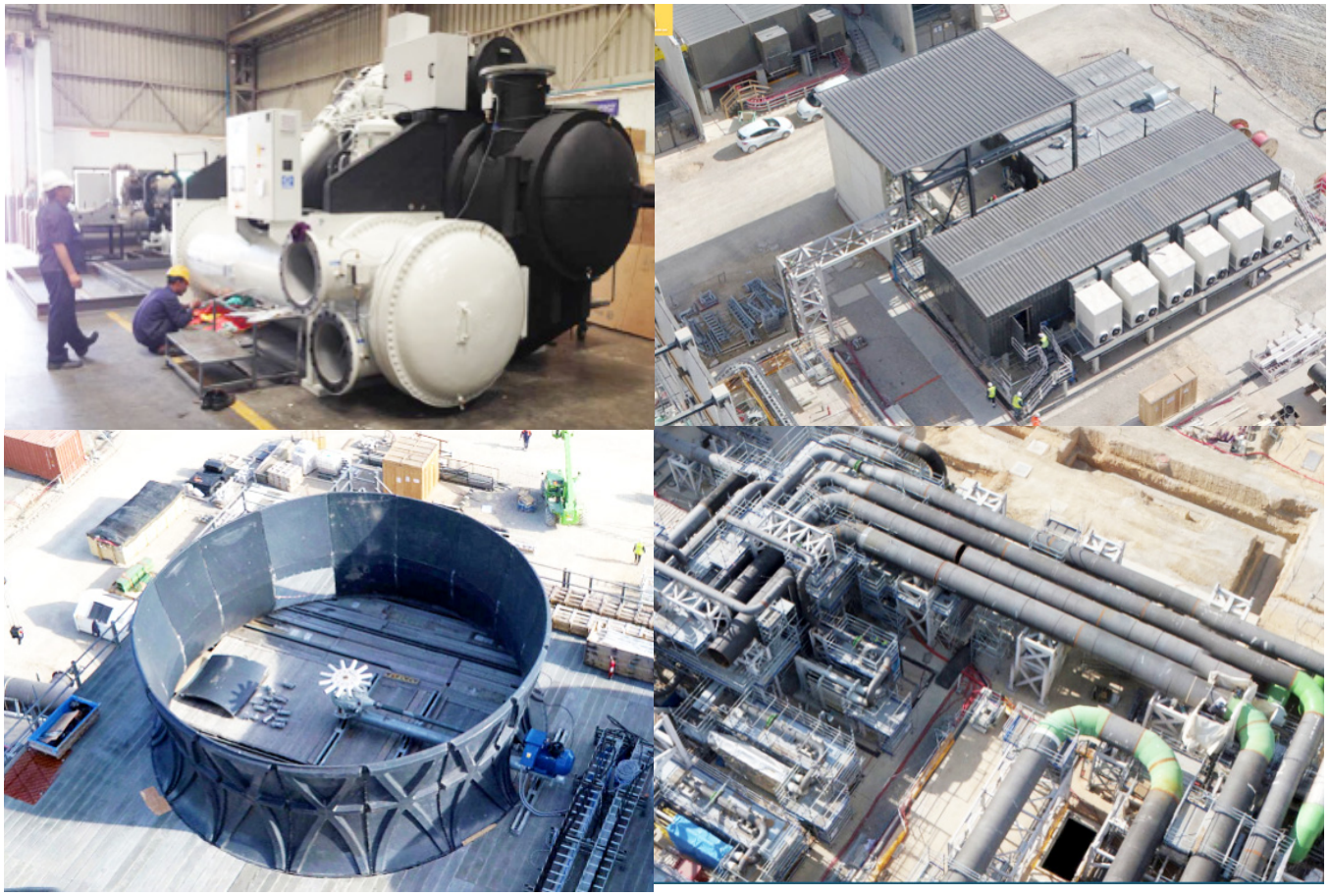

Figure B.4 Chiller and polishing unit, CWS Cooling Tower, E-House, Piping delivered by ITER-India and under installation at ITER site

installation activities are in progress with support from ITER India and under the responsibility of IO.

B.3.Vacuum Vessel In-Wall Shielding

The In-Wall shielding for the ITER Tokamak consists of modular blocks made of borated and ferritic stainless steel plates which fill the space between the double walls of the vessel structure. The main function of these inserts is to provide neutron shielding and to reduce toroidal field ripple. Water flow channels provide the desired cooling of the material. The scope of delivery of the manufactured IWS blocks is to Korea and EU domestic agencies as the responsibility of supply of vessel sectors to IO is split between the two. In continuation of the work performed in previous years, the progress made this year has ensured manufacturing and shipping of 90% of the total deliverables under this package, which in-

Figure B.5 Installtion of IWS blocks in vessel section at Korean domestic agency

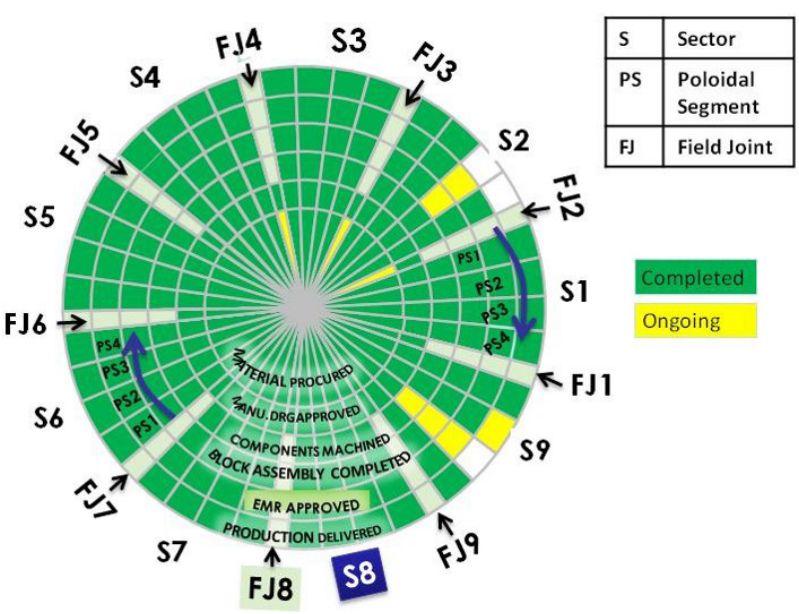

Figure B.7 Rose Diagram for the IWS block manufacturing completion. (Green - completed)

Figure B.6 Manufactured Block Assemblies

cludes completion of 4 of the 9 sector components. Manufacturing of 8.5 out of 9 sectors has been completed and 8 sector blocks have been delivered. All deliveries to Korea have been completed and a part of the supplied blocks have been installed successfully in the vacuum vessel sector 6. Majority of the blocks for 4.5 of the 5 vessel sectors under charge of the European domestic agency have also been completed.

B.4. Cryoline and Cryo-Distribution system

The ITER magnets need to be cooled with supercritical helium at 4 K (-269°C) to enable operation at the desired magnetic fields, 5T, necessary for the confinement and stabilization of the plasma. They are surrounded by cryostat and an actively-cooled thermal shield with a forced flow of helium at 80 K. The ITER cryoplant produces the required cooling power, and distributes it through a complex system of cryolines and cold boxes that make up the cryo-distribution system. The Indian scope of supply includes 5.75 km of cryolines (4k, 50 K and 80 K), 5.5 km of warm lines (room temperature) and 7 cryogenic distribution boxes. Work progress on this package has resulted in the successful completion and closure of the PA related to early delivery cryolines (PA 3.4.P2.IN.01). In addition the final design reviews of all cryoline and warmlines have been completed. Several lots of the cryolines, in group X (consisting of 3 to 7 multi-process pipes in one cryoline) and group Y (upto 3 multi process pipes in one cryoline) are under manufacturing and several of them delivered to IO. The installation of first batch of cryolines is underway in the tokamak building (B11) basement -2 (B2) level which also happens to the first system installation inside the ITER tokamak building. In addition installation of cryolines (group-Y) and warmlines in cryoplant Building (B51, B52 and Area 53) without the interface connections has been completed. The cryoplant termination cold box (CTCB) has been delivered to ITER site and is located in cryoplant building B52. Cold circulators have successfully completed the factory acceptance tests and delivered to IO for further integration

B.5. Diagnostic Neutral Beam

The diagnostic neutral beam is to be used to diagnose the

Figure B.8 Installation of warm lines and cryolines underway at ITER site

helium ash content in plasma during the DT phase of operation at ITER using charge exchange recombination spectroscopy. The mandate of the diagnostic neutral beam line is to deliver 100 keV ~20 A Ho beams with divergence < 7 mrad. The injector uses a 8 driver based RF negative ion source designed to produce 100 keV 60 A H- beam which is converted to 100 keV Ho beam @ 60% efficiency for the considered energy in the gas neutralizing cell. During its transport over a distance of 21 m to the ITER plasma the beam undergoes further losses due to direct interception because of inherent divergence and re-ionization, ~20%, due to its interaction with the back ground gas atoms for the estimated pressure profile considering active (gas feed in ion source, neutralizer and from tokamak) and passive (gas desorption due to beam interaction along its transport path) sources of gas in the beam line pumped using cryopumps with a pumping speed of 106 l/s. The successful activities for this package during the year include substantial advancement in the manufacturing of the beam source (BS) and beam line components (BLCs). Noticeable this year are the first of its kind activities in terms of characterization of copper electrodeposited layers over a temperature range from room temperature to 150 oC and successful implementation of hot helium leak tests (HHLT) on electrodeposited components at high temperature (150 oC) and high pressure (25 bar). This has provided the much needed database for actively cooled/heated electrodeposited components which often find extensive use on components used in fusion machines. HHLT has been performed successfully on three of the four plasma grid segments and bias plate segments of the extractor and accelerator system coupled to the beam source. In addition manufacturing of 4 angled segments of the extractor grid has been completed. Another important indigenous first of its kind development relates to remotely operated lip seal laser welding and provides important inputs for high vacuum lip seals for large vacuum vessels relevant to ITER. The other areas of fusion technology development activities and applicable to the DNB components include production of high thickness (>25mm) full penetration welds on CuOF material by electron beam welding and proof of principle development for the cladding technologies like explosion bonding (in collaboration with TBRL) and laser additive manufacturing (in collaboration with RRCAT) for applying thick (~1mm) Molybdenum over Copper / Copper alloy.

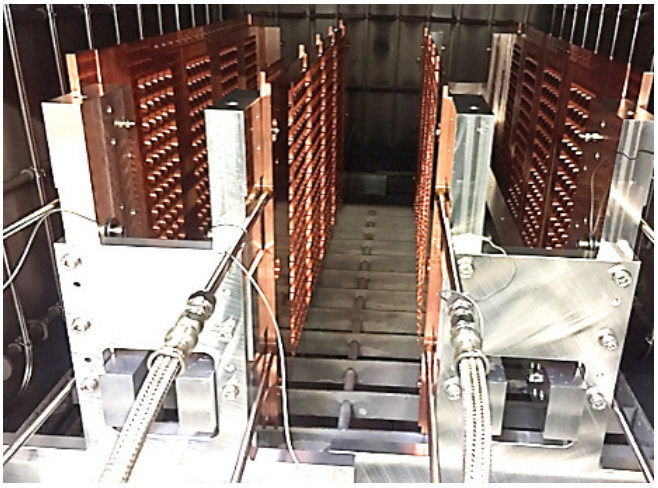

Figure B.9 Successful Hot Helium Leak Testing for 3 electro-deposited segments of Plasma Grids and 5 segments of Bias plated

B.6. Ion Cyclotron Resonance Frequency Heating Sources

The Indian contribution to this 20 MW auxiliary heating system at ITER includes supply of 9 + 1 (spare) RF sources specified to deliver 2.5 MW power per source for the frequency range 35 – 65 MHz and 3 MW power per source for the frequency range 40 – 55 MHz. It may be noted that at present there is no such amplifier chain which delivers the desired power and such a delivery is being attempted for the first time through a series of indigenous efforts. The activities

Figure B.10 A New type of wide-band Hybrod Mega-Watt level Continous Wave Radio Frequency Combiner / Splitter

this year towards ensuring the desired deliverable of such an RF source include developments and related tests at the ITER India test facility in IPR. Noticeable among them are successful testing of a high power dummy load for MW level RF power and a new type of wideband Hybrid MW Level CW Radio Frequency Combiner/Splitter. In addition a feasibility study for in-house development of CODAC core compatible local control unit for ICRF source has been initiated. Procurement activity for ITER deliverable ICRF Power Source system has also been initiated.

B.7. Electron Cyclotron RF heating sources

The Indian contribution to this 20 MW auxiliary heating and start up system for ITER includes supply of 2 out of 24 gyrotron units each rated for 1 MW power @ 170 GHz. Manufacturing of gyrotron components is in advanced stage of completion at M/s GYCOM. Fabrication of rest of the deliverables is nearing completion. In order to enable testing of the gyrotron units post their delivery to ITER India, the activities completed at the ITER India test facility include integration testing and characterization of the fast switching power supply setup including the control system integration for remote mode operation, cubicle arrangement of auxiliary power supply and signal conditioning modules and manufacturing & acceptance testing of full-scale signal conditioning modules. Prototype development and full-scale production of some of the in-house designed control system equipment has also been completed. In order to enable indigenous development of a 170 GHz gyrotron, the conceptual design phase has been completed in collaboration with CSIR-CEERI, Pilani.

Figure B.11 Prototype high voltage power supply for Gyrotron body circuit through local industry

B.8. Power Supplies for DNB, ICRF and ECRH

The power supply procurement package for ITER India includes multi-megawatt power supplies for DNB (1.4 MW extraction, 6.3 MW acceleration, 0.5 MW ERID), ICRH (0.3 MW driver and 2.8 MW end stage) and ECRH (5.5 MW) systems. The highlights for this year include extended FAT of DNB-AGPS at ITER-India lab witnessed by IO and concluded in shortest ever time span of less than a week and the successful operation of SPIDER 100kVPS integrated with SPIDER test facility for a year without any reported issues thereby establishing the high quality of indigenous product as well as elaborate training & understanding imparted to the user about equipment.

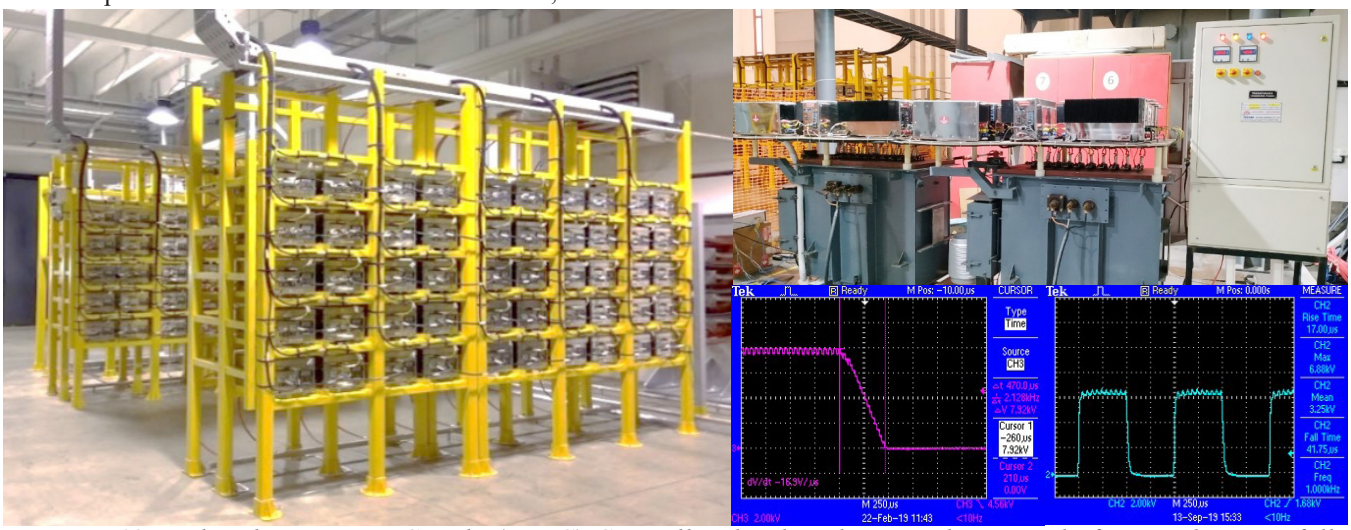

Figure B.12 High Voltage Power Supply (HVPS) Controller developed on an alternate platform and successfully integrated for operation of 8kV, 500kW Power supply.
Waveform captured for 1 kHz voltage modulation and 500 microsecond fall time.

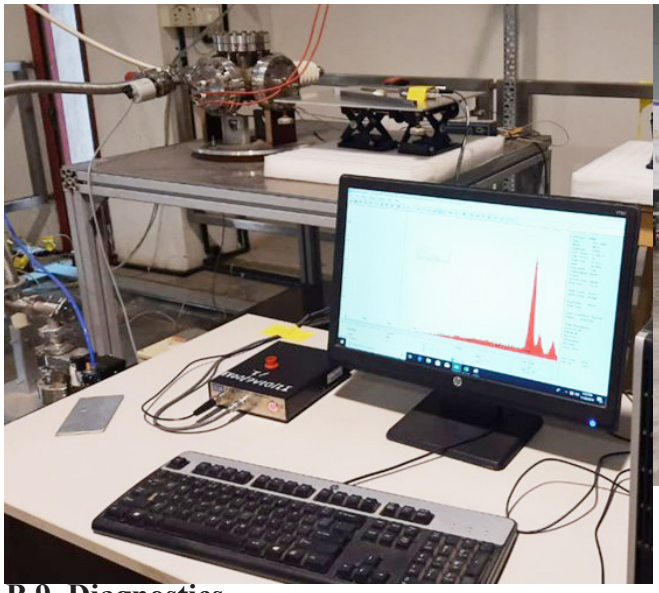

Figure B.13Fixed Anoe X-Ray source (left)
Protoype set up for Transmission measurements (top)

B.9. Diagnostics

Indian contribution to ITER diagnostics includes X-ray crystal spectroscopy, electron cyclotron emission diagnostics, edge charge exchange spectroscopy system and the upper port plug – 09. This year's achievements include prototype development of an X-ray anode source and transmission line including polarizer splitter unit. In addition the preparation of the CXRS edge diagnostic package for PA signature and system integration study for the upper port plug 09 have been completed.

B.10. Other Actvities

In addition to addressing the needs related to ensuring the timely deliveries to ITER, several initiatives have been undertaken to address to the issues of increasing participation of the Indian industry on national and global platforms, management of knowledge gained through participation in ITER, addressing the needs related to quality through audits and staff training, improvements in the area of information and technology and requirements of the design office to attend to the needs thereby controlling any delays related to design inputs wherever applicable.

B.10a. Efforts to involve Indian Industries in ITER and increasing our in-kind contribution

• Towards its efforts to involve Indian industries in ITER project, ITER-India had organized first one-day Industrial meet at IPR on Dec 21, 2019. Total 40 representatives from 25 Indian industries participated in this meet.

• Indian Industries have started deputing their manpower to provide technical support to ITER in different areas selected through competitive process. As of now, 101 persons from Indian industries are deputed at ITER site in France.

• Towards increasing our in-kind contribution in ITER, after several interactions and meetings, ITER Organization has made firm commitments (agreements signed) worth about 1,499,000 Euro (~ INR 12 Crore) in the area of specialized technical support from ITER-India.

• Confirmation for proposal of Task Agreements for about 283,000 Euro (~ INR 2.26 Crore) has been received and shall be signed soon. Further discussions are at advanced level for providing specialized technical support of additional 2,50,000 Euro (~ INR 2.0 Crore) by ITER-India.

B.10b. Activities related to Knowledge management

• An 8 member knowledge management team was formed in March 2020.

• The goal is to extract information related to design documents and data especially for those ITER systems outside the scope of ITER India deliverable but relevant from future perspectives.

• Presently the Team is working on 4 ITER systems - Superconducting Magnets, Vacuum Vessel, Diverter Cassettes and Blanket modules.

• The available information shall be analyzed and stored systematically in local repositories.

B.10c. Activities related to Quality

• Completion of ITER-India audit by ITER-IO: The quality audit was completed with only 3 Non Conformities and opportunity for improvement.

• Several trainings were arranged to improve staff knowledge related to (i) preparation of design review templates (ii) DRR (Delivery Readiness Review) requirements (iii) Release Note Template (iv) MQP Doc Change Control Process (v) QMD training session on '' inspection and testing process''(vi) MRR procedure (vii) Root Cause Analysis (RCA) methodology (viii) multi-Party Amendment to PA Applicable Documents (PA-AD)

• Various IO MQP procedures were reviewed internally and communicated to the relevant groups for implementation, as applicable

B.10d. Activities related to Information and Technology

• Renewal and up-gradation of Zimbra mail server, renewal of 4800 next generation Firewall Appliance and up-gradation of Hardware management console, VMware Software Operational management.

• During the lockdown period regular exchange of information between the ITER India employees working from home and their ITER counterparts through teleconferences and skype meetings ensured continuity and substantial progress of work in the desired areas.

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CHAPTER C, D, E, & F

C. Academic Programme

D. Technical Services

E. Publications and Presentations

F. Other Activities

C. ACADEMIC PROGRAMMES

C.1 DOCTORATE PROGRAMME

Fourteen (14) new students with Physics (09) and with different Engineering background (05) including Nuclear engineering have joined this pro¬gramme during this year and are going through the course work. After successful completion of this course work, they will be enrolled for their Ph.D, in HBNI. Overall there are total sixty two (62) PhD students are enrolled at present in HBNI including some IPR employees.

Ph.D. THESIS SUBMITTED (during April 2019 - March 2020)

Study of Novel Features in Laser-Plasma Interactions
Atul Kumar
Homi Bhabha National Institute, 2019

Collective Structures in Two-Dimensional Strongly Coupled Dusty Plasmas
Sandeep Kumar
Homi Bhabha National Institute, 2019

Development of Permanent Magnet Based Helicon Plasma Source
Arun Pandey
Homi Bhabha National Institute, 2019

Study of Plasma Turbulence in Large Volume Plasma Device (LVPD),
Amulya Kumar Sanyasi
Ravenshaw University, Cuttack, 2019

Design and Development of Microwave Interferometer and Reflectometer Systems for Plasma Diagnostics in Tokamak
Praveen Kumar Atrey
Nirma University, Ahmedabad, 2019

Experimental Study of Near Anode Plasma in Hollow Cathode Cross Field Discharges
Ramkrishna Rane
Homi Bhabha National Institute, 2019

Study of Plasma in a Multi-Pole Line Cusp Magnetic Field
Amitkumar Patel
Homi Bhabha National Institute, 2019

Experimental Study on ETG Turbulence Induced Plasma Transport in Large Volume Plasma Device
Prabhakar Srivastav
Homi Bhabha National Institute, 2019

Driven Phase Space Structures in a 1D Vlasov-Poisson Plasma
Pallavi Trivedi
Homi Bhabha National Institute, 2019

Turbulence, Flows and Magnetic Field Generation in Plasmas using a Magnetohydrodynamic Model
Rupak Mukherjee
Homi Bhabha National Institute, 2019

Investigation of Laser Induced Plasma in Various Configurations
Alamgir Mondal
Homi Bhabha National Institute, 2019

Molecular Dynamics Simulation Study of Resonance Absorption Phenomena in Intense Laser-Driven Atomic Nano-Clusters
Sagar Sekhar Mahalik
Homi Bhabha National Institute, 2019

Study of Two-Phase Flows in Fusion Magnets
Gaurav Kumar Singh
Homi Bhabha National Institute, 2019

Flow Effects on Visco-Resistive MHD in a Tokamak
Jervis Ritesh Mendonca
Homi Bhabha National Institute, 2019

Molecular Dynamics Study of Single Particle and Collective Effects in Dusty Plasmas
Srimanta Maity
Homi Bhabha National Institute, 2019

Study of Generation and Transport of Runaway Electrons in Aditya and Aditya-U Tokamak
Harshita Raj
Homi Bhabha National Institute, 2019

Long-Time Confinement of Toroidal Electron Plasma in Smartex-C
Lavkesh Lachhvani
Homi Bhabha National Institute, 2020

Effect of Inhomogeneous Magnetic Field on Helicon Antenna Produced Expanding Plasma
Sonu Yadav
Homi Bhabha National Institute, 2020

Study of Transmutation, Gas Production and Displacement Damage in Iron, Tungsten and Chromium for D-T Neutron Irradiation
Mayank Rajput
Homi Bhabha National Institute, 2020

C.2 SUMMER SCHOOL PROGRAMME (SSP)

The Summer School programme for the year 2019 is being held at IPR from May 27- July 5, 2019. For this 6 week programme, 32 students of science (22) and engineering streams (10) have been selected. The students will first have a week of class room lectures on various domains of plasma physics and applications by IPR faculty, followed by a five week project work. The students' projects will be evaluated based on the presentations made on their projects at the end of the School. As part of the programme, the students visited the ICRH facility of ITER-India laboratory located at the IPR campus. In the course of the school, the students will visit most of the labs in IPR, FCIPT, ITER-India and IPR extension labs at Gandhinagar. The SSP-2019 students were also taken for a leisure-cum-adventure trip to the Orsang Camp Resort located in Vadodara.

C.3 ACADEMIC PROJECTS FOR EXTERNAL STUDENTS

Around 90 students, pursuing Under Graduate (UG)/ Post Graduate (PG) courses in science and engineering, were engaged to do various academic projects at IPR under their course curriculum in different fields of science and technology from various colleges/universities/Institutes during April 2019 to March 2020.

D. TECHNICAL SERVICES

D.1. SIRC (Library) Services

Scientific Information Resource Centre (SIRC) at Institute for Plasma Research (IPR) is a specialized Information and Publication Management Centre providing services using modern tools, to the scientific community involved in the Research and Development activities of Plasma Physics and Fusion Science and Technology.

The library website (http://www.ipr.res.in/library/) is continuously updated with latest information and full-text access to both subscribed and internal e-resources.
During the year 2019-20 a total budget of Rs. 25972608.00 was utilized and added the following to its collection during the year 2019-20:
Books – 147; Scientific & Technical Reports from other institutes – 24; Reprints – 164; Pamphlets – 32; Software – 27

As part of user-driven focused collection development strategy, the Library organized a One-Day Books Exhibition by inviting local book vendors to exhibit their selected collection.

The library continued to subscribe 112 periodicals adding 4 new online journal titles to the e-collection and continued to subscribe to major databases such as SCOPUS, APS-ALL, Online Archives of core journals, and it has access to SCIENCEDIRECT as part of the DAE Consortium.

Keeping the scientific community updated, the Library continued to provide Current Awareness Services by delivering email-based Fusion News Alerts and REcent Articles to Discover (READ) services to IPR, CPP and ITER-India users. Total 296 News items were sent/displayed and archived as an Alerting Service.

Library continued to collaborate with DAE units and other National and International libraries to provide Inter-Library Loan (ILL) services. 83.60% of the requests made by staff members were satisfied through ILL service. IPR Library provided documents to other institutes against their queries

and 100% of the total need were satisfied.

In 2019-20, Library provided 13736 photocopies/ prints and 1682 scanned copies to the users.

Publication Management Services were carried out efficiently and SIRC continued to subscribe to anti-plagiarism software tool for checking similarity index of the publications. SIRC published the following during the year 2019-20:

Internal Technical Reports – 29; Internal Research Reports – 82; IPR Publications in Journals –170; IPR Publications in Conference Proceedings - 21.

An intranet-based Pre-Publication Broadcasting System was developed and implemented collaboration with the Computer Centre.

Library is actively carrying out Information Literacy and Training programmes by conducting various trainings and workshops. Orientation was given to newly joined members, SSP Students and Research Scholars. Library internship training was provided to 04 LIS students from Gujarat University, Ahmedabad during the year 2019-20.

Library actively participated and contributed to other Institutional activities, such as ADITYA-30 Years, Swacchata Abhiyan, Safety Week, NSD, IYD, etc. Library is actively involved in OLIC and promoting usage of Hindi language and also organized Hindi Books Exhibition by displaying the Hindi Books collection of the library.

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E. PUBLICATIONS AND PRESENTATIONS

E.1 Articles Publications

E.1.1 Journal Articles

Beyond the Conventional Collisional Absorption of Laser Light in Under-Dense Plasma: A Particle-In-Cell Simulation Study
M. KUNDU
Pramana - Journal of Physics, 92, 50, 2019

Comparative Study of Discharge Characteristics and Associated Film Growth for Post-Cathode and Inverted Cylindrical Magnetron Sputtering
R. RANE, A. JOSHI, S. AKKIREDDY, S. MUKHERJEE
Pramana - Journal of Physics, 92, 55, 2019

Automation and Interlock System Design for Pb-Li Liquid-Metal Purification Experimental Facility
ABHISHEK SARASWAT, ANKUSH V. DEOGHAR, R. BHATTACHARYAY
Fusion Engineering and Design, 141, 43, 2019

Development of an Optimised Magnetic Field Source for Flowmeter Applications
SRIKANTA SAHU, ASHOK PRAJAPATI, MRITUNJAY KUMAR, RAJENDRAPRASAD BHATTACHARYAY
Flow Measurement and Instrumentation, 66, 190, 2019

Sensitivity Analysis on Predicted Microwave Performance of Mode Converters with Geometrical Tolerances for 42-Ghz Transmission Line Components
K. SATHYANARAYANA and S. V. KULKARNI
Fusion Science and Technology, 75, 234, 2019

Spatio-Temporal Evolution of Electric Field inside a Microwave Discharge Plasma during Initial Phase of Ignition and Its Effect on Power Coupling
C. MALLICK, M. BANDYOPADHYAY, and R. KUMAR
Physics of Plasmas, 26, 043507, 2019

Whistler Wave Propagation and Interplay between Electron Inertia and Larmor Radius Effects
GARIMA JOSHI, G. RAVI, and S. MUKHERJEE
Physics of Plasmas, 26, 042106, 2019

Sheath Formation in Collisional, Low Pressure, and Magnetized Plasma
R. MOULICK, S. ADHIKARI, and K. S. GOSWAMI
Physics of Plasmas, 26, 043512, 2019

Delta (δ) Ferrite Formation in the Welds of Aluminized 9Cr-1Mo Steels
A. B. ZALA, N. I. JAMNAPARA, V. J. BADHEKA, C. SASMAL, S. SAM, M. RANJAN
Metallography, Microstructure, and Analysis, 8, 256, 2019

Coherent Nonlinear Oscillations in Magnetohydrodynamic Plasma
RUPAK MUKHERJEE, RAJARAMAN GANESH, and ABHIJIT SEN
Physics of Plasmas, 26, 042121, 2019

Development of a Test Bench of 2.45 Ghz ECR Ion Source for RFQ Accelerator
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E.1.3 Book Chapters

Simulation of Radiation Damage and Ion Irradiation Experiments with Tungsten
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E.2 INTERNAL RESEARCH AND TECHNICAL REPORTS

E 2.1 Research Reports

DETERMINING ELECTRON TEMPERATURE AND NEGATIVE ION CONCENTRATION USING BIASED HAIRPIN RESONATOR PROBE
A. K. PANDEY, JAY K. JOSHI and S. K. KARKARI
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DETERMINATION OF MUELLER MATRIX FOR METAL REFLECTORS BY STOKES POLARIMETRY
ASHA ADHIYA and RAJWINDER KAUR
IPR/RR-1080/2019 APRIL 2019

PERFORMANCE ANALYSIS OF SST-1 X-DIVERTOR CONFIGURATION USING SOLPS5.1
M. HIMABINDU, ANIL K.TYAGI, DEEPTI SHARMA, DEVENDRA SHARMA, R. SRINIVASAN, Z. P. CHEN and SWADESH MAHAJAN
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FAST WAVE INDUCED ICRF PLASMA EXPANSION IN ADITYA TORUS

KISHORE MISHRA, S. KULKARNI, R. TANNA, R. MANCHANDA, N. RAMAIYA, M. GUPTA, J. GHOSH, A. VARIA, M. JADHAV, R. JOSHI, B. KADIA, K. PARMAR, M. PARIHAR, Y. SRINIVAS, S. KUMAR, D. RATHI, G. ASHOK, K. JADEJA, S. BHATT, ICRH TEAM and ADITYA TEAM
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S. BINWAL, J. K. JOSHI, S. K. KARKARI and L. NAIR
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DEVELOPMENT AND TESTING OF PROTOTYPE COMPONENTS OF NAS FOR IN-LLCB TBM
ARVIND KUMAR, SHAILJA TIWARI and VILAS CHAUDHARI
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A. J. DEKA, BHARATHI P., M. BANDYOPADHAY, M. J. SINGH and A. K. CHAKRABORTY
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A. K. VERMA, B. K. YADAV, A. GANDHI, A. SARASWAT, S. VERMA and E. RAJENDRA KUMAR
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EFFECT OF ACTIVATING FLUXES ON MICROSTRUCTURE AND HARDNESS PROPERTIES OF A-TIG WELDED ALUMINIZED COATED 9Cr-1Mo STEELS
ARUNSINH B. ZALA, N. I. JAMNAPARA, VISHVESH J. BADHEKA, C. S. SASMAL, SHIJU SAM and MUKESH RANJAN
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S. KHAMARU, M. SENGUPTA and R. GANESH
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DRIFT WAVES WITH DUST ACOUSTIC WAVE COUPLING
ATUL KUMAR, AMITA DAS and PREDHIMAN KAW
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DYNAMICS OF NEON IONS AFTER NEON GAS SEEDING AND PUFFING INTO TOKAMAK PLASMA
N. BISAI, M. B. CHOWDHURI, S. BANERJEE, HARSHITA RAJ, RITU DEY, R. L. TANNA, R. MANCHANDA, K. A. JADEJA, J. GHOSH and ADITYA TEAM
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BIO-TRIBOLOGICAL RESPONSE OF DUPLEX SURFACE ENGINEERED SS316L FOR NOVEL HIP-IMPLANT
ANIRUDDHA SAMANTA, RAMKRISHNA RANE, BISWANATH KUNDU, DIPAK CHANDA, SNEHASIS MISHRA, JITEN GHOSH, SANDIP BYSAKH, GHANSHYAM JHALA, ALPHONSA JOSEPH, SUBROTO MUKHERJEE, MITUN DAS, VAMSI KRISHNA BALLA, KRISHNA DAS SAHA, CHANDAN KUMAR GHOSH and ANOOP K.MUKHOPADHYAY
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PAYANK PATEL, N. I .JAMNAPARA, ARUNSINH ZALA and S. D. KAHAR
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S. BINWAL, Y. PATIL, S. K. KARKARI and L. NAIR
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M. G. HARIPRASAD, P. BANDYOPADHYAY, GARIMA ARORA and A. SEN
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AMRITA BHATTACHARYA, JOYDEEP GHOSH, MALAY B. CHOWDHURI, PRABHAT MUNSHI, IZUMI MURAKAMI and D THE ADITYA TEAM
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PAWANDEEP KAUR and RAJARAMAN GANESH
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MODELING OF THE Hα EMISSION FROM ADITYA TOKAMAK PLASMAS
RITU DEY, M. B. CHOWDHURI, J. GHOSH, R. MANCHANDA, N. YADAVA, U. C. NAGORA, P. K. ATREY, J. V. RAVAL, Y. SHANKARA JOISA, R. L. TANNA and ADITYA TEAM
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DESIGN AND DEVELOPMENT OF TRANSIENT HOT WIRE TECHNIQUE BASED EXPERIMENTAL SYSTEM FOR EFFECTIVE THERMAL CONDUCTIVITY MEASUREMENT OF LITHIUM METATITANATE PEBBLE BEDS
MAULIK PANCHAL, ABHISHEK SARASWAT, SHRIKANT VERMA and PARITOSH CHAUDHURI
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DESIGN AND ANALYSIS OF TWIN SOURCE EXTRACTION SYSTEM (GRIDS) WITH INDIGENOUS MANUFACTURING FEASIBILITY ASSESSMENT
RAVI PANDEY, MAINAK BANDYOPADHYAY, M. J. SINGH, JAYDEEP JOSI and ARUN K. CHAKRABORTY
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PASSIVE GRAVITY COMPENSATION (PGC) OF SERIAL LINK MANIPULATORS FOR REMOTE HANDLING (RH) APPLICATION
MANOAH STEPHEN MANUELRAJ and N. RAMASUBRAMANIAN
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INFLUENCE OF SELECT DISCHARGE PARAMETERS ON ELECTRIC FIELD TRANSIENTS TRIGGERED IN COLLISIONLESS VERY HIGH FREQUENCY CAPACITIVE DISCHARGES
SARVESHWAR SHARMA, NISHANT SIRSE, ABHIJIT SEN, MILES M. TURNER and ALBERT R. ELLINGBOE
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STUDY ON EFFECT OF ATMOSPHERIC PRESSURE AIR PLASMA ON JUTE FIBER PROPERTIES
NISHA CHANDWANI and SUDHIR K. NEMA
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DRIVEN ELECTROSTATIC PHASE SPACE VORTICES IN A 1D WEAKLY DISSIPATIVE VLASOV-POISSON SYSTEM
PALLAVI TRIVEDI and RAJARAMAN GANESH
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EFFECT OF PERIODIC GAS-PUFFS ON DRIFT-TEARING MODES IN ADITYA/ADITYA-U TOKAMAK DISCHARGES
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EVALUATION OF OXYGEN TRANSPORT COEFFICIENT IN ADITYA TOKAMAK USING RADIAL PROFILE OF O4+ EMISSIVITY AND IMPORTANCE OF ATOMIC DATA USED THEREIN
M. B. CHOWDHURI, J. GHOSH, RITU DEY, S. PATEL, N. YADAVA, R. MANCHANDA, AMRITA BHATTACHARYA, I. MURAKAMI and ADITYA TEAM
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PHASE TRANSITION AND EMERGENCE OF ACTIVE TEMPERATURE IN ACTIVE BROWNIAN SYSTEM IN UNDERDAMPED BACKGROUND
SOUMEN DE KARMAKAR and RAJARAMAN GANESH
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CFD ANALYSIS AND EXPERIMENTAL VALIDATION OF PRIMARY CHAMBER OF PLASMA PYROLYSIS SYSTEM USING ANSYS CFX
DEEPAK SHARMA, ATIK MISTRY, HARDIK MISTRY, PARITOSH CHAUDHURI, P. V. MURUGAN, S. PATNAIK, AADAM SANGHARIYAT, VISHAL JAIN, SHASHANK CHATURVEDI and S. K. NEMA
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HELIUM COOLED DUAL BREEDER BLANKET - A CANDIDATE BREEDING BLANKET CONCEPT FOR NEAR TERM INDIAN DEMO FUSION REACTOR
H. L. SWAMI, DEEPAK SHARMA, A. N. MISTRY, C. DANANI, P. CHAUDHARI and R. SRINIVASAN
IPR/RR-1113/2019 SEPTEMBER 2019

STUDY OF MICROSTRUCTURES & MECHANICAL PROPERTIES OF TIG WELDED ALUMINIZED 9CR-1MO STEEL
A. B. ZALA, N. I. JAMNAPARA, C. S. SASMAL, S. SAM and M. RANJAN
IPR/RR-1114/2019 SEPTEMBER 2019

PHASE MIXING AND WALK-OFF OF NONLINEAR ELECTRON OSCILLATIONS IN A WARM INHOMOGENEOUS PLASMA
NIDHI RATHEE, ARGHYA MUKHERJEE, R. M. G. M. TRINES and SUDIP SENGUPTA
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ELECTRIC FIELD NON-LINEARITY IN VERY HIGH FREQUENCY CAPACITIVE DISCHARGES AT CONSTANT ELECTRON PLASMA FREQUENCY
SARVESHWAR SHARMA, NISHANT SIRSE, ANIMESH KULEY and MILES M. TURNER
IPR/RR-1116/2019 SEPTEMBER 2019

A NEW MECHANISM OF DIRECT COUPLING OF LASER ENERGY TO IONS
AYUSHI VASHISTHA, DEVSHREE MANDAL, ATUL KUMAR, CHANDRASEKHAR SHUKLA and AMITA DAS
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SUB-SURFACE ACCUMULATION OF DEEPLY IMPLANTED DEUTERIUM: EVIDENCE FROM POSITRON ANNIHILATION SPECTROSCOPY
P. N. MAYA, S. MUKHERJEE, P. SHARMA, V. KARKI, M. SINGH, A. SATYAPRASAD, R. KUMAR, S. VALA, M. ABHANGI, S. KANNAN, P. K. PUJARI, P. M. RAOLE and S. P. DESHPANDE
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X-BAND SHAPED ANISOTROPIC METASURFACE BASED PERFECT CROSS POLARIZATION CONVERTOR
PRIYANKA TIWARI, SURYA KUMAR PATHAK, ANITHA V.P., VARSHA SIJU and ABHISHEK SINHA
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PHASE NOISE DUE TO VIBRATIONS IN FAR-INFRARED INTERFEROMETER OF SST-1 TOKAMAK
ASHA ADHIYA, PRAMILA GAUTAM and RAJWINDER KAUR
IPR/RR-1120/2019 OCTOBER 2019

DENSITY AND POTENTIAL WAKE PAST AN INSULATING OBSTACLE IN A PARTIALLY MAGNETIZED FLOWING PLASMA
S. DAS and S. K. KARKARI
IPR/RR-1121/2019 OCTOBER 2019

EXPERIMENTAL OBSERVATION OF A FIRST ORDER PHASE TRANSITION IN A COMPLEX PLASMA MONO-LAYER CRYSTAL
M. G. HARIPRASAD, P.BANDYOPADHYAY, GARIMA ARORA and A. SEN
IPR/RR-1122/2019 OCTOBER 2019

PARAMETRIC STUDY OF ELECTRON DRIFT INJECTION SYSTEM TO FORM NEGATIVE POTENTIAL WELL FOR BETTER PLASMA START-UP IN A TOKAMAK
JYOTI AGARWAL, SOMESWAR DUTTA, D. RAJU and R. SRINIVASAN
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ESTIMATION OF POWER TRANSMISSION OF FAST WAVE IN ICRF RANGE THROUGH TOKAMAK PLASMA EDGE WITH THE HELP OF REFLECTION COEFFICIENT
AJIT KUMAR DASH and ASIM KUMAR CHATTOPADHYAY
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SIMULATION OF THE INTERNAL KINK MODE IN VISCO -RESISTIVE REGIMES
J. MENDONCA, D. CHANDRA, A. SEN and A. THYAGARAJA
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PARAMETER SPACE VALIDATION THROUGH OOPS SIMULATIONS OF PLASMA BURN-THROUGH AND DISCHARGE EVOLUTION IN THE SST-1 TOKAMAK
AMIT K. SINGH, SANTANU BANERJEE, I. BANDYOPADHYAY, R. SRINIVASAN, U. C. NAGORA, JAYESH RAVAL, K. TAHILIANI and THE SST-1 TEAM
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EFFECT OF MAGNETIC FIELD ON THE LATERALLY COLLIDING PLASMA PLUMES
ALAMGIR MONDAL, R. K. SINGH, VISHNU CHAUDHARI and H. C. JOSHI
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OBSERVATION OF NEUTRALS CARRYING ION-ACOUSTIC WAVE MOMENTUM IN PARTIALLY IONIZED PLASMA
MEENAKSHEE SHARMA, A. D. PATEL, ZUBIN SHAIKH, N. RAMASUBRAMANIAN, R. GANESH, P. K. CHATTOPADHAYAY and Y. C. SAXENA
IPR/RR-1128/2019 NOVEMBER 2019

STUDY OF DIAMAGNETISM IN LASER-PRODUCED PLASMA USING B-DOT PROBE
NARAYAN BEHERA, R. K. SINGH, G. VEDA PRAKASH, KIRAN PATEL, H. C. JOSHI and AJAI KUMAR
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Li2TiO3 PEBBLE FABRICATION BY FREEZE GRANULATION & FREEZE DRYING METHOD
AROH SHRIVASTAVA, TEJAS KUMAR, RIDDHI SHUKLA and PARITOSH CHAUDHURI
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PRECURSOR MAGNETO-SONIC SOLITONS IN A PLASMA FROM A MOVING CHARGED OBJECT
ATUL KUMAR and ABHIJIT SEN
IPR/RR-1131/2019 DECEMBER 2019

EXPERIMENTAL STUDY OF NEUTRON IRRADIATION EFFECT ON ELEMENTARY SEMICONDUCTOR DEVICES USING AM-BE SOURCE
H. L. SWAMI, RAJAT RATHOD, T. SRINIVAS RAO, M. ABHANGI, S. VALA, C. DANANI, P. CHAUDHURI and R. SRINIVASAN
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RADIAL CONTROL OF ELECTRON TEMPERATURE GRADIENT WITH OPTIMIZED OPERATIONAL CONFIGURATION OF DOUBLE PLASMA DEVICE
PRINCE ALEX, A. K. SANYASI, PRABHAKAR SRIVASTAV, L. M. AWASTHI, P. K. SRIVASTAVA and RITESH SUGANDHI
IPR/RR-1133/2019 DECEMBER 2019

ELECTROMAGNETIC EFFECT ON SHORT WAVELENGTH ION TEMPERATURE GRADIENT MODE
J. MAHAPATRA, J. CHOWDHURY, R. GANESH and L. VILLARD
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COMPARISON OF CONVENTIONAL AND HOLLOW PIPE CAGE PLASMA NITRIDING PROCESSES ON 16MNCR5 TREATED AT DIFFERENT TEMPERATURES
GHANSHYAM JHALA, ALPHONSA JOSEPH, SAISIKHA NAIDU and BHARATI MAHESH
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INVESTIGATION OF CS NOZZLE STRUCTURE FOR UNIFORM AND CONTROLLED CS INJECTION INTO VACUUM
PRANJAL SINGH, CHINMAY ANDHARE and MAINAK BANDYOPADHYAY
IPR/RR-1136/2019 DECEMBER 2019

THERMAL CONVECTION STUDIES IN LIQUID METAL

FLOW INSIDE A HORIZONTAL DUCT UNDER THE INFLUENCE OF TRANSVERSE MAGNETIC FIELD
S. SAHU, C. COURTESSOLE, A. RANJAN, R. BHATTACHARYAY, T. SKETCHLEY and S. SMOLENTSEV
IPR/RR-1137/2019 DECEMBER 2019

DESIGN AND COMPARISON STUDY OF STEAM GENERATOR CONCEPTS AND POWER CONVERSION CYCLES FOR FUSION REACTORS
PIYUSH PRAJAPATI, PARITOSH CHAUDHURI, SHRISHAIL PADASALAGI and SHISHIR DESHPANDE
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CHARACTERIZATION OF THE PLASMA CURRENT QUENCH DURING DISRUPTIONS IN ADITYA TOKAMAK
S. PUROHIT, M. B. CHOWDHURI, J. GHOSH, Y. S. JOISA, J. V. RAVAL, S. KUMAR, D. RAJU, K. A. JADEJA, M. K. GUPTA, S. K. PATHAK, C. N. GUPTA, S. B. BHAT, R. L. TANNA, P. K. CHATTOPADHYAY and ADITYA TEAM
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TIME-OF-FLIGHT MASS SPECTROMETRY OF ALUMINIUM PLASMA: INVESTIGATION OF MULTIPLY CHARGED IONS AND CLUSTERS
ARVIND KUMAR SAXENA, R. K. SINGH and H. C. JOSHI
IPR/RR-1140/2020 JANUARY 2020

EMERGING ADVANCED TECHNOLOGIES DEVELOPED BY IPR FOR BIO MEDICAL APPLICATIONS- A REVIEW
A. VAID, C. PATIL, A. SANGHARIYAT, R. RANE, A. VISANI, S. MUKHERJEE, J. ALPHONSA, M. RANJAN, S. AUGUSTINE, K. P. SOORAJ, V. RATHORE, S. K. NEMA, A. AGRAJ, G. GARG, A. SHARMA, M. SHARMA, K. PANSARE, C. MURALI KRISHNA, JYOTIRMOY BANERJEE and SARAT CHANDRA
IPR/RR-1141/2020 JANUARY 2020

ACTIVATED CHARCOAL COOLED TO LIQUID HELIUM TEMPERATURE EXHIBITING PUMPING FOR HYDROGEN AND HELIUM GASES
R. GANGRADEY, V. L.TANNA, S. MUKHERJEE, J. MISHRA, P. NAYAK and P. PANCHAL
IPR/RR-1142/2020 JANUARY 2020

EXPERIMENTAL MEASUREMENT OF EFFECTIVE THERMAL CONDUCTIVITY OF CERAMIC PEBBLE BEDS USING TRANSIENT HOT WIRE TECHNIQUE
HARSH PATEL, MAULIK PANCHAL, ABHISHEK SARASWAT, NIRAV PATEL and PARITOSH CHAUDHURI
IPR/RR-1143/2020 FEBRUARY 2020

DOUBLE LAYER FORMATION AND THRUST GENERATION IN AN EXPANDING PLASMA USING 1D-3V PIC SIMULATION
V. SAINI and R. GANESH
IPR/RR-1144/2020 FEBRUARY 2020

UNPRECEDENTED CONFINEMENT TIME OF ELECTRON PLASMAS WITH A PURELY TOROIDAL MAGNETIC FIELD IN SMARTEX-C
LAVKESH LACHHVANI, SAMBARAN PAHARI, RAJIV GOSWAMI, YOGESH G. YEOLE and PRABAL K. CHATTOPADHYAY
IPR/RR-1145/2020 FEBRUARY 2020

HAZOP STUDY REPORT OF EXPERIMENTAL HELIUM COOLING LOOP (EHCL)
BRIJESH KUMAR YADAV, ANKIT GANDHI, ABHISHEK SARASWAT, SHRIKANT VERMA, RUDREKSH PATEL, PARITOSH CHAUDHURI and AMIT SIRCAR
IPR/RR-1146/2020 FEBRUARY 2020

A REVIEW ON PELLET-INJECTOR TECHNOLOGY: BRIEF HISTORY & RECENT KEY DEVELOPMENTS
SHASHI KANT VERMA, SAMIRAN SHANTI MUKHERJEE, RANJANA GANGRADEY, R. SRINIVASAN, VISHAL GUPTA, PARESH PANCHAL and P. NAYAK
IPR/RR-1147/2020 FEBRUARY 2020

BIOCOMPATIBILITY AND CYCLIC FATIGUE RESPONSE OF SURFACE ENGINEERED Ti6Al4V FOR HIP-IMPLANT APPLICATION
ANIRUDDHA SAMANTA, RAMKRISHNA RANE, GHANSHYAM JHALA, BISWANATH KUNDU, SUSMIT DATTA, JITEN GHOSH, ALPHONSA JOSEPH, SUBROTO MUKHERJEE, SANDIPAN ROY, MITUN DAS and ANOOP K. MUKHOPADHYAY
IPR/RR-1148/2020 FEBRUARY 2020

SPONTANEOUS FORMATION OF MAGNETIC DIPOLES BY INTERACTION OF INTENSE LASER WITH OVERDENSE PLASMA
DEVSHREE MANDAL, AYUSHIVASHISTHA and AMITA DAS
IPR/RR-1149/2020 FEBRUARY 2020

DUST VORTEX FLOW ANALYSIS IN WEAKLY MAGNETIZED PLASMA
PRINCE KUMAR and DEVENDRA SHARMA
IPR/RR-1150/2020 FEBRUARY 2020

EXPERIMENTAL MEASUREMENTS OF GAS PRESSURE DROP OF PACKED PEBBLE BEDS
MAULIK PANCHAL, ABHISHEK SARASWAT and PARITOSH CHAUDHURI
IPR/RR-1151/2020 FEBRUARY 2020

OUT-GASSING MEASUREMENT OF AIR-BAKED SS 304L MATERIAL BY PRESSURE-RISE METHOD
ZIAUDDIN KHAN and SIJU GEORGE
IPR/RR-1152/2020 MARCH 2020

DEVELOPMENT OF COMPACT HTS COIL FOR HIGH CURRENT RAMP RATE
U. PRASAD, P. RAJ, A. BANO, A. PANCHAL, D. KANABAR, S. DATTA, H. AGRAWAT, B. PARGHI, P. VARMORA, M. PARAMESH, U. K. PAL, R. SRINIVASAN and MAGNET SYSTEM DIVISION
IPR/RR-1153/2020 MARCH 2020

ER2O3 COATING BY MULTILAYER METALLIC SPUTTERING AND INTERMEDIATE OXIDATION APPROACH
P. A. RAYJADA, N. P. VAGHELA and AMIT SIRCAR
IPR/RR-1154/2020 MARCH 2020

3D MHD PB-LI FLOW ANALYSIS IN A RECTANGULAR CHANNEL U-BEND
A. PATEL, R. BHATTACHARYAY, V. VASAVA, A. JAISWAL, M. KUMAR, R. KUMAR, P. PEDADA, A. N. MISTRY and P. SATYAMURTHY
IPR/RR-1155/2020 MARCH 2020

A COMPUTER MODELING AND ITS PARTIAL EXPERIMENTAL VALIDATION TO STUDY THE ATTENUATION OF ELECTROMAGNETIC WAVES IN PLASMA USING CST MICROWAVE STUDIO®
HIRAL B. JOSHI, N. RAJAN BABU, RAJESH KUMAR and ASHISH R. TANNA
IPR/RR-1156/2020 MARCH 2020

A DOUBLE NEGATIVE META-MATERIAL ABSORBER AT RESONANT FREQUENCY OF 9.25 GHz IN X-BAND
B. RISCOB, ABHISHEK SINHA, YOGESH SHARMA and S. K. PATHAK
IPR/RR-1157/2020 MARCH 2020

RADIATION SHIELDING ASSESSMENT OF PROPOSED LAB FOR IECF NEUTRON SOURCE FACILITY AT CPP-IPR
H. L. SWAMI, S. R. MOHANTY, N. BUZARBARUAH, S. VALA and R. SRINIVASAN
IPR/RR-1158/2020 MARCH 2020

OPERATIONAL AND CONTROL SYSTEM OF THE EXPERIMENTAL HELIUM COOLING FACILITY (EHCL) OF IPR
B. K. YADAV, A. SARASWAT, ANKIT GANDHI, SRIKANT VERMA, P. CHAUDHURI and AMIT SIRCAR
IPR/RR-1159/2020 MARCH 2020

EXCITATION OF DUST ACOUSTIC SHOCK WAVES IN AN IN-HOMOGENEOUS DUSTY PLASMA
GARIMA ARORA, P. BANDYOPADHYAY, M. G. HARIPRASAD and A. SEN
IPR/RR-1160/2020 MARCH 2020

E.2.2 Technical Reports

Validation of Smartex-C Vacuum Vessel Heating Results with FEM Radiation Analysis
RITESH KUMAR SRIVASTAVA, MANOJ KUMAR GUPTA, BHARAT R. DOSHI, LAVKESH T. LACHHVANI, MANU BAJPAI and YOGESH YEOLE
IPR/TR-541/2019 (APRIL 2019)

CAE v1.1 - A Code for Magnetic Field Due to Arbitrary Electromagnets
DIVYANG R. PRAJAPATI and GATTU RAMESH BABU
IPR/TR-542/2019 (MAY 2019)

Parallel & Distributed Computing (PDC) Using Low Cost, Compact and Portable Raspberry Pi Mini-Cluster: Pradyut
DEEPAK AGGARWAL, PRASHANT KUMAR, HARISH CHARAN, HEMANT JOSHI and N. C. PATEL
IPR/TR-543/2019 (MAY 2019)

PLC based Data Acquisition and Control System for SST-1 Pumping Facility
KALPESHKUMAR R. DHANANI, PARAVASTU YUVAKIRAN, SIJU GEORGE, DILIP C. RAVAL and ZIAUDDIN KHAN
IPR/TR-544/2019 (MAY 2019)

Design, Development and High Power Testing of a 3.7 GHz, 125 kW RF Vacuum Window for LHCD System of

ADITYA-U Tokamak
YOGESH M. JAIN, P. K. SHARMA, P. R. PARMAR, KIRANKUMAR AMBULKAR and HARISH V. DIXIT
IPR/TR-545/2019 (JUNE 2019)

LabVIEW Based Data Archival and Processing System for ICRH Experiment
RAMESH JOSHI, H. M. JADAV, SUNIL KUMAR and HIGH POWER ICRH SYSTEMS DIVISION
IPR/TR-546/2019 (JUNE 2019)

Design, Erection, Testing and Commissioning of 220V DC, 50A Float Charger (FC), 100 A Float cum Boost battery Charger (FCBC) at 132kV IPR Substation
CHANDRA KISHOR GUPTA, SUPRIYA NAIR, PRAKASH PARMAR and CHIRAG BHAVSAR
IPR/TR-547/2019 (JUNE 2019)

Revised Design of Signal Conditioning Electronics for SST-1 Thomson Scattering Detection Sub-System
VISHNU CHAUDHARI, JINTO THOMAS and H. C. JOSHI
IPR/TR-548/2019 (July 2019)

A Hierarchal Approach to Extract Application Logs with Visualization in a Containerized Environment
SHARAD JASH, R. GANESH, TASMAY D. RACHHADIA and PURVA. K. SHAH
IPR/TR-549/2019 (July 2019)

Thermohydraulic Analysis of Flexible Cryostat towards Cryoline for Superconducting Cables
M. GHATE, H. AGRAVAT, V. TANNA, U. PRASAD and R. SRINIVASAN
IPR/TR-550/2019 (July 2019)

Design & Development of Instrumentation & Control System for Lead-Lithium MHD Experimental Loop
T. SRINIVAS RAO, S. VERMA, A. SARASWAT, D. MOHANTA, A. PATEL, S. GUPTA and R. BHATTACHARYAY
IPR/TR-551/2019 (July 2019)

A Comparison of Computational Fluid Dynamics (CFD) Simulation and Experimental Results of Plasma Pyrolysis Reactor
HARDIK MISTRY, A. N. MISTRY, DEEPAK SHARMA, P. V. MURUGAN, A. SANGHARIYAT, V. JAIN, C. PATIL, B. K. PATEL, S. PATNAIK, P. CHAUDHURI, S. K. NEMA and SHASHANK CHATURVEDI
IPR/TR-552/2019 (July 2019)

Effect of Plasma Processed Ti-Al Coating on Oxidation Resistance and Tensile Behavior of Ti6Al4V
TEJAS PAREKH, PAYANK PATEL, C. SASMAL and N. I. JAMNAPARA
IPR/TR-553/2019 (July 2019)

Python based Post Processing/Data Analysis Utility for Ka-band Reflectometer
MANISHA BHANDARKAR, IMRAN MANSURI, JJU. BUCH, SURYA KUMAR PATHAK and KIRTI MAHAJAN
IPR/TR-554/2019 (August 2019)

Validation of Phase Measurement using Digital IQ Technique on Down Converted IF Signal
DIPAL SONI, KUMAR RAJNISH and SRIPRAKASH VERMA
IPR/TR-555/2019 (August 2019)

Design of Trans-Impedance Amplifier for Avalanche Photo-Diode Detector and LabVIEW based Automated Testing for Laser Assisted Applications
VISHNU CHAUDHARI, BHUMIKA ISARANI, H. C. JOSHI and USHA NILKANTHAN
IPR/TR-556/2019 (August 2019)

Evaluation of ModSecurity for Implementation of Secure Web Application Firewall
SHARAD JASH
IPR/TR-557/2019 (September 2019)

Testing and Performance Evaluation of Signal Conditioning Electronics Boards for SST-1 Thomson Scattering Detection Sub-System
VISHNU CHAUDHARI, JINTO THOMAS and H. C. JOSHI
IPR/TR-558/2019 (October 2019)

An Overview of High Current Fast Response Power Supplies for the Fusion Machines
N. RAJAN BABU and R. B. JADEJA
IPR/TR-559/2019 (October 2019)

Development of High Voltage Series Switch Technology for the Microwave Tube Anode Power Supply Pulsing Application
N. RAJAN BABU, B. K. SHUKLA and R. B. JADEJA
IPR/TR-560/2019 (November 2019)

Vacuum Equipments Requirement for Prototype Basic Symmetric Chamber and Horizontal Access Module

Chamber in Indian Laser Interferometer Gravitational Wave Observatory (LIGO)
S. SUNIL
IPR/TR-561/2019 (November 2019)

Design and Assessment of Basic Symmetric Chamber (BSC) for Laser Interferometer Gravitational-Wave Observatory (LIGO)-India Project
RAKESH KUMAR, MANOJ KUMAR GUPTA and ZIAUDDIN KHAN
IPR/TR-562/2019 (December 2019)

Hardware Integration of Stepper Drives Based Digital Control System for Probes Positioning
V. TANK, P. K. SRIVASTAVA, R. SUGANDHI, S. JAISWAL, K. KARMUR, V. SOUMYA, PRABHAKAR SRIVASTAV, A. K. SANYASI and L. M. AWASTHI
IPR/TR-563/2019 (December 2019)

Design and Analysis of Liquid Nitrogen Cooled Sorption Cryopump for SST-1 Tokamak
VISHAL GUPTA, RANJANA GANGRADEY, SAMIRAN S. MUKHERJEE, JYOTI SHANKAR MISHRA, PRATIK A. NAYAK, PARESH PANCHAL, VIPUL L. TANNA, YUVAKIRAN PARAVASTU, DILIP C. RAVAL, ZIAUDDIN KHAN, SIJU GEORGE and PRASHANT L. THANKEY
IPR/TR-564/2019 (December 2019)

Mechanical Characterization of Steel Tendons for Actuation of Robotic Systems
JIGNESH CHAUHAN, PRAMIT DUTTA, RAVI RANJAN TIWARI and KRISHAN KUMAR GOTEWAL
IPR/TR-565/2020 (January 2019)

ANTYA High Performance Computing (HPC) System at IPR
DEEPAK AGGARWAL, ARVIND MOHAN SINGH, HEMANT JOSHI, GOVIND LOKHANDE, PRASHANT KUMAR, JUGAL CHOWDHURY, SWAPNALI KHAMARU, PAWANDEEP KAUR, RUPAK MUKHERJEE, VINOD SAINI, JASWANT PANCHUMARTI, GAURAV GARG, AGRAJ ABHISHEK, GURSHARN SINGH, HARDIK MISTRY, SRIKANTA SAHU, YOGESH JAIN, RAJARAMAN GANESH and R. SRINIVASAN
IPR/TR-566/2020 (February 2020)

3D Magneto-Structural Analysis of Magnetic Pulse Welding
A. AMARDAS and BHARAT R. DOSHI
IPR/TR-567/2020 (February 2020)

Evaluating Various Open Source Software Tools for Tracking System Issues and Usage of "Redmine" Software Tool
HITESH K. GULATI, ARNAB DASGUPTA and AMIT K. SRIVASTAVA
IPR/TR-568/2020 (February 2020)

ECE RADIOMETER SYSTEM FOR ADITYA-UPGRADE
VARSHA. S. and S. K. PATHAK
IPR/TR-569/2020 (March 2020)

E.3 CONFERENCE PRESENTATION

20th International Vacuum Electronics Conference (IVEC-2019), Seoul, Korea, 29th April-01st May 2019

Conceptual RF design of 3.7GHz 20kW CW magnetron for LHCD system of tokamaks
A. R. Jadhav, J. John, K. Tuckley, H. V. Dixit, P. K. Sharma

17th International Conference On Plasma Facing Materials And Components For Fusion Applications, Eindhoven, Netherlands, 20-24 May 2019

High He^+-flux and heat-flux exposure of Indian RAFM in the CIMPLE-PSI device
Trinayan Sarmah, Mizanur Rahman, Pubali Dihingia, J. Ghosh, P. Choudhury, M. Kakati, and G. De Temmerman

12th IAEA Technical Meeting on Control, Data Acquisition and Remote Participation for Fusion Research (CODAC 2019), Daejeon, Republic of Korea, 13 May 2019

Design and Development of a Cost Optimized Timing System for Steady State Superconducting Tokamak (SST-1)
J. Dhongde, A. Kumar, D. Raju and SST-1 Operations Division

28th IEEE Symposium on Fusion Engineering (SOFE-2019), Florida, USA, 02-06 June 2019

Structural Integrity Assessment of ITER Torus Cryo Pump Housing (TCPH)
Gaurav Jogi, Vaibhav Joshi, Avik Bhattacharya, Girish Gupta, Olivier Tailhardat, Anil Bhardwaj

Welding Development and Implementation for ITER Cryostat
Mitul Patel, Vaibhav Joshi, GirishKumar Gupta, Rajnikant Prajapati, Jimmy Dutt, Jibin Jose, Anil Kumar Bhardwaj, Amit Palaliya, Jagrut Bhavsar, Mukesh Jindal

Radiation Impact on Ceramic Materials Intended for Nuclear Reactor Applications
Sejal Shah, Sunil Kumar, A. Chakraborty, S Vala, R Kumar, M Abhangi, I Sulania, F Singh

Microstructure Evaluation of Plasma Tempered Aluminized INRAFM Steels
Rakesh Tunk, Sasmal C, Nirav I. Jamnapara, Arunsinh Zala, P Chauhdury, Jyoti Mukhopadhyay, Amit Arora

Effect of Heat Inputs on Alumina Coated RAFM steels by GTAW Process
Arunsinh Zala, Nirav Jamnapara, Chandra Shkehar Sasmal, Shiju Sam, Mukesh Ranjan

Implementation of Novel Technique to ensure the Structural Integrity of refurbished Toroidal Field Magnets of the ADITYA Upgrade Tokamak
Bharatkumar Doshi, Rakesh Tanna, Joydeep Ghosh

Structural Validation of Transportation and Assembly frame with support structure for the Cryostat Upper Cylinder by Finite Element Analysis
Jagrut Bhavsar, Avik Bhattacharya, Shrishail Padasalagi Padasalagi, Gaurav Jogi, Mitul Patel, Rajnikant Prajapati, Girish Gupta

Challenges encountered in India's contribution to ITER Cooling Water System
Ajith Kumar,Dinesh Gupta, Nirav Patel, Gumansinh Gohil, Hiren Patel, Jinendra Dangi, Lalit Sharma, Mahesh Jadhav, Aditya Singh, Rakesh Ranjan, Mohit Kumar, Dilshad Sulaiman, Hitesh Pandya, Arun Chakraborty, Shishir Deshpande

Electro-mechanical design and verification of Grid post insulators for 8 driver RF Ion source
Venkata Nagaraju Muvvala, Jaydeep Joshi, Sejal Shah, Deepak Parmar, Mahendrajit Singh, Mainak Bandyopadhyay, Arun Chakraborty

Manufacturing Design of TWIN source Extraction Grid - Alternate Approach
Ravi Pandey, M.J. Singh, Jaydeep Joshi, Mainak Bandyopadhyay, Arun Chakraborty

Design and Development of Fast Protection & Fast Monitoring Module compatible with NI™ Compact RIO system for ITER-India Gyrotron Test Facility
Ronak Shah, Vipal Rathod, Rajvi Parmar, Deepak Mandge, Sharan Dilip, Anjali Sharma, Amit Yadav, Shambhu Laxmikanth Rao

Tuning of Wave Shaping and Ohmic Circuit for ADITYA-U Tokamak Operation
Balakrishnan V Nair, C N Gupta, K S Shah, M N Makwana ,S Gupta, V Ranjan, R L Tanna, J Ghosh, R Kumar, S Aich, T Macwan, D Kumavat, H Raj, K A Jadeja, K M Patel, M B Kalal, D S Varia, D H Sadarakya , S B Bhatt, K Satyanarayana, B K Shukla, P K Chattopadhyay, V K Panchal, E V Praveenlal, B Arambhadiya, M Shah, V Raulji, M B Chowdhari, S Banerjee, R Manchanda, D Raju, P K Atrey, S K Pathak, U Nagora, J Raval, Y S Joisa, M Kumar, K Tahiliani, S K Jha, M V Gopalakrishna, J Thomas, A Kumar, S Pandya

Implementation of data acquisition and control system for high power ICRH system using EPICS
Rameshkumar Joshi, HM Jadav, Sunil kumar Gupta, Sanjay Kulkarni

24th International Symposium on Plasma Chemistry (ISPC24), Naples, Italy, 09-14 June 2019

Studies on Bulk Synthesis of Tungsten-Oxide Nanomaterials by a Novel Plasma Technique and their Visible-Light Photocatalytic Properties for Degradation of Dyes in Wastewater
Trinayan Sarmah, Pubali Dihingia, Mizanur Rahman, Dulen Saikia, Divesh N. Srivastava, and Mayur Kakati

Composite Materials Technology and Applications, Ahmedabad Textiles Industries Research Association (ATIRA), Vastrapur, Ahmedabad, 15 June 2019

In-house Development of Composite Materials for Superconducting Fusion Reactor and Cryogenic Applications
Rajiv Sharma

Workshop on Future Trends of cryogenic engineering and applied Superconductivity, Inter-University Accelerator Center, New Delhi, 21 June 2019

Superconducting Magnets Operation and Developmental Plans at IPR
Upendra Prasad and Team

2019 IEEE Pulsed Power and Plasma Science Conference (PPPS2019) and 46th International Conference on Plasma Science (ICOPS2019), Orlando, Florida, USA, 23-28 June 2019

Novel High Voltage Pulsing to Generate Uniform Glow Discharge Air Plasma for Environment Friendly Inline Treatment of Textile
Vishal Jain, Kushagra Nigam, Nisha Tanwani, Adam Sanghariyat, Nimish Sanchania, Sudhir Kumar Nema

Parametric Study of a Cylindrical Inertial Electrostatic Confinement Fusion Device and its Application
S. R. Mohanty, N. Buzarbaruah, D. Bhattacharjee, D. Jigdung, E. Hotta

Implementation of line type high voltage nanosecond rectangular pulse generator with adjustable pulse widths for liquid discharge applications
Amol Deshpande, G Veda Prakash, Uttam Goswami, Raj Singh, V P Anitha

Optical and electrical diagnostic of surface arcs
Suryakant Gupta

Indigenously developed pulsed power sources for non-equilibrium plasma applications
Suryakant Gupta, Keena Kalaria, Naresh Vaghela

International Conference on Power, Control and Communication Infrastructure 2019 (ICPCCI 2019), Institute of Infrastructure, Technology, Research and Management (IITRAM), Ahmedabad, 4-5 July 2019

Design and analysis of dc power supply for solid state power amplifier
Rohit Agarwal, Rajesh Kumar, Gajendra Suthar, Hrushikesh Dalicha

10th International Workshop on Nanoscale Pattern Formation at Surfaces, University of Surrey, Guildford, UK, 7-10 July 2019

Superhydrophobic PTFE Surface Achieved by Low Energy Ar+ Ion Beam Irradiation
Vivek Pachchigar, Mukesh Ranjan and Subroto Mukherjee

46th European Physical Society Conference on Plasma Physics (EPS 2019), Milan, Italy, 8-12 July 2019

Characterization of a TE_{10}-TM_{01} Mode converter for Microwave Plasma Interaction Experiments
Priyavandana J. Rathod, Jitendra K., Raj Singh and Anitha V.P.

Development of Triple Probe Diagnostics for Pulsed Laboratory Plasma
P. K. Srivastava, P. Srivastav, A. K. Sanyasi, R. Sugandhi and L. M. Awasthi

Fundamental O-mode ECRH assisted low-loop voltage plasma start-up in tokamak ADITYA-U
Braj Kishore Shukla, Joydeep Ghosh, R.L. Tanna, S.K. Pathak, P.K. Atrey, Mahesh Kushwah, Jatin Patel, Harshida Patel, D Purohit, Hardik Mistry, K.G. Parmar and ADITYA-U Team

7th PSSI-Plasma Scholars Colloquium (PSC-2019), Institute of Advanced Research (IAR), Gandhinagar, 8-10 August 2019

Effect of Negative Ions on the Magnetized Plasma Sheath
R.Paul, S. Adhikari, R. Moulick, S. S Kausik, B.K Saikia

Study of weakly collisional two-electron temperature plasma sheath
G. Sharma, S. Adhikari, R. Moulick, S. S. Kausik, and B. K. Saikia

Effect of collisions on the plasma sheath in the presence of a gradient magnetic field
K. Deka, S. Adhikari, R. Moulick, S. S. Kausik, B. K. Saikia

Observation of Runaway Electron Beam Position Using Cosine Coil in ADITYA-U Tokamak
Tanmay Macwan, Harshita Raj, Kaushlender Singh, Suman Dolui, Rohit Kumar, Suman Aich , K A Jadeja, K M Patel, Jayesh Raval, R L Tanna, J Ghosh, ADITYA-U Team

Effect of Gas puff and SMBI on MHD activity in ADITYA and ADITYA-U Tokamak
Kaushlender Singh, S. Dolui, Tanmay Macwan, Harshita Raj, S. Aich, R. Kumar, B. Arambhadiya, Siju George, Yuvakiran Paravastu, Dilip Raval, K.A. Jadeja, K.M. Patel, N.C. Patel, V.K. Panchal, R.L. Tanna, J. Ghosh

PPPL-Simons Summer School, Princeton University, New Jersey, USA, 19-23 August 2019

Study of Plasma Transport due to ETG Turbulence in Large Volume Plasma Device
Prabhakar Srivastav, Rameswar Singh, L M Awasthi, P K Srivastava, R. Sugandhi and R. Singh

Turbulence, Transport and Runaway Electrons Studies in ADITYA-U Tokamak
Tanmay Macwan, Harshita Raj, Kaushlender Singh, Suman Dolui, Umesh Nagora, J. Ghosh, R. L. Tanna, Rohit Kumar, Suman Aich, K. A. Jadeja, K. M. Patel, Devilal Kumawat, P. K. Atrey, S.K. Jha, D. Raju and Aditya Team.

Workshop on Material characterization: Structure Spectroscopy and Microscopy, Institute of Infrastructure Technology Research and Management, Ahmedabad, 19-24 August 2019

Exposure of In-RAFM steel to high He+-flux in the CIMPLE-PSI device
Pubali Dihingia and Mizanur Rahman

36th DAE Safety and Occupational Health Professionals Meet, Nuclear Fuel Complex, Hyderabad, 21-23 August 2019

Implementation and Enhancement of Safety Measures in SST-1 Cryogenic system
Rajiv Sharma, V.L. Tanna and Cryogenic division SST-1

Plasma Physics Colloquium, Columbia University, USA, 26 August 2019

Study of Plasma Transport due to Electron Temperature Gradient Induced Turbulence in Large Volume Plasma Device
Prabhakar Srivastav

International Conference Frontires in Optics (FIO), Washington, USA, 15-18 September 2019

Fabrication and analysis of LPG by Electric arc discharge
Koustav Dey, Kanchan Ghosh, Sourabh Roy, B.Ramesh Kumar, M.Sai Shankar

14th International Symposium on Fusion Nuclear Technology (ISFNT), Budapest, Hungary, 22-27 September 2019

Design and Comparison Study of Steam Generator Concepts and Power Conversion Cycles for Fusion Reactors
Piyush Prajapati, Partiosh Chaudhuri, Shrishail Padasalagi, Shishir Deshpande

MT26-International conference on Magnet Technology, Vancouver, Canada, 22-27 September 2019

Comparative study of cryogenic Nb-Ti/Cu and MgB_2/Brass based current leads
Atul Garg, H. D. Nimavat, R. N. Panchal, D. Sonara, G. Mahesuria, R. Patel, D. Christian, N. Bairagi, G. Purwar, R. Sharma, P.R. Shah, K. M. Patel, P. N. Panchal, V. L. Tanna and U. Prasad

4th ISSE National Conference on Systems for Transforming India: Challenges & Opportunities, Space Application Centre, (ISRO), Ahmedabad, 26-27 September 2019

Additive Manufacturing Technology and post processing requirements
Gautam Vadolia, K P Singh, Bharat Doshi, Manoj Kumar Gupta

Concept on the application of High Power Gyrotrons for Satellite Launch
B K Shukla and P K Atrey

6th IAEA DEMO Programme Workshop (DPWS-6), Moscow, Russian Federation, 1-4 October 2019

Status of material R&D activities relevant for Fusion power reactors
Author(s): Rajamannar Swamy, Alpesh Patel, Shailesh Kanpara, S.Khirwadkar, Kedar Bhope, Mayur Mehta, Sejal Shah, P.N.Maya, P.Sharma, C.S.Sasmal, P.Chaudhuri

International Conference on New Frontiers in Nuclear Physics, Banaras Hindu University, Varanasi, 14-17 October 2019

Measurement of (n,γ) reaction cross section of ^{186}W-isotope at neutron energy 20.02±0.58 MeV
Mayur Mehta, N.L. Singh, R. Makwana, P.V. Subhash, S.V. Suryanarayana, S. Parashari, Rakesh Chauhan, R.K. Singh, H. Naik, S. Mukherjee, B. Soni, S. Khirwadkar, J. Varmuza, K. Katovsky

61st Annual Meeting of the APS Division of Plasma Physics, Fort Lauderdale/Broward County Convention Center, Florida, 21-25 October 2019

Finite Plasma Beta Scaling of ETG Induced Turbulent Transport in Large Laboratory Plasma
Prabhakar Srivastav, Rameswar Singh, L. M. Awasthi, A. K. Sanyasi, P. K. Srivastava, R. Sugandhi, and R. Singh

Electric field filamentation and higher harmonic generation in very high frequency capacitive discharges
Sarveshwar Sharma, Nishant Sirse, Abhijit Sen, Jong-Shinn Wu, Miles Turner

Study of Argon impurity line emissions using high resolution spectroscopy diagnostic in Aditya-U tokamak
Kajal Shah, G. Shukla, M.B. Chowdhuri, R. Manchanda, K.A. Jadeja, K.M. Patel, R.L. Tanna, K.B.K. Mayya, J. Ghosh and Aditya-U Team.

Study of toroidal and poloidal rotation on Aditya-U tokamak
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The influence of conical and cylindrical hollow cathode geometries on the characteristics of a magnetized plasma column
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Minsha Shah, Hitesh Mandaliya, Lavkesh Lachhvani, Manu Bajpai, Rachana Rajpal

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Interaction of Charged particles in an Inertial Electrostatic Confinement device
N. Buzarbaruah, D. Bhattacharjee, D. Jingdu, S.R. Mohanty

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Plasma-Wall Interactions in Fusion Power Reactors: Opportunities and Challenges
P.N. Maya and S.P Deshpande

Characterization of Defects Induced in Tungsten Due to Ion Irradiation by Transmission Electron Microscopy
Prashant Sharma, P.N. Maya, S. Akkireddy and S.P. Deshpande

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Numerical study of hydrogen storage in $LaNi_5$ based metal hydride reactor
Sudhir Rai, Swaraj D Lewis, Purushothama Chippar, Amit Sircar

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Nuclear Activation Code Development for Fusion Systems
Priti Kanth, P.V. Subhash

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Modelling and Analysis of 100kV, 100mA DC Modular Symmetrical Voltage Multiplier (SVM) unit
Urmil Thaker, Amardas Alli, Amal S., Kumar Saurabh, Aritra Chakraborty, Christian Paul, Ashok Mankani, Ujjwal Baruah

Design, Development & Testing of 100kV, 10A DC Pluggable Feed-through
Urmil Thaker, Amardas Alli, Amal S., Kumar Saurabh, Aritra Chakraborty, Christian Paul, Ashok Mankani, Ujjwal Baruah

Automation of the instruments for the Plasma column experiment
Priyadarsini Gaddam, Kirti Mahajan, Nisha Pangal, Unnati Patel, Rajesh Kumar

Electron Temperature Gradient Turbulence induced Energy Flux in the Large Volume Plasma Device
Prabhakar Srivastav

Helium Cooled Dual Breeder Blanket for near term Indian DEMO Fusion Reactor
H.L. Swami, Deepak Sharma, A.N. Mistry, C. Danani, P. Chaudhari, R. Srinivasan

Detecting & specify faulty locations of RF power transmission line and quantifying the degree of fault
Debjyoti Basu, Raj Singh, P. Ajesh Subbarao, Manojkumar A. Patel, Yuvakiran Paravastu, Raju Daniel and Praveen Kumar Atrey

Feasibility Study of Fiber Optic Current Sensors Using 1550 nm on Aditya Tokamak
Asha Adhiya, Rajwinder Kaur, Ankur Pandya, and Prabal Chattopadhyay

Application of High Power Microwave Gyrotrons for Plasma Heating, Sterilization of Stored Food Grains, Defense and Space
B K Shukla and P K Atrey

Parametric study of atmospheric pressure DBD plasma with kilo-Volt and kilo-Hz range power source
Jyoti Agarwal, Shahrukh Barejia, Vishal Jain, R. Srinivasan

Study, Design, Simulation and Development of RF Matching Network for Electromagnetic Surface Wave Launcher
Unnati Patel, Rajesh Kumar, Nisha Panghal

Challenges Associate in Design of Bio-Medical Waste Disposal System using Thermal Plasma Process
A. N. Mistry, P. V. Murugan, S. K. Nema

Gyrotron control system for plasma start-up and heating experiments in Aditya-U tokamak
Jatinkumar Patel, B.K. Shukla, M. Kushwah, K.G. Parmar, H. Patel, D. Purohit, H. Mistry

Conceptual design considerations for helicon current drive in SST1 tokamak
J. Ganji, P. K. Sharma, H. V. Dixit

Effect of multiple gas puffs and external electrode biasing on poloidal asymmetry in the Aditya-U tokamak Tanmay Macwan, H. Raj, K. Singh, S. Dolui, L. Lachhvani, P. Gautam, R. Kumar, S. Aich, K.A. Jadeja, K.M. Patel, R.L. Tanna and J. Ghosh

Initial results on plasma potential measurements in the edge region of Aditya-U tokamak by laser heated emissive probe
Abha Kanik, Arun Sarma, P. Pandit, T. Macwan, Minsha Shah, R.L. Tanna, R. Manchanda, J. Ghosh

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Amal S., Kumar Saurabh, Urmil M. Thaker, Aritra Chakroborty, Paul D Christian, Ratnesh Kumar., Mitul R Abhangi, Vala Sudhirsinh J, Praveenlal Edappala, Vismay Raulji, Rachana Rajpal, Rajesh Kumar, Ashok D. Mankani, and Ujjwal K. Baruah

Experiments on a gridded ion source for applications in ion thrusters
S.K. Sharma, Bharat Singh Rawat, V. Prahlad, B. Choksi, S.L. Parmar, L.N. Gupta, N. Contractor, D. Thakkar, C.B. Sumod, P.J. Patel and U.K. Baruah

A Faraday cup array for the measurement of ion current density profiles for a gridded ion thruster
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3D Magneto-structural analysis of Magnetic Pulse Welding
Amardas Alli, Bharat R. Doshi

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Brownian Ratchets
Anshika Chugh, R. Ganesh

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Effect of Plasma Beta on Electromagnetic ETG Turbulence Induced Plasma Transport
Prabhakar Srivastav, L.M. Awasthi, A.K. Sanyasi, P.K. Srivastava, R. Sugandhi, Rameswar Singh and R. Singh

2D-3V PIC-MCC Simulation of Plasma Transport across Magnetic Filter in Robin: Importance of Wall Effects
Miral Shah, Bhaskar Chaudhury, Mainak Bandyopadhyay, Arun Chakraborty

Technology Developments for ITER Class Neutral Beam Systems and a Road Map for the Indigenization
Jaydeep Joshi, Arun Chakraborty, Hitesh Pate, Ashish Yadav, Mainak Bandyopadhyay, M.J, Singh

Cryostat Design and Fabrication Experiences
Girish Kumar Gupta, Rajnikant Prajapati, Mitul Patel, Vaibhav Joshi, Vipul More, Jagrut Bhavsar, Mukesh Jindal, Avik Bhattacharya, Gaurav Jogi, Amit Palaliya, Saroj Jha, Manish Pandey, Anil Bharadwaj

Generation of Electrostatic Mode in a Laser Plasma Interaction
Ayushi Vashistha, Devshree Mandal, Atul Kumar Chandrasekhar Shukla, Amita Das

Impurity Ion Temperature Measurement using Zeeman Influenced Spectral Lines in Aditya-U Tokamak
Nandini Yadava, J. Ghosh, M. B. Chowdhuri, R. Manchanda, Sripathi Punchithaya K, Ismayil, Ritu Dey, K. A. Jadeja, R. L. Tanna and Aditya-U Team

Initial Results of Laser Heated Emissive Probe for SOL Region in Aditya-U Tokamak
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Plasma Surface Engineering of Stainless Steel for HIP Implant Application
Ramkrishna Rane, Aniruddha Samanta, Biswanath Kundu, Jiten Ghosh, Sandip Bysakh, Ghanshyam Jhala, Alphonsa Joseph, Subroto Mukherjee, Mitun Das, Anoop, Mukhopadhyay

Advanced Insulators for NNBs: Challenges and involved R&D
Sejal Shah, D. Sharma, D. Parmar, H. Tyagi, J. Joshi, H. Patel, M. J. Singh, M. Bandyopadhyay, A. Chakraborty

DC and High Frequency Edge Electrode Biasing Experiments in Aditya-U Tokamak
Tanmay Macwan, Harshita Raj, Kaushlender Singh, Suman Dolui, Rohit Kumar, Suman Aich, J. Ghosh, Lavkesh Lachhvani, Pramila Gautam, Bharat Arambadiya, Jayesh Raval, Umesh Nagora, R. L. Tanna, K. A. Jadeja, K. M. Patel, S. K. Jha, D. Raju, and Aditya-U Team

Studies on Fusion Relevant Plasma Exposure Behavior of India Specific Reduced Activation Ferritic Martensitic Steel in Cimple-PSI
T. Sarmah, P. Dihingia, M. Rahman, G. Sabavath, S. Kumar, J. Ghosh, P. Choudhury, D. N. Srivastav, M. Kakati and G. De Temmerman

Joining of SS316L with Heat Sink Material for Divertor Application
K P Singh, Kedar Bhope, Alpesh Patel, Samir S Khirwadkar

Thermal-Hydraulic Analysis of Steam Generators (SG) for Power Extraction from Future Fusion Reactors
Piyush Prajapati, Paritosh Chaudhuri, Shrishail Padasalagi, Shishir Deshpande

Experimental and Computational Studies on the Formation of Defect Clusters in Gold Irradiated Tungsten Foil
Prashant Sharma, P.N. Maya, S. Akkireddy, S. Mukherjee and S.P. Deshpande

Integration of Proprietary Software using Open Source Tool in ICRH DAC System

Ramesh Joshi, H. M. Jadav, Manoj Singh, Sunil Kumar & High Power ICRH Systems Division

Generating RF Pulses of Different Duty Cycles and Amplitudes with Rise and Decay for ICRH Operation
Ramesh Joshi, H. M. Jadav, Manoj Singh, Kishor Misra, Sunil Kumar & High Power ICRH Systems Division

Development of 7kV, 6A Solid State HVDC Switch with Series Connected IGBTS
Bhavesh Kadia, Kirit Parmar, YSS Srinivas, S.V. Kulkarni, Sunil Kumar and ICRH Group

Recent Plasma Experiments in SST-1
Daniel Raju and SST-1 Team

Impact of Nitrogen Gas on Edge and SOL Plasma Turbulence
Shrish Raj, N.Bisai

Modification & Up-Gradation in Existing ICRH Interlock Protection System as 30kV-130A RHVPS Integrated for HPA4 Stage RF-Amplifier
Manoj Singh, HM Jadav, Ramesh Joshi, Sunil Kumar, Bhavesh Kadia, Kirit Parmar, Kishore Misra, Dharmendra Rathi, Atul Varia, Gayathri and RHVPS Development Team

Development of -4kV, 1A High Voltage DC Power Supply for SST-1 Current Start up Experiment
Kirit Parmar, Bhavesh Kadia, Debjyoti Basu, Raj Singh, Sunil Kumar and High Power ICRH Systems Division

Implementation of an Improved Halo Model with Self-consistent Power Balance in TSC
Amit Kumar Singh, I. Bandyopadhyay

Design of Post Insulator for Electro-Mechanical Requirement of Beam Source to Characterize in Indian Test Facility (INTF)
A. Yadav, J. Joshi, S. Shah, M. Bandyopadhyay, M. Singh, A. Chakraborty

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Vikas Rathore, Divyesh Patel, Shital Butani, S K Nema

Design, Testing, Installation and Commissioning of Low Voltage Electrical Power Distribution
Prakash Parmar, Supriya Nair, Chandra Kishor Gupta, Chirag Bhavsar

Development of Arc Detection System for RF Source and Microwave Components
Hrushikesh Dalicha, Gajendra Suthar, Kartik Mohan, Rohit Agarwal, Rajesh Trivedi, Kumar Rajnish, Raghuraj Singh, Aparajita Mukherjee

Energetic Plasma Ion Beam Produced Ripple Patterns for SERS Based Detection of Complex Molecules
Sooraj K P, Sebin Augustine, Mukesh Ranjan, Subroto Mukherjee

Estimation of Plasma Parameters using Neural Network for Large Volume Plasma Device
R. Sugandhi, Prabhakar Srivastav, A. K. Sanyasi, L. M. Awasthi, and P. K. Srivastava

Investigation of Electro-Thermal Characteristics of a Novel Low Pressure Non-Transferred DC Plasma Torch
Ram Krushna Mohanta, G. Ravi

Sheath as a Mitigation Scheme in Communication Blackout
S. Adhikari, B. J. Saikia

Centralized Data Logging System for Large Volume Plasma Device
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Development of FDTD Model for Plasma Antenna Design
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3D Electrostatic Analysis for High Voltage Applications by Finite Element Method
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Remote Operation and Status Monitoring of Air Compressor System
Dikens Christian, Rakesh Patel, Gaurang Mahesuria, Gaurav Purwar and Vipul L Tanna

Control of Radial Gradient Scale Length of Electron Temperature in a Double Plasma Device
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Intouch Wonderware SCADA Software Upgradation for the SST-1 Cryogenic System
Gaurang Mahesuria, Rakesh Patel, Pradip Panchal, Rohit Panchal, Dashrath Sonara, Hiren Nimavat and Vipul L Tanna

Design and Development of Alarm Annunciation System for SST-1 Cryogenics
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Role of Temperature Fluctuations on ETG Induced Particle Flux Measurement in LVPD
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P. Pandit, R. Manchanda, M.B. Choudhury, R. Dey, J. Ghosh

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Performance Validation of Vacuum Insulated Cryo Flexible Hoses
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Behavior of Different Reactive Species of Atmospheric Pressure Plasma Jets in Presence of Strong Magnetic Field
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Laser Cluster Interaction in Strong External Magnetic Field
Kalyani Swain and Mrityunjay Kundu

Characterization of Plasma Turbulence in a Mirror Leaked Plasma of LVPD
A. K. Sanyasi, Prabhakar Srivastav, L. M. Awasthi, P. K. Srivastava and R. Sugandhi

Variational Moment Method for Solving Gradshafranov Equation in Axisymmetric Tokamak Plasmas with Up-Down Asymmetry
Udaya Maurya, R. Srinivasan

Design of a Multichannel CDTE Based Fast Electron Bremsstrahlung Detection System for Aditya-U LHCD Discharges
Jagabandhu Kumar, P. K .Sharma, Santosh P. Pandya, A L Thakur

Acceleration of Electrons from a Thin Foil Plasma by Tightly Focused Few-Cycle Laser Beam
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Establishing Manufacturing Feasibility of ITER Cryostat through Mock-Ups
Vaibhav Joshi, Mitul Patel, Rajnikant Prajapati, Girish Gupta, Jagrut Bhavsar, Amit Palaliya, Mukesh Jindal, and Jimmy Dutt, Viren Patel, Chirag Patel, Dipen Shah, Nayan Desai, Pruthviraj Shekhva, Sivakumar S

Properties of Plasmoid Instability in Double Tearing Mode
Jagannath Mahapatra, R Ganesh

Welding Improvements for Cryostat Fabrication: Experience and Learnings So Far
Mitul Patel, Vaibhav Joshi, Rajnikant Prajapati, Girish Gupta, Jimmy Dutt

Magnetic Field and 3D Ion Trajectory Calculation for SST NBI Bending Magnet
M R Jana and U K Baruah

Understanding the Role of Thickness of Plasma in the Propagation of Electromagnetic Waves in Collisional Plasma using Computer Simulation Technology
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Study of Impurity Behavior in SST-1 Tokomak Plasma using Visible Spectroscopy
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Role of Finite Extent of Laser Pulse in Overdense Plasma
Devshree Mandal, Ayushi Vashistha, Atul Kumar, Chandrasekhar Shukla, Amita Das

Development of Steerable ECRH Launcher for Aditya-U and SST-1
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Impact of Nitrogen Gas on Edge and SOL Plasma Turbulence
Shrish Raj, N.Bisai

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Edge Biasing on the Edge and Scrape-Off Layer Tokamak Plasma Turbulence
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Building Management Control System for New Laboratory Building HVAC Plant at IPR
Manish Vasani and E. Rajendra Kumar

Plasma Characterisation in a Spherically Convergent Ion Source
D. Jigdung, D. Bhattacharjee, N. Buzarbaruah, S. R. Mohanty

Numerical Studies for Bath Cooled Heat Exchangers in Sub-Cooled LN_2 for the Cryogenic Gaseous Helium
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Retro-Fitment of Eurotherm PC3000 PLC of Purifier for 1.3kW at 4.5K Helium Refrigerator cum Liquefier for SST-1
Pradip Panchal, Kirti Mahajan, Vishnu Patel, Rohit Panchal, Rakesh Patel, Gaurang Mahesuria, Dashrath Sonara, Hiren Nimavat, Gaurav Purwar and Vipul Tanna

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Identification of Drift Waves in Imped
Rosh Roy, Neeraj Wakde, Sayak Bose, Prabal K Chattopadhyay

Problem of Phase Jump and Methods for Removal of it from the Density Signal
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Pankaj Varmora, Imran Mansuri, Bhadresh Parghi, Chirag Dodiya, Upendra Prasad, R. Srinivasan and Daniel Raju

Development of Signal Conditioning Electronics for Prototype Magnet Cryostat Test
Bhadresh R Parghi, Pankaj Varmora, Upendra Prasad and R. Srinivasan

Mechanical Design of 24 KA Busbar System for LLMHD Experiment
Prosenjit Santra, Subhadip Das, Shrikant Verma, Kanubhai Rathod, Rajendra Bhattacharya, Azadsinh Makwana Bharat Doshi, Amit Sircar

Absolute Calibration of TE Cooled IR Enhanced Silicon Avalanche Photodiode Detector with an Integration Sphere
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Stress Analysis of Cryogenic Piping Layout of Experimental Set-Up for 3-Stream Plate-Fin Heat Exchanger
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Testing and Set Up of 2.45 GHz ECR Ion Source on 300KV High Voltage Deck
Sudhirsinh Vala, Ratnesh Kumar, Mitul Abhangi, Rajesh Kumar and Mainak Bandyopadhyay

Effect of CZTS Thickness on Solar Cell Performance

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Sagar Agrawal, Rinkal Kanani, Ramkrishna Rane, Subroto Mukherjee

Effect of Sulfurization Time on CZTS Thin Film for Solar Cell Applications
Rinkal Kanani, Sagar Agrawal, Subroto Mukherjee, Alphonsa Joseph

Development of Tokamak Models for Exhibits
Pratibha Gupta, Manoj Kumar Gupta, Bharat Doshi, Harsha Machchar, A.V. Ravi Kumar

Piping Layout and Flexibility Analysis of the Closed Loop Indigenous Helium Compressor
R Bhatasana, A K Sahu, N. Patel

Building Management Control System for New Laboratory Building HVAC Plant at IPR
Manishkumar Vasani, Sudhir Sharma and Yagnesh Trivedi

Development of Graphical User Interface using Labview for Machine Vision Acquisition in SST-1
V Chaudhari, Suraj Kumar Gupta, Manoj Kumar, and SST-1 Team

Understanding of Particle Transport using Estimated τ p Profile of Aditya Tokamak Plasma
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Study of Microinstabilities in a Multispecies Vlasov-plasma using Kinetic Simulation
K. Paul, D. Sharma

Visible Imaging of the Tokamak Plasma
Suraj Kumar Gupta, Vishnu Chaudhari, Manoj Kumar & SST-1 Team

Non-Thermal Atmospheric Pressure Plasma Torch Power Source Development for Denim Jeans Colour Fading
Chirayu Patil, Adam Sanghariyat, S. K. Nema

Feasibility Study of Capacitor Bank Based Power Supply for Toroidal Field Coil of Small Scale Spherical Tokamak at IPR
Vaibhav Ranjan, Supriya A Nair, Y S S Srinivas, E Rajendra Kumar

Studies on Electron Energy Groups in a Hot Cathode Dishcharge in Presence of a Magnetic Filter
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Numerical Solver for Collision-Less Plasmas: Development and Applications of A 1D2V Vlasov Model
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Role of Ions in a Toroidal Electron Plasmas: A Particle-In-Cell Study
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Design and Development Study of a Cryocooler Based Cryosorption Pump
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Characterization of Black Body Target Materials for Calibration of Michelson Interferometer Diagnostic
Abhishek Sinha, Abdul Shabir, S.K. Pathak

Mode Spectra Analysis of a DC Coulomb Crystal
P. Bandyopadhyay, Garima Arora, M. G. Hariprasad, Saravanan A. and A. Sen

Design, Fabrication, Installation and Testing of Nb_3Sn Supercunductor Based Solenoid Coil
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First Order Solid-Liquid Phase Transition in Complex Plasmas

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Conceptual Design of Data Acquisition and Control System of Large Scale Cryogenics Plant System
Vishnu Patel, Haresh Dave, A.K. Sahu and Kirti Mahajan

Excitation of Pinned Structures in Flowing Complex Plasma
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Low-Temperature Plasma Nitrocarburizing of Austenitic Stainless Steels to Improve Surface Hardness
Jeet Sah, Alphonsa Joseph, Ganshyam Jhala, Subroto Mukherjee

The Study of the Effect of Compressive Load on Critical Current of High Temperature Superconducting Tapes
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Sheet Model of Upper-Hybrid Oscillation in an Inhomogeneous Cold Plasma in Presence of Inhomogeneous Magnetic Field
Nidhi Rathee and Sudip Sengupta

Preliminary Design and Analysis of Flywheel System for Pulsed Alternator
Rambabu Sidibomma, Prasada Rao Pedada, Y S S Srinivas and E Rajendra Kumar

Remote Handling of VFD using Labview and Modbus Protocol Non-Conventional Antenna Experiments
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Use of Acoustic Trap as Nano Powder Collection Mechanism: An Investigation
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Atul Kumar, and Abhijit Sen

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Kishore Mishra, Harsh Patel and ICRH Division

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A. Sarada Sree and Rajesh Kumar

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P. N. Maya and S. P. Deshpande

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Tungsten Coating Deposition on Graphite and Process Optimization
P A Rayjada, K. A. Jadeja, N. L. Chauhan, S. B. Bhatt

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Investigation of Impurity Seeded ADITYA & ADITYA-U Tokamaks Plasmas
M. B. Chowdhuri, J. Ghosh, R. L. Tanna, K. A. Jadeja, K. M. Patel, R. Manchanda, N. Yadava, S. Patel, G. Shukla, K. Shah, R. Dey, N. Ramaiya, Tanmay Makwan, U. C. Nagora, S. K. Pathak, J. V. Raval, S. Purohit, M. K. Gupta, S. K. Jha, M. V. Gopalakrishna, K. Tahiliani, Rohit kumar, Suman Aich, Suman Dolui, Kaushlender Singh, P. K. Atrey, B. V. Nair, C. N. Gupta, P. K. Chattopadhyay, ADITYA Team and ADITYA-U Team

Investigation of atomic and molecular processes in ADITYA and ADITYA-U tokamak plasmas
Ritu Dey, J. Ghosh, M. B. Chowdhuri, Ranjana Manchanda, Nandini Yadava, R.L.Tanna, Santanu Banerjee, P. Vasu, Vinay Kumar and Aditya Team

Population-Alignment Collisional-Radiative Model for Polarization in Lyman-α Line
Nilam Ramaiya and Motoshi Goto

Electronics for Langmuir Probe in Aditya-U for the measurement in the SOL layer.
Pramila, Tanmoy, Harshita, Lavkesh, Shwetang, Rachana Rajpal

Role of Poloidal Flows on the Particle Confinement in a Current-less Toroidal Device
Umesh Kumar, R. Ganesh, K. Sathyanarayana, Y. C. Saxena and D. Raju

Investigation of Neutral Recycling and Ion Temperature of Various Plasma Species in ADITYA and ADITYA-U Tokamak
Nandini Yadava, J. Ghosh, M. B. Chowdhuri, R. Manchanda, Sripathi Punchithaya K, Ismyil, Ritu Dey, Tanmay Macwan, S. Patel, N. Ramaiya, K. A. Jadeja, R. L. Tanna and Aditya-U

Study Small Amplitude Ion-Acoustic Solitons in Negative Ion Plasmas with Superthermal Electrons
P. C. Singhadiya

Topology Optimization of a Planetary Gearbox for Fusion RH Application
Ratna .A. Rajgor, Manoah Stephen M, Krishan Kumar Gotewal, Hitesh .K. Patel

Passive Charge eXchange (PCX) Spectroscopy to Measure Plasma Rotation on Aditya-U Tokamak
G Shukla, K Shah, M.B.Chowdhuri, R Manchanda, R.L. Tanna, K.A. Jadeja, K.B.K. Mayya, J Ghosh and Aditya-U team

Characterization of Ohmic Breakdown Phase for the ADITYA discharges
Sharvil Patel, Joydeep Ghosh, R. L. Tanna, P.K. Chattopadhyay, Harshita Raj, M. B. Chowdhuri, Ranjana Manchanda, Nilam Ramaiya, Umesh Nagora, P. K. Atrey and Aditya Team

An Estimation of the Edge Impurity Transport in the ADITYA Tokamak through Comparison between the Simulated and Analytical (Model–Based) Edge Impurity Diffusion Coefficients
Amrita Bhattacharya, Joydeep Ghosh, Malay Bikas Chowdhuri, Prabhat Munshi and the ADITYA team

ECRH Power Supply System for Aditya Tokamak
Mahesh Kushwah, B K Shukla, KG Parmar, Jatin Patel, Harshita Patel,Dharmesh Purohit and Hardik Mistry

Indigenously Developed Data Acquisition System for Plasma Diagnostics in Aditya-U Tokamak
Praveena kumari Shukla, Vismaysinh Raulji, Hitesh Mandaliya, Rachana Rajpal, Pramila, Praveenlal E.V, C.J Hansalia

Gas Puff Induced Drift Waves in ADITYA and ADITYA-U Tokamak
Tanmay Macwan, Harshita Raj, Kaushlender Singh, Suman Dolui, J. Ghosh, R. L. Tanna, Rohit Kumar , Suman Aich, Lavkesh Lachhvani, Pramila Gautam, K. A. Jadeja, K. M. Patel, N C Patel, V Panchal, Umesh Nagora, P. K. Atrey, S. K. Jha, D. Raju and ADITYA-U Team

Laser Heated Emissive Probes Diagnostic in ADITYA-U TOKAMAK
Abha Kanik, Arun Sarma, Joydeep Ghosh , Tanmay Macwan, R. L. Tanna, Minsha Shah, Ranjana Manchanda, Payal Pandit, Shwetang Pandya, Jayesh Raval, Umesh Nagora and ADITYA-U Team

ADITYA Upgrade New Circular Shaped Torus Vacuum Vessel and Pumping System
K. A. Jadeja , S. B. Bhatt, K. M. Patel, J. Ghosh, V. R. Prajapati, Kulav Rathod, K. S. Acharya, Kiran Patel, B. G. Arambhadiya, R. L. Tanna, M. B. Kalal, D.S. Varia, D.H. Sadhrakiya, P. K. Chattopadhyay, Y. C. Saxena, A.Das, D. Bora

Control System Development for LIGO outgassing setup
S.Sunil, Faiz Mohammed Masi, Sabbir Ahmed, Gaurav Kumar Singh and Subroto Mukherji

Water Cooling System of ADITYA Tokamak
Yagneshkumar Trivedi, M. Vasani, S. K. Sharma, K. Padia and J.M. Gandhi

The Refurbishment of Damaged Toroidal Magnetic Field coils for ADITYA-U
D.H. Sadharakiya, R.L. Tanna, J. Ghosh, B.R. Doshi, P.K. Chattopadhyay, Sharvil Patel, Vaibhav Ranjan, Rohit Kumar, Harshita Raj, K. Sathyanarayana, M.B. Kalal, D.S. Varia, Ram Krushna Panchal, Kulav Rathod, S.B. Bhatt, A.Vardharajulu, Y. C. Saxena, and Shell-N-Tube Team

Study of Argon Line Emissions in ADITYA-U Tokamak using Spectroscopic Diagnostic
K. Shah, M. B. Chowdhuri, G. Shukla, R. Manchanda, K. A. Jadeja, N. Yadava, N. Ramaiya, K. M. Patel, R. L. Tanna, K. B. K. Mayya, J. Ghosh and ADITYA-U team

Real-time Horizontal Plasma Position Control in ADITYA –U
Rohit Kumar, Pramila Gautam, Shivam Gupta, Tanmay Macwan, Praveen Lal E.V., Minsha Shah, Ranjana Manchanda, M. B. Chowdhuri, Nandini Yadav, Kunal Shah, M. N. Makwana, V. Balakrishnan, C. N. Gupta, R. L. Tanna, Suman Aich, Devilal Kumawat, K. Sathyanarayana, S. Jha, D. Raju, Joydeep Ghosh, P. K. Chattopadhyay, Y. C. Saxena and the ADITYA –U Team.

Large amplitude ion acoustic Solitons in warm negative ion plasmas with Maxwellians electrons.
Kishan Kumar and M. K. Mishra

Preliminary Study of Supersonic Molecular Beam Injection in ADITYA-U Tokamak.
Kaushlender Singh, Suman Dolui, Tanmay Macwan, K A Jadeja, K M Patel, Harshita Raj, Suman Aich, Rohit Kumar, B Arambhadiya, Siju George, Y Pravastu, D C Raval, V K Panchal, Jayesh Raval, D. Raju, S.K. Jha, R L Tanna, J Ghosh and ADITYA-U Team

Experimental Investigation on Electron Temperature Gradient Driven Instability in the Curvature Magnetic Field of MPD
A. D.Patel, Meenakshee sharma, N.Ramasubramanian, Lavkesh Lachhvani, Y. C. Saxena, R. Ganesh, P. K. Chatopadhaya

Spectroscopic Diagnostic for Magnetic Field in Tokamak Plasma
Subir Biswas

Study of ADITYA-U Tokamak Plasma using Fast Imaging Camera
Devilal Kumawat, Kumudni Tahiliani, Sameer Kumar, Gopalakrishna M V, Santosh Pandya, S.K Pathak and ADITYA-U Team

Design and Development of Different Analog and Digital Electronic Circuits for ADITYA Tokamak
Minsha Shah, Praveenlal E.V., Hitesh Mandaliya, Vismay Raulji, C J Hansalia, Rachana Rajpal and Electronics Group, R L Tanna, J Ghosh and Aditya team

Homodyne and Heterodyne Microwave Interferometer Systems for ADITYA Tokamak
Umesh Nagora, S.K. Pathak, P.K. Atrey and Aditya Team

Non-linear Time Series Analysis of ADITYA-U Plasma discharges
Balamurali Krishna, Mayya Kolake, Sharvil Patel, Tanmay Macwan, M.B. Choudhury, R. Manchanda, J. Ghosh, and Sameer Kumar

Investigations of Plasma Disruption Prediction in Tokamak using Machine Learning Tools
Yogesh Meghrajani, Himanshu Mazumdar, Indranil Bandyopadhyay, Satvik patel, Jignasa Patel and Aditya Team

X-Ray Diagnostics Systems in ADITYA/ADITYA-U Tokomak
Jayesh Raval, S. Purohit, M. K. Gupta, Y.S. Joisa, Praveena kumari, Minsha Shah,Vishmay Raulji, Imran Mansuri, Manisha Bhandarkar, K. A. Jadeja, K. M. Patel, V.K.Panchal, R.L. Tanna, J. Ghose, R. Rajpal, K.Mahajan, Aditya Team

Self-inductance of finite straight wire using Biot-Savart's law
Ashvin Mali

Self-Inductance of Circular Loop using Biot-Savart's Law
Deenganesh Mali

Design of Interlock Systems for Real Time Control of Plasma Events and Experiments in Aditya Tokamak
Praveenlal Edappalli, Minsha Shah, Rachana Rajpal, K.A. Jadeja, Rohit Kumar, Suman Aich, Tanmay Macwan, K.M. Patel, R. L. Tanna, J. Ghosh and Aditya Team

Limiter and Divertor of ADITYA-U tokamak
K. M. Patel, K. A. Jadeja, J. Ghosh, R. L. Tanna, S. B. Bhatt, Deepti Sharma, R. Shrinivasan, Y. C. Saxena, Rohit Kumar, Suman Aich, Tanmay Macwan, Kaushlender Singh, Suman Dolui and ADITYA-U Team

Forecasting of Disruption in ADITYA-U Tokamak
Suman Dolui, Kaushlender Singh, Tanmay Macwan, Harshita Raj, Suman Aich, Rohit Kumar, K A Jadeja, K M Patel, V K Panchal, D. Raju, Jayesh Raval, S.K. Jha, R L Tanna, J. Ghosh and ADITYA-U Team

Recent advances and Upgradation of ICRH System on ADITYA-U
Kishore Mishra, Atul Varia, H. M. Jadhav, Sunil Kumar, and ICRH Team

Mechanical Design of a Pressurized Variable Pre-matching Stub for ICRH System on ADITYA-U
Atul Varia, Kishore Mishra, Sunil Kumar, and ICRH Team

Bio-inspired Nanomaterials for Environmental Applications, Indian Institute of Technology Guwahati, Assam, 12-13 February 2020

Studies on Synthesis and Photocatalytic Properties of WO_3 Nanomaterials
Pubali Dihingia, Trinayan Sarmah, Mizanur Rahman, Dulen Saikia, Divesh N. Srivastava, and Mayur Kakati

1st International Conference on Advances in Plasma Science and Technology (ICAPST-2020), Sri Sakthi Institute of Engineering Science and Technology, Coimbatore, Tamilnadu, 12-14 February 2020

Fusion Relevant Plasma Material Interaction Studies on India Specific Reduced Activation Ferritic Martensitic Steel in CIMPLE-PSI Device
Trinayan Sarmah, Pubali Dihingia, Mizanur Rahman, Gopikishan Sabavath, Sanjiv Kumar, J. Ghosh, P. Choudhury, Divesh N. Srivastava, Mayur Kakati, and G. De Temmerman

Stress Analysis of Cryogenic Piping Layout of Experimental Set-Up for 3-Stream Plate-Fin Heat Exchanger
O Chandratre, Vivek sharma, A K Sahu, H Kavad

Novel Method for In-Line Collection of Nano Powder Synthesized using Thermal Plasma
Satya Prakash Reddy K

Study of dislocations on nanostructures using low energy ions produced by plasma source
Sukriti Hans, Vivek Pachchigar, Sebin Augustine, Mukesh Ranjan

Test Results of Indigenous Prototype 2 Stream (HE/HE) Plate-Fin Heat Exchanger of HE Plant
Hitesh R kavad, A K Sahu, A Singh, H Dave, R Bhatasana, N Kumar, P Brahmbhatt and O Chandratre

3rd National Seminar on Nonlinear and Complex Phenomena, Jadavpur University, Kolkata, 18-19 February 2020

Effect of radiation reaction on electron dynamics in laser cluster interaction
Kalyani Swain and Mrityunjay Kundu

6th National Symposium on Shock Waves, Indian Institute of Technology Madras, Chennai, 26-28 February 2020

Numerical Simulations of Detonation Wave Propagation between different media.
Sunil Bassi, Sanjay Kumar Soni, Manika Sharma, Shashank Chaturvedi

8th Topical conference (TC-2020) on Atomic and Molecular Collisions for Plasma Applications, IIT Roorkee, Uttarakhand, 3-5 March 2020

Behavior of impurities in radiative improved mode plasmas of ADITYA-U Tokamak
M.B. Chowdhuri, J. Ghosh, R. Manchanda, R.L. Tanna, K.A. Jadeja, N.Yadava, N. Ramaiya, S. Patel, G. Shukla, K. Shah, K.M. Patel, T. Macwan, U.C. Nagora, S.K. Pathak, J.V. Raval, M.K. Gupta, M.V. Gopalakrishana, K. Tahiliani, Rohit Kumar, Suman Aich, B.V. Nair, C.N. Gupta and ADITYA-U Team

Radial profile of visible continuum emission from ADITYA-U tokamak plasmas
R. Manchanda, M. B. Chowdhuri, J, Ghosh, N. Yadava, N. Ramaiya, S. Patel, U. C. Nagora, S. K. Pathak, J. V. Raval, M. K. Gupta, K. A. Jadeja, R.L. Tanna, C. N. Gupta and ADITYA-U Team

Iron impurity behavior in the ADITYA tokamak
S. Patel, A.K. Srivastava, M.B Chowdhuri, R. Manchanda, A. Bhattacharya, J.V. Raval, U. Nagora, P.K. Atrey, R.L. Tanna, J. Ghosh and ADITYA Team

Edge temperature and density measurements in ADITYA-U Tokamak with helium spectral line intensity ratio Tanmay Macwan, Sharvil Patel, N. Yadava, Ritu Dey, Kaushlender Singh, Suman Dolui, Rohit Kumar, Suman Aich, M.B Chowdhuri, R. Manchanda, R.L. Tanna, K.A. Jadeja, K.M. Patel and J. Ghosh

Neutral and impurity influx measurement from limiter and wall of ADITYA-U Tokamak
Nandini Yadava, J. Ghosh, M B. Chowdhuri, R. Manchanda, Sripathi, Punchithaya K, Ismyil, N. Ramaiya, Ritu Dey, Tanmay Macwan, S. Patel, R.L. Tanna and ADITYA-U team

AWARDS and ACHIEVEMENTS

On the characteristics of argon plasma in a multi-pole line-cusp variable magnetic field.

A. D. Patel, M. Sharma, N. Ramasubramanian, R.Ganesh and P. K. Chattopadhyay received **Best Poster Award** at the 9th International Conference on Frontiers of Plasma Physics and Technology (FPPT-9) 8-12 April 2019, Colombo, Sri Lanka

Study on Ion Dynamics in Inertial Electrostatic Confinement Fusion Device
D. Bhattacharjee, D. Jigdung, N. Buzarbaruah, S. R. Mohanty received **Best Poster Award** at National conference on Green, Sustainable and Evolving Sciences (GSES-2019), Cotton University, Guwahati, 28-29 June 2019

Effect of porosity on thermal conductivity of Li_2TiO_3 ceramic compacts
Aroh Shrivastava, Riddhi Shukla, Paritosh Chaudhuri received **Best Poster Award** at Workshop on "Materials Characterization: Structure, Spectroscopy, and Microscopy, Institute of Infrastructure, Technology, Research and Management (IITRAM), Ahmedabad, 19-24 August 2019
Superhydrophobic PTFE Surface Prepared by Low Energy Ar+ Ion Beam Irradiation
Vivek Pachchigar, Mukesh Ranjan, Sooraj K P, Sebin Augustine received **Best Poster Award** at Workshop on "Materials Characterization: Structure, Spectroscopy, and Microscopy, Institute of Infrastructure, Technology, Research and Management (IITRAM), Ahmedabad, 19-24 August 2019

Vivek Pachchigar, Mukesh Ranjan, Sooraj K P, Sebin Augustine received **Best Poster Award** at Workshop on "Materials Characterization: Structure, Spectroscopy, and Microscopy, Institute of Infrastructure, Technology, Research and Management (IITRAM), Ahmedabad, 19-24 August 2019

Static and Dynamic Wettability Behaviour of Superhydrophobic PTFE Surface Prepared by Low Energy Ar+ Ion Beam Irradiation
Vivek Pachchigar, Mukesh Ranjan, Sebin Augustine and Sooraj K P received **Best Oral Presentation award** at 5th International Conference on Nanostructuring by Ion Beams (ICNIB-2019), IGCAR, Kalpakkam, 6-8 November 2019

Magnetic Island Coalescence Dynamics in Multiple Current Sheets
Jagannath Mahapatra, R. Ganesh received **Best poster**

presentation award at 12th International Conference on Plasma Science and Application (ICPSA-2019), Lucknow University, Lucknow, 11-14 November 2019

Electron Cyclotron (EC) Power Supply System
Mahesh Kushwah, B K Shukla, KG Parmar, Jatin Patel, Harshita Patel, Dharmesh Purohit and Hardik Mistry received **Best poster presentation award** at 12th International Conference on Plasma Science and Application (ICPSA-2019), Lucknow University, Lucknow, 11-14 November 2019

International Award for Former IPR Research Scholar
Former research scholar of IPR, Dr. Rupak Mukherjee received the 2019 PPPL under 30 Scientist and Student Award, in recognition of his exceptional contribution to plasma physics at the start of his career. He has been a postdoctoral fellow at the Princeton Plasma Physics Laboratory (PPPL) since June 2019. The award was given based on his thesis work and publications in areas that describe the evolution of non-linear plasma flows. Dr. Mukherjee worked under Dr. Rajaraman Ganesh for his PhD at IPR. The award of $300 cash and a certificate and citation will be presented to him at the AAPPS-DPP Conference in Hefei, China, in November 2019.

Buti Foundation Award 2019
Dr. Pintu Bandyopadhyay, Associate Professor at IPR received the biennial "Buti Foundation Award" in the field of Plasma Science & Technology for the year 2019. The award was presented to him during the foundation day function of PRL, at the Physical Research Laboratory, Ahmedabad on 11th November 2019. Dr. Bandyopadhyay was conferred with this award for his outstanding contribution in the field of Experimental Basic Plasma Physics, particularly in the area of Complex (dusty) Plasmas.

IPR received **Official Language Shield** (Runner Up) and **Best Official Language Magazine Award** in Aided Institute Category of DAE for year 2018-19 at DAE 20th All India Official Language Conference held at Atomic Minerals Directorate for Exploration and Research (AMD), Hyderabad on 20 November 2019

Praveen Kumar Atrey and Harish Chandra Khanduri received **Hindi Sevi Sammaam Puraskar** for the year 2018-19 with a memento by the DAE for excellent and creative contribution in the propagation of Hindi, at DAE 20th All India Official Language Conference held at Atomic Minerals Directorate for Exploration and Research (AMD), Hyderabad on 20 November 2019

Hindi Vigyan Sahitya Parishad, Bhabha Atomic Research Center, Mumbai organized a Science Skit Competition in Hindi among units of Department of Atomic Energy at Anushaktinagar, Mumbai during 28-30 November 2019, in which IPR Science Skit "**Vigyan Manthan**" received **Best Entertainment Skit Award**

Multiphysics Analysis of a High Power RF Window using COMSOL
Yogesh M. Jain, P. K. Sharma, P. R. Parmar, K. K. Ambulkar, Harish V. Dixit received **Best Poster Award** at COMSOL conference 2019, ITC Gardenia, Bangalore, 28-29 November 2019

Development, Testing & Commissioning of Automatic Charging of High Voltage Capacitor Bank in Aditya-U Tokamak
Bharat Arambhadiya, Vismaysinh Raulji, Rohit Kumar, Tanmay Macwan, Kaushlendra Singh, Suman Dolui, Rachana Rajpal, Rakesh Tanna, Joydeep Ghosh received **1st Prize as Best Poster Award** under Z.H. Sholapurwala Award for Fusion Research 2019 at 34th National Symposium on Plasma Science & Technology (PLASMA 2019), VIT Chennai, Chennai, 3-6 December 2019

Forecasting of disruption in Aditya-U Tokamak
Suman Dolui, Kaushlender Singh, Tanmay Macwan, Harshita Raj, Suman Aich, Rohit Kumar, K. A. Jadeja, K M Patel, V K Panchal, D. Raju, Jayesh Raval, S.K. Jha, R L Tanna, J. Ghosh and ADITYA-U Team received **Best Poster Award** at 34th National Symposium on Plasma Science & Technology (PLASMA 2019), VIT Chennai, Chennai, 3-6 December 2019

Design and Development of a Passive Active Multijunction (PAM) Launcher for LHCD system of ADITYA-Upgrade Tokamak
Yogesh M. Jain, P. K. Sharma received **Best Poster Award** at Electromagnetics and Microwave Engineering: Pedagogy, Research Trends and Applications (EMPRA 2020), BITS-Pilani, Hyderabad, 2-4 January 2020

Measurement of effective thermal conductivity of lithium ceramic packed bed
Aroh Shrivastava, Paritosh Chaudhuri received **Best Oral Presentation Award** at 22nd DAE-BRNS workshop &

symposium on thermal analysis (THERMANS 2020), Bhabha Atomic Research Center, Mumbai, 28 January to 1 February 2020

Development of MW level RF Source for ITER Project
Aparajita Mukherjee, Rajesh Trivedi, Raghuraj Singh, Kumar Rajnish, Akhil Jha, Dipal Soni, Sriprakash Verma, P. Ajesh, Gajendra Suthar, Manoj Patel, Kartik Mohan, Rohit Anand, Rohit Agarwal, Pareshkumar Vasava, Hrushikesh Dalicha received **Best Poster Award** at International Summit on Women in STEM: "Visualizing the Future: New Skylines", India Habitat Centre, New Delhi, 23-24 January 2020

Plasma assisted, single-step synthesis of Ag-C nanocomposites with less than ten nanometer average sizes for antibacterial application
Mizanur Rahman (presenting author), Gopikishan Sabavath, Trinayan Sarmah, Pubali Dihingia, Swati Sharma, Lalit M. Pandey, and Mayur Kakati received **Best Poster Award** at Bio-inspired Nanomaterials for Environmental Applications, Indian Institute of Technology Guwahati, Assam, 12-13 February 2020

E.4. INVITED TALK DELIVERED BY IPR STAFF

ARGHYA MUKHERJEE

Gave an Invited talk on "Surfing of electrons on plasma waves and production of electron Tsunami" at GTU Central Tech Fest, 2019, Vishwakarma Government Engineering College, Ahmedabad, 8 April 2019

JOYDEEP GHOSH

Gave an Invited talk on "Tokamak: the configuration of a Controlled Fusion Reactor", at the Annual Seminar of the Department of Physics, Ravenshaw University, Cuttack, April 2019

Gave an Invited talk on "What is a Tokamak?" at 7th PSSI-Plasma Scholars Colloquium (PSC-2019), Institute of Advanced Research, Gandhinagar, 08-10 August 2019

Gave an Invited talk on "Runaway Electron Dynamics in ADITYA and ADITYA-U tokamak" at 12th International Conference on Plasma Science and Applications (ICPSA), Department of Physics, University of Lucknow, India, 11-14 November 2019

Gave an Invited talk on "Diagnosis of Tokamak plasma using passive spectroscopy" at 8th Topical conference (TC-2020) on Atomic and Molecular Collisions for Plasma Applications, IIT Roorkee, Uttarakhand, 3-5 March 2020

S MUKHERJEE

Gave an Invited talk on "LIGO India - Opportunities for the Industry" at Vigyan Samagam, Nehru Science Centre, Mumbai, 8-9 May 2019

Gave an invited talk on "Status update on LIGO-India" at LVK 2020 International Conference to be held at Hotel Grand Geneva, Michigan, USA, on 12 March 2020 (Remote presentation from IPR because of COVID19)

S K NEMA

Gave an Invited talk on "Non-thermal atmospheric pressure plasma technologies for societal benefits" at the 9th International Conference on Frontiers of Plasma Physics and Technology (FPPT-9), Colombo, Sri Lanka, 8-12 April 2019

SAROJ DAS

Gave an Invited talk on "Scientific Information and Scholarly Publication: Role of a Research Library" at SSP-2019 Popular Talk, IPR Seminar Hall, Gandhinagar, 29 May 2019

RAJIV SHARMA

Gave an Invited talk on "In-house Development of Composite Materials for Superconducting Fusion Reactor and Cryogenic Applications" (co-author V. L. TANNA) at One day seminar on Composite Materials Technology and Applications, Ahmedabad Textiles Industries Research Association (ATIRA), Vastrapur, Ahmedabad, 15 June 2019

SARVESHWAR SHARMA

Gave an Invited talk on "Effect of driving frequency on plasma parameters and electron heating mechanism in a symmetric capacitive discharge under constant power density condition" (co-authors: Nishant Sirse and Miles Turner) at 9th Radio-frequency Discharge Workshop, Dublin City University, Dublin Ireland, 24-25th June 2019

Gave an Invited talk on "Electric field filamentation and higher harmonic generation in very high frequency capacitive discharges" (co-authors: Nishant Sirse, Abhijit Sen, Jong-

Shinn Wu, Miles Turner) at 12th International Conference on Plasma Science and Applications (ICPSA), Department of Physics, University of Lucknow, India, 11-14 November 2019

MAYUR KAKATI

Gave an Invited talk on "Controlled plasma fusion research relevant plasma surface interaction studies in CPP-IPR CIMPLE-PSI laboratory" at National Conference on Green, Sustainable and Evolving Sciences (GSES-2019) & 64th Annual Technical Session of Assam Science Society, Cotton University, Guwahati, Assam, India, 28-29 June 2019

Gave an Invited talk on "A supersonic plasma jet assisted experimental reactor configuration for bulk synthesis of high temperature nanomaterials" at National Seminar and Workshop on Applications of Nanotechnology and Biotechnology in Daily Life (NSW-ANBDL-2019), Sibsagar College, Joysagar, 26-28 September 2019

Gave an invited talk on "Fusion relevant plasma surface interaction studies in CPP-IPR CIMPLE-PSI laboratory" 3rd International Conference on Material Science (ICMS2020), Tripura University, Agartala, 4-6 March 2020

Gave an invited talk on "Fusion relevant plasma surface interaction studies in CIMPLE-PSI device, proposed exposure experiments with high entropy alloys" at 3rd International Workshop on High Entropy Materials, Indian Institute of Technology, Kanpur, 7-8 March 2020

MUKESH RANJAN

Gave an Invited talk on "Low Energy Ions for Fabricating Ordered Plasmonic Structures for Second Harmonic Generation and Sensing Applications" at 10th International Conference on Nanoscale Pattern Formation at Surfaces, University of Surrey, Guildford, UK, 7-10 July 2019

Gave an Invited talk on "Fundamentals of Ellipsometry and its application" at Workshop on Materials Characterization: Structure, Spectroscopy and Microscopy, Department of Physics, Institute of Infrastructure, Technology, Research and Management (IITRAM), Maninagar, Ahmedabad, 19-24 August 2019

Gave an invited talk on "Nanopatterning by plasma to detect early formation of abnormalities" at 12th International Conference on Plasma Science and Applications, University of Lucknow, Lucknow, 11-14 November 2019

Gave an Invited talk on "Application of plasma produced nanostructures in surface wettability and molecular sensing" at 1st International Conference on Advances in Plasma Science and Technology (ICAPST), Department of Physics, Sri Shakthi Institute of Engineering and Technology Coimbatore, 12-14 February 2020

Gave an Invited talk on "Molecular process responsible for glow switching and producing nanostructures and dense arrays for surface wettability and molecular sensing" at 8th Topical Conference of the Indian Society of Atomic and Molecular Physics (ISAMP) with a theme of Atomic and Molecular Collisions for Plasma Applications, IIT-Roorkee, Roorkee, 3-5 March 2020

PINTU BANDYOPADHYAY

Gave an Invited talk on "Dusty Plasma: A Multidisciplinary field of Research" at 7th PSSI-Plasma Scholars Colloquium (PSC-2019), Institute of Advanced Research, Gandhinagar, 08-10 August 2019

AMIT SIRCAR

Gave an Invited talk on "Study and characterization of potential adsorbent materials for the design of the Hydrogen Isotopes Extraction and Analysis System" (co-authors: V. Gayathri Devi, Deepak Yadav, Jyoti Shankar Mishra, Ranjana Gangradey, Gayathry J. M., Rahul Tomar, Pragnesh B Dhorajiya and Purvi Dave) at 14th International Symposium on Fusion Nuclear Technology (ISFNT-14), Budapest, Hungary, 22-27 September 2019

G. RAVI

Gave an Invited talk on "A new regime of whistler waves in the laboratory" (co-author: Garima Joshi presenting author) at International Conference on Electromagnetics in Advanced Applications (ICEAA - IEEE APWC 2019), Granada, Spain, 9-13 September 2019

Gave an Invited talk on "Thermal Plasma Torches – Transition from Atmospheric to Low Pressure and Applications" (co-authors: Vidhi Goyal, Yugesh V., Ram Krushna Mohanta) at International Conference on Advances in Plasma Science and Technology, Sri Shakthi Institute of Engineering and Technology, Coimbatore, 12 - 14 February 2020

P.N. MAYA

Gave an Invited talk on "Modelling and Simulations of neutron-induced radiation damage in plasma-facing materials" at Pre-Conference School on Ion Beams in Materials Science (With focus on Radiation damage in Nuclear Materials), IGCAR Kalpakkam, 4-5 November 2019

S.R. MOHANTY

Gave an Invited talk on "Basics of Inertial Electrostatic Confinement Fusion and its Application" (Co-authors: N. Buzarbaruah, D. Bhattacharjee, D. Jingdu) at 14th Asia Pacific Physics Conference (APPC14) at Kuching, Sarawak, Malaysia, 17-21 November 2019

Gave an Invited talk on "Overview of Inertial Electrostatic Confinement Fusion Research at CPP-IPR" (Co-authors: D. Bhattacharjee and N. Buzarbaruah) at Trends in Modern Physics 2020, Assam Don Bosco University, Tepesia, Assam, 24-25 February 2020

MAINAK BANDYOPADHYAY

Gave an Invited talk on "Neutral Beam Injector - Present and Future" at 9th Indian Particle Accelerator Conference (InPAC-2019), Inter- University Accelerator Centre, (IUAC), New Delhi, 18-21 November 2019

S.S KAUSIK

Gave an Invited talk on "Effect of cesium monolayer on tungsten particles in negative ion production" (co-author: B.K Saikia and M. Bandyopadhyay) at 14th Asia-Pacific Physics Conference, Kuching, Malaysia, 17-21 November 2019

PROMOD KUMAR SHARMA

Gave an Invited talk on "Overview of activities of IPR" at Overview of DAE Programmes and Honing Leadership Skill Meet-2019, NPCIL, Kaiga Site, Uttar Kannada District, Karnataka, 19 November 2019

Gave an Invited talk on "High Power microwave system for driving non-inductive plasma current in tokamak" at National Symposium on Vacuum Electronic Devices & Applications (VEDA-2019) Conference, National Institute of Technology, Patna, 21-23 November 2019

Gave an Invited talk on "Application of electromagnetic waves in plasmas" at Electromagnetics and microwave engineering: Pedagogy, research trends and applications (EMPRA-2020), BITS PILANI, Hyderabad Campus, Hyderabad, 2-4 January 2020

BRAJ KISHORE SHUKLA

Gave an Invited talk on "Fusion Energy, Plasma Heating and High Power Gyrotrons" at National Symposium on Vacuum Electronic Devices and Applications (VEDA-2019), NIT, Patna, 21-23 November 2019

BALASUBRAMANIAN C,

Gave an Invited talk on "Thermal Plasma Process of Nanomaterial Production – Advantages and Challenges" (Co-authors: Subrat Kumar Das, Satya Kandada) at 1st International Conference on Advances in Plasma Science & Technology (ICAPST 2020), Sri Shakthi Institute of Engineering and Technology, Coimbatore, 12-14 February 2020

Gave an Invited talk on "Plasma based Nano Titania Production and its Self-Cleaning Applications in Textiles" at National Seminar on Two Decade of Nanotechnology in Textile: Progress and Prospects, Bhaikaka Bhavan, Law College Road, Ahmedabad (organised by Institute of Engineers India), 20-21 February 2020

SUDIP SENGUPTA

Gave an Invited talk on "Stationary Bernstein-Greene-Kruskal Waves in a Current Carrying Cold Relativistic Fluid-Maxwell System" at 3rd National Seminar on Nonlinear and Complex Phenomena, Jadavpur University, Kolkata, 18-19 February 2020

Gave an invited talk on "Spatio-temporal evolution of Buneman instability: A Particle-in-Cell simulation study" at 3rd Asia-Pacific Conference on Plasma Physics (AAPPS-DPP2019), Hefei, China, 4-8 November 2019

MRITYUNJAY KUNDU

Gave an Invited talk on "Resonances in Driven Non-linear Oscillators: Does maximum light absorption happen at resonance as we expect?" (Co-author: Sagar Mahalik) at 3rd National Seminar on Nonlinear and Complex Phenomena, Jadavpur University, Kolkata, 18-19 February 2020

Gave an invited talk on "Short-pulse laser cluster interaction: unification of resonances" (Coauthor: S. S. Mahalik) at 3rd Asia-Pacific Conference on Plasma Physics, Hefei, China, Crowne Plaza, Hefei, China, 4-8 November 2019

UJJWAL KUMAR BARUAH

Gave a plenary talk on "ITER: Progress of Indian Contribution towards Construction" at 12th International Conference on Plasma Science and Applications (ICPSA-2019), Lucknow, University of Lucknow (venue: Hotel Hilton Inn), 11-14 November 2019

VISHAL JAIN

Gave an invited talk on "Novel Atmospheric Pressure Nonthermal Uniform Glow Discharge Air Plasma and its application for Inline Surface Treatment of Textile" (Coauthors: Nisha Chandwani, S K Nema) at International Conference on Plasma Science Applications (ICPSA2019), Hotel Hilton, Lucknow, 11-14 November 2019

DEVENDRA SHARMA

Gave an invited talk on "Coherent structures in collisionless plasmas: subcritical stability in some limiting cases" at 12th International Conference on Plasma Science and Applications, University of Lucknow, Lucknow, 11-14 November 2019

S. SUNIL

Gave an invited talk on "Black Holes" at Commemorating Stephan Hawkings birth anniversary, Science City, Ahmedabad, 08 January 2020

Invited talks given at 34th National Symposium on Plasma Science & Technology (PLASMA 2019), VIT Chennai, Chennai, 3-6 December 2019

SHISHIR DESHPANDE gave an Invited talk on "ITER Project Overview and India's Contribution"

MRITYUNJAY KUNDU gave an Invited talk on "Acceleration of Electrons from a thin Foil Plasma by Tightly Focused Few-Cycle Laser Beam"

M. B. CHOWDHURI gave an Invited talk on "Radiation Based Diagnostics on Tokamaks in IPR and Application of those for Investigation of Plasma"

HITESH KUMAR B. PANDYA gave an Invited talk on "Microwave Plasma Diagnostics for Fusion Research Machines"

P. N. MAYA and S. P. DESHPANDE gave an Invited talk on "Tungsten Compatibility for Spherical Tokamak Reactors: Modeling of Radiation Damage and Fuel Retention"

DANIEL RAJU gave an Invited talk on "Recent Plasma Experiments in SST-1"

RITU DEY, J. GHOSH, M. B. CHOWDHURI, R. MANCHANDA, N. YADAVA, H. RAJ, R. L. TANNA and ADITYA Team gave an Invited talk on "Investigation of Neutral Particle Dynamics in Aditya and Aditya-U Tokamak Plasmas using DEGAS2 and UEDGE Codes"

Invited talks given at Conference on Plasma Simulation (CPS-2020), Institute for Plasma Research, Gandhinagar, 23-24 January 2020

RAJARAMAN GANESH gave an Invited talk on "Particle-in-Cell Simulations of Non-neutral Plasmas"

DEVENDRA SHARMA gave an Invited talk on "Stochastic solutions of Plasma Fluid Equations: 3D boundary value problem of Scrape-off Layer (SOL) transport equilibria"

SUDIP SENGUPTA gave an Invited talk on "Spatio-temporal evolution of space charge waves in a warm inhomogeneous plasma"

ATUL KUMAR and ABHIJIT SEN gave an Invited talk on "Precursor magneto-sonic solitons in a plasma from a moving charged object"

MRITYUNJAY KUNDU gave an Invited talk on "Non-conventional collisional absorption of laser light in under-dense plasma"

Invited talks given at National Symposium for Commemorating 30-years of ADITYA Tokamak, Institute for Plasma Research, Gandhinagar, 27-28 January 2020

ABHIJIT SEN gave an Invited talk on "ADITYA-30: a look back and some thoughts on the future"

P.I. JOHN gave an Invited talk on "ADITYA: The Beginnings"

Y.C. SAXENA gave an Invited talk on "ADITYA-Commissioning, Operations and Results"

R. SRINIVASAN gave an Invited talk on “ADITYA Upgradation with Divertor Configuration”

JOYDEEP GHOSH gave an Invited talk on “ADITYA Upgrade Tokamak”

PRABAL K CHATTOPADHYAY gave an Invited talk on “RF Experiment in ADITYA & ADITYA-U”

BALAKRISHNAN V NAIR gave an Invited talk on “Overview of Pulsed Power Systems (Apps) for ADITYA/ ADITYA-U Tokamak”

S.B. BHATT gave an Invited talk on “Vacuum System ADITYA / ADITYA Tokamak-Upgrade”

BHARAT DOSHI gave an Invited talk on “ADITYA/ ADITYA-U Support Structure & Mechanics”

HARSHAD D PUJARA gave an Invited talk on “ADITYA Data Acquisition & Electronics”

K. SATHYANARAYANANA gave an Invited talk on “ADITYA-Electrical Subsystems”

BRAJ KISHORE SHUKLA gave an Invited talk on “Pre-ionization and start-up systems (28GHz & 42GHz ECRH) in Aditya and Aditya-U Tokamak”

S.V. KULKARNI gave an Invited talk on “Experiments on Tokamak ADITYA using Indigenously Developed 20-40 MHz, 1 MW ICRH System”

PROMOD K. SHARMA gave an Invited talk on “Lower Hybrid Current Drive System on ADITYA”

INDRANIL BANDYOPADHYAY gave an Invited talk on “ADITYA Modeling Studies using TSC”

NIRMAL BISAI gave an Invited talk on “Impurity gas injection studies”

C.V. SRINIVASA RAO gave an Invited talk on “ADITYA Diagnostics Progress”

E.5 TALKS DELIVERED BY DISTINGUISHED VISITORS AT IPR

Dr. P. N. Maya, University of Greifswald, Germany, gave a talk on "Role of Fusion-Plasma Surface Interactions in Tokamaks: Recent Results and Emerging Areas” on 30th April 2019

Mr. Pravin Kumar Tiwari, Department of Physics, University of Allahabad, gave a talk on "Elemental analysis using spectral emission from laser produced plasma" on 1st May 2019

Dr. Arkaprava Das, Inter-University Accelerator Centre, New Delhi, gave a talk on "Phase transformation studies for CdO based thin films and nano-composites" on 2nd May 2019

Mr. Yogesh Sharma, Banaras Hindu University, Varanasi, gave a talk on "Studies on Dispersion Characteristics of Electromagnetic Waves in Magnetized One Dimensional Ferrite Photonic Crystals" on 10th May 2019

Dr. Sunita Negi, Amity School of Applied Sciences, Haryana, gave a talk on "Application of Carbon Nanotubes in combination with proteins for nano-delivery systems" on 20th May 2019

Ms. Janki Shah, Sardar Vallabhbhai National Institute of Technology, Surat, gave a talk on "Morphological and Thermophysical Properties of Metal- Oxide Nanofluids" on 7th June 2019

Dr. Rudrodip Majumdar, IIT Bombay, gave a talk on "Modelling of Flow Patterns of Impurity Particulates following a Disruption in the Fusion Reactor Chamber" on 17th June 2019

Dr. Lalita, Department of Physics, IIT Delhi, gave a talk on "Self Focusing and Frequency Shift of Super-Gaussian Laser Beam in a Plasma" on 28th June 2019

Dr. P J Bhuyan, CPP-IPR, Assam, gave a talk on "NDOT-1D: A MATLAB code for preparation & execution of Monte Carlo transport code input files for 1-D radial model of fusion reactors" on 3rd July 2019

Dr. Boby Joseph, Elettra Synchrotron Radiation Facility, Italy, gave a talk on "Pressure tuning of material properties: selected examples from the high pressure powder diffraction beamline “Xpress” at Elettra synchrotron radiation facility, Trieste" on 9th July 2019

Prof. Avinash Khare, Central University of Sikkim, gave a talk on "Thermodynamics and simulations of gravitating systems" on 10th July 2019

Dr. Arkaprava Bokshi, University of York, UK, gave a talk on "Towards understanding the origins of small ELMs and rotation reversals in tokamak plasmas" on 25th July 2019

Dr. Ankita Gaur, M.L.V. Textile and Engineering College, Bhilwara, Rajasthan, gave a talk on "Studies on multi-mode Erbium doped fiber amplifiers" on 29th July 2019

Ms. Prachi B. Orpe, Nirma University, Ahmedabad, gave a talk on "The study of magnetic nanostructures in relation to its atomic ordering and oxidation state" on 2nd August 2019

Dr. Debraj Mandal, Aix-Marseille Universite, PIIM-Laboratory, Marseille, France, gave a talk on "Cross-field chaotic transport of electrons by E × B electron drift instability in Hall thruster" on 9th August 2019

Dr. Dipak Bhowmik, VECC, Kolkatta, gave a talk on "Surface and interface modification by low energy ion beams" on 12th September 2019

Dr. Omkant Jha, I. Sc., B. H. U., Varanasi, gave a talk on "Structural and Vibrational Investigations of Some Neurotransmitter Molecules" on 16th September 2019

Dr. Santanu Banerjee, Department of Physics, William & Mary, Williamsburg, USA, gave a talk on "Effect of onaxis ECRH on ELM dynamics and pedestal behavior in DIII-D" on 25th September 2019

Dr. Saikat Ghosh, Indian Institute of Technology, Kanpur, gave a talk on "Nonlinear dynamics of atomically thin graphene oscillators" on 27th September 2019

Dr. Subir Biswas, Institute of Advanced Study in Science and Technology, Guwahati, Assam, gave a talk on "Spectroscopic measurements of electric and magnetic field distributions in a relativistic self-magnetic-pinch diode" on 24th October 2019

Dr. Promit Moitra, Indian Institute of Science Education and Research (IISER), Mohali, gave a talk on "Dynamics on spatially extended systems" on 25th October 2019

Dr. Parnika Das, Variable Energy Cyclotron centre, Kolkata, gave a talk on "Precision mass measurement using Penning Ion trap at VECC" on 30th October 2019

Prof. Vinod Krishan, Indian Institute of Astrophysics, Bangalore, gave a talk on "Three Fluid Effects in Magnetic field Generation" on 13th November 2019

Dr. Gayatri Dhamale, BARC, Mumbai and Pune University, Pune, gave a talk on " Thermal plasma synthesis of nanoparticles: simulation and experimental based study" on 15th November 2019

Dr. Basanta Kumar Parida, Indian Institute of Technology Ropar, Punjab, gave a talk on "Low energy ion beam nanopatterning of CoxSi1-x surfaces" on 10th December 2019

Dr. Srinivasarao Bukkuru, Andhra University, Visakhapatnam, gave a talk on "Molecular Dynamics study of defect diffusion" on 13th December 2019

Dr. Falguni G. Bhabhor, Navjivan Science College, Dahod, Gujarat, gave a talk on "Synthesis, Characterization and Biological Evaluation of Some Nitrogen Based Heterocyclic Compounds" on 16th December 2019

Dr. Christian Hopf, Max Planck Institute for Plasma Physics, Germany, gave a talk on " Towards steady-state tokamak operation: recent current drive experiments on ASDEX Upgrade and challenges for neutral beam current drive on DEMO and beyond" on 10th January 2020

Dr. Nageswara Rao Epuru, Physical Research Laboratory, Ahmedabad, gave a talk on "Laser Induced Plasma spectroscopic studies of Nitroazoles, Brass and Rocks" on 10th January 2020

Dr. Paramita Patra, Indian Institute of Technology (IIT), Kharagpur, gave a talk on "Assessment of thermal spike model via swift heavy ion mixing" on 21st January 2020

Ms. Sonakshi Sachdev, Chennai Mathematical Institute, Tamil Nadu, gave a talk on "Conservative regularization of ideal fluids and plasmas" on 29th January 2020

Dr. Deepa Verma, LSPM-CNRS, France, gave a talk on "Terahertz generation from a collective plasma dynamics in a thin semiconductor gap" on 31st January 2020

Dr. Arup Sarkar, Indian Institute of Science Education and Research (IISER), Berhampur, gave a talk on "Surface properties of ultrathin films" on 11th February 2020

Dr. Abhijit Boruah, Institute of Advanced Study in Science and Technology, Guwahati, Assam, gave a talk on "Wave experiments in strongly coupled dusty plasma" on 20th February 2020

Dr. Pallabi Pathak, Institute of Advanced Study in Science and Technology, Guwahati, Assam, gave a talk on "Ion acoustic rogue waves" on 26th February 2020

E.6 COLLOQUIA PRESENTED AT IPR

Mr. R. Jehadeesan, IGCAR, Kalpakkam, gave a talk on “Scientific Computing Infrastructure and related R&D activities at IGCAR" on 11th July, 2019 (Colloquium # 295)

Dr. Surojit Gupta, University of North Dakota, Netherland, gave a talk on “High Performance Nanolaminates based Functional Materials for High Temperature and Multifunctional Applications" on 12th July, 2019 (Colloquium # 296)

Prof. Amit Roy, Former Director, Inter-University Accelerator Centre, New Delhi, gave a talk on “Can one plan to do Great Research?" on 20th September 2019 (Colloquium # 297)

Prof. Frederick J. Raab, Associate Director for Observatory Operations, LIGO Laboratory, California Institute of Technology, California, gave a talk on “The Bright Future of Gravitational-Wave Astronomy" on 18th December 2019 (Colloquium # 298)

Prof. Kushal K. Shah, Indian Institute of Science Education & Research [IISER] Bhopal, gave a talk on “Can ergodicity impede statistical equilibration, and non-ergodicity support it?" on 20th December, 2019 (Colloquium # 299)

Dr. Dipanjan Mitra, NCRA-TIFR, Pune, gave a talk on “Relativistic charge solitons caused due to Nonlinear Landau Damping: An excellent candidate for explaining the Coherent Radio Emission from Pulsars" on 21st January 2020 (Colloquium # 300)

Prof. B. K. Dutta, Homi Bhabha National Institute, gave a talk on “Mechanical Properties of OFE Copper Subjected to Electron Irradiation" on 5th February, 2020 (Colloquium # 301)

Prof. Bruce T. Tsurutani, Pasadena Research Associates, Pasadena, California, USA, gave a talk on “From the Sun: Solar Flares, Auroras, Magnetic Storms and the Van Allen Radiation Belts: A General Summary of Space Weather" on 21st February, 2020 (Colloquium # 302)

E 7. SCIENTIFIC MEETINGS HOSTED BY IPR

Training on High Performance Computing

IPR has recently setup a 1 PetaFlop High Performance Computing System having 236 Compute Nodes, 22 Compute Nodes with GPU, 2 High Memory node and 1 Visualization Node. A training session was organized for this HPC system for the benefit of users from various groups of IPR who are involved in computation and simulation studies. The training was carried out by experts of the industry. Dr. R. Ganesh, Head, Computer Division, gave an overview of the new system. Over 50 staff members and PhD scholars of IPR attended this training programme.

Seminar on High Frequency Structure Simulator (HFSS)

A one-day seminar on electromagnetic solvers was organized at IPR on 19 July, 2019. The three talks related to the topic were delivered by Dr. S. B. Sharma, retired scientist of Space Application Center, Ahmedabad. He has 34 years of academic and diversified research and development experience in the field of electromagnetic modeling and microwave engineering in general and antenna engineering. His major contributions to space research were ground based, airborne and space borne antenna systems for satellite communication and remote sensing programs of ISRO.

Plasma Technologies for Health Sector (PTHS-2019)

A one day seminar “Plasma Technologies for Health Sector (PTHS-2019)” was held on 29th November 2019 at IPR. Around 120 delegates from various health sectors (Hospitals, R&D centres, academic institutions and private industries and medical practitioners) participated in the event. Dr. Sudeep Gupta (Director ACTREC, TMC Mumbai), Dr. Srikanth Prasad Tripathy (Director NIRT, National Institute for Research in Tuberculosis, Chennai), Dr. Sarat Chandra (AIIMS, New Delhi) were the guests of honour for the event. The purpose of organising PTHS-2019 seminar was to introduce the Indian community of medical practitioners, biotechnologies, bio-researchers, and Bio-industries about current development in the field of plasma medicine and particularly efforts of Institute for Plasma Research (IPR) in this direction. The Convener and Co-Convener of this seminar was Dr. Mukesh Ranjan and Mr. Akshay Vaid respectively. As part of the PTHS-2019, the participants were given a tour of the FCIPT facility and a glimpse of the R&D work being carried out there in the area of plasma applications.

ITER-India - Industry Meet Held at IPR

The first ITER-India Industry meet was conducted in IPR on 21st December 2019 with the participation of 40 representatives from 25 industries. Shri. Ujjwal Baruah welcomed the participants and explained the need to create awareness and to encourage Indian industries to participate in competitive bidding of ITER Organizations' direct procurements. Prof. Shishir Deshpande presented about Nuclear fusion, ITER Project and the progresses made in ITER-India procurement packages. The other speakers Shri. Ajith Kumar, Shri. Dilshad Sulaiman and Shri. Malay Vora talked about the engagement of Indian industries so far with ITER project, forthcoming opportunities, various modes of engagement with ITER project and the steps involved during bidding process. In his remote presentation, Dr. Sergio Orlandi explained about the progresses made at ITER site, upcoming opportunities, ITER's tendering processes with stress on expected quality of bid documents. Shri. Arun Chakraborty in his talk, sensitized the need to prepare the bid, complete in all aspects. The interaction session was led by Shri. Arun Chakraborty in which the participants from the industries requested for continuous interactions with ITER-India as well as they shared their willingness to find collaborating industries within Indian and/or abroad for joint biddings. A set of actions on ITER-India was identified for future actions, including nominating industrial liaising officer, consolidating the list of industries with their expertise, introducing known European industries to the Indian industries for possible tie-ups, etc. Moreover, ITER-India agreed to engage with ITER to bring more clarifications on contract terms & conditions, tender budget estimates, eligibility criteria, bid submission, etc. General expectation of industry representatives is to conduct similar workshops periodically for greater success of Indian industries. The participants had chance to visit Aditya Tokamak, SST-1 and ITERIndia laboratories too. Finally, Shri Ujjwal Baruah thanked the participants and expressed the hope of conducting a similar meeting at a larger forum.

30 Years of Aditya Tokamak

IPR organised a two-day National Symposium for Commemorating 30-years of the successful operation of the first indigenous tokamak in India - "ADITYA and its Upgrade" (NSC30AT2020) at the Entrepreneurship Development Institute (EDI), Gandhinagar during January 27 - 28, 2020. The main focus of the symposium was to celebrate 30 years of scientific activities of ADITYA -tracing its historical evolution, highlighting its scientific and technical achievements, discussing the experimental program of its latest avatar (the upgraded ADITYA-U) and finally, discussing the possible future scientific and technological roadmap of the program. The meeting was inaugurated by lighting the traditional lamp by the chief guest Dr. Anil Kakodkar (Former Chairman, AEC), the guest of honour Dr. R. B. Grover (Homi Bhabha Chair, DAE, HoD ITER Council), Dr. S. Chaturvedi (Director, IPR) and Dr. S. Deshpande (Chairman, NSC30AT). Over 300 participants from all over the country participated in this symposium. During the opening session, Dr. S. Chaturvedi welcomed the gathering and shared his memories of ADITYA early days. Dr. Anil Kakodkar delivered the Inaugural Address and shared his valuable thoughts on this occasion.

Dr. R. Grover and Prof. A. Sen delivered the Keynote Addresses. Dr. Grover emphasized upon the India's electricity demand and the economic aspects of electricity generation and Prof. A. Sen deliberated on the journey of how ADITYA tokamak was born and the efforts made towards expanding the fusion program in India. The two-day symposium had 23 invited talks delivered by eminent speakers from IPR as well as from DAE units and other institutes. A 'Panel Discussion' was conducted on how ADITYA Upgrade tokamak could be made a national facility to provide hands-on experience on tokamak research for the students of different universities within the country. A poster session was also organized, where a total of 55 posters were presented. An ADITYA-U visit was organized for participants on the evening of 27th January, 2020 followed by welcome dinner organised by the LOC, NSC30AT at IPR.

Conference on Plasma Simulations (CPS) @ IPR

A Conference on Plasma Simulations (CPS) was held at the Institute for Plasma Research during January 23-24, 2020. The conference was well attended and was rich in scientific content. There were 22 invited talks and 52 poster presentations during the 2-day event. The participants came from more than 23 different universities and research institutes across India and their research interests and contributions covered a wide range of plasma science topics such as magnetic and inertial fusion, space and astrophysical plasmas, plasma surface interactions, industrial applications of plasma, plasma based propulsion devices, plasma based particle accelerators etc. A host of simulation models and techniques such as gyro-kinetic and gyro-fluid models, MHD models, fluid and PIC simulations were discussed. This conference was supported by IPR, DAEBRNS and SERB.

Vikram Sarabhai Centenary National Science Day

In the centenary year of the founder of Department of Atomic Energy, IPR celebrated the Vikram Sarabhai Centenary National Science Day during 1-2 February 2020 at the IPR main campus with immense amount of enthusiasm. The event was inaugurated by Director, IPR Dr. Shashank Chaturvedi and Mr Ravi Shankar, AGM, SBI Regional Business Office-1, Gandhinagar. The centenary event had several posters and videos on Dr. Vikram Sarabhai on display. Over 900 students and teachers from both urban and rural schools across Gujarat participated in this event. The NSD also had competitive live events like Quiz, Eloquence, Skit as well as science exhibits by schools and by IPR staff, in collaboration with the BSc Physics students of St. Xavier's College, Ahmedabad. Offline competitions like poster and essay writing were conducted for the school students in the month of December. In the competition organized for school teachers for innovative teaching aids, Shri H. K. Gohil of Kalapi Vinay Mandir, Lathi, won the first prize. This event had over 3000 visitors visiting IPR during the two days to see the exhibition and open house. The concluding session was held on 3rd February where the prizes for the various competitions were given out by Dean R&D, Dr. P.K. Atrey. Some of the schools that won prizes in multiple events are Poddar International School, Ahmedabad, Saint Mary School, Amreli, Divyapath Science School, Ahmedabad, GK Dholakiya School, Rajkot, New Era Senior Secondary School, Vadodara etc

National Science Day @ CPP-IPR

National Science Day was celebrated at CPP-IPR on 28th February, 2020. About 350 students and teachers from 20 different schools nearby participated in various events organized at CPP-IPR. Four competitions were organized for the participating students, viz., Quiz competition, Science Model competition, Extempore and Drawing competition. The day-long program was inaugurated by Prof. B. K. Saikia, Acting Centre Director. The occasion was graced by Prof. B. Bhattacharjee, HOD, Dept. of Physics, Gauhati University, as Chief Guest, who addressed the gathering and encouraged the students to have a scientific temperament. Dr. M. Dey, retired Scientist of CPP-IPR also interacted with the students and delivered a talk on the life and works of Dr. Vikram Sarabhai. Posters and audio-visual presentations were displayed featuring various activities of the institute along with the theme ('Women in Science') of this year's science day.

3-Day GPU Bootcamp @ IPR

Graphics Processing Units (GPUs) offer high performance and massive parallelization but writing scientific applications/ codes to fully exploit the performance of GPUs can be a very challenging and difficult task. To help IPR HPC users to reduce the barrier to run their codes on GPU nodes of ANTYA HPC Cluster, IPR Computer Division partnered with NVIDIA and held its first GPU Bootcamp from 12th -14th February 2020 at IPR. 40 participants which included employees, PhD scholars and PDFs attended the Bootcamp. The first day was open for all those with no previous experience with OpenACC directives or GPU programming, and the last two days were only for registered IPR teams with one code per team. On the first day, participants were introduced to available libraries, programming models, and platforms and learned the basics of GPU programming through extensive hands-on sessions based on sample codes using the OpenACC programming model. A number of good quality codes (serial as well as parallel) spanning Computational Fluid Dynamics (CFD), Molecular Dynamics (MD) and Particle-in-Cell (PIC) domains were received for the event. On 2nd – 3rd days, 7 teams out of 13 registered teams, each comprising of 3-5 members worked alongside NVIDIA mentors with GPU-programming expertise. IPR teams primarily gained knowledge and expertise about GPU programming and applied that knowledge to port and accelerate their scientific codes on ANTYA GPU nodes. The participants were benefited in the following ways;

• Learned to profile their codes to find performance bottlenecks or hotspots.
• Gained foundation skills of OpenACC which can be applied to the full code.
• With the help of experienced Mentors, some team members got different insights into their code which helped them in restructuring their code.
• Out of 7 codes, 6 codes were successfully ported on GPUs and some of them even achieved speedup. The code which could not be ported required restructuring and will be ported after resolving the legacy issues in the code.

Around 40 IPR staff who participated in this boot-camp got to learn the potential gains of porting their computational work to GPUs.

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F. OTHER ACTIVITIES

F.1 Outreach

• As part of the outreach programme, over 1100 students and 60 faculty from 26 different educational institutions have visited IPR during this period. They were shown various labs in IPR main campus, FCIPT and extension labs. Visitors included students and faculty from engineering & science colleges and schools from Ahmedabad and other cities/towns of Gujarat and neighboring states, and also from ISRO.

• ***IPR participated in the following exhibitions/Events organized/Supported by DAE as well as those organized by other institutions***

o DAE-CII event "Paramanu Expo-2019" at Anushakti Nagar, Mumbai on 17-June-2019

o Scientific Outreach, interaction with plus 2 science students at Ramseth Thakur Public School at Kharghar, Navi Mumbai on 18th June, 2019

o DAE-NJU Workshop and Exhibition at RAPS, Rawatbhata during 5-9 August, 2019

o Dr. Vikram Sarabhai Centenary Exhibition at Ahmedabad on 12th Aug, 2019

o "TARANG 2K19-Space Science Fest" held at the LD College of Engineering, Ahmedabad on 30th August, 2019.

o Dr. Vikram Sarabhai Centenary Celebration programme organized by DAE at the DAE Convention Centre, Anushakti Nagar, Mumbai during 17-18 October, 2019

o "JIGYASA-2019" Scientific Outreach activity event which was organized by "UMNESH Gyan Vigyan Vichar Sangathan" and supported by DAE Outreach during 02-03 December 2019 at Government Science College, Jabalpur (MP) .

o Scientific Outreach activity on plasma science & technology at R.K. University, Rajkot on 2-Dec, 2019

o 107th Indian Science Congress, "Pride of India" exhibition, Bengaluru, 3-7 January, 2020.

o Vikram Sarabhai Centenary National Science Day was organized at IPR on 1-2 February, 2020. Over 900 students, teachers ~ 3000 visitors participated in the event.

o 34th Gujarat Science Congress, Ganpat University, Mehsana during 8-9 February, 2020.

o 2-day "Awareness Programme on Plasma Science & Technology & Energy from Nuclear Fusion" at M G Science College, Ahmedabad during 13-14 February, 2020.

• Conducted the ITER week event at the "Vigyan Samagam", Megascience exhibition organized by DAE, DST and NCSM, at the following venues with popular talks and hands-on experiments on plasma and its applications.

o Nehru Science Center, Mumbai, 20-26 May, 2019

o Viswesvaraya Industrial and Technological Museum, Bengaluru, 20-24 August, 2019

o Science City, Kolkata, 12-16 November, 2019

o National Science Center, new Delhi, 03-07 March, 2020

• ***Generated the following touch-interactive content for use at the upcoming technology exhibition center at IPR***

o Various units of DAE with detailed, interactive information
o Various technologies developed by IPR
o Touch screen based quiz on plasma for student visitors.

•Technology exhibition-cum-visitors hands-on experiments hall was set up in IPR to facilitate educational visits to IPR.


NFC
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IPR


ITER-India

F.2 Official Language Implementation

For the smooth implementation of the Official Language continuous efforts are being made in the Institute. While complying with the Official Language policy many achievements were obtained during this period.

The details of the Official language activities completed during this period are as follows:

• Hindi Quarterly / Half Yearly Progress Reports were sent to the Department of Atomic Energy and Town Official Language Implementation Committee, Gandhinagar. All the quarterly reports were submitted online at the portal of the Department of Official Language.

• On 26 April 2019 the Deputy Director, Regional Implementation Office, Mumbai visited IPR for inspection of progressive use of Hindi of the Institute. During the inspection, the Deputy Director appreciated the Official Language implementation in the institute and Gave suggestions for further progress.

• The 13th Half-yearly meeting of TOLIC, Gandhinagar was held on October 16, 2019 at the premises of Institute for Plasma Research. Dr. Susmita Bhattacharya, Deputy Director (Implementation) - Department of Official Language, Ministry of Home Affairs, Regional Implementation Office - Mumbai, Shri Pankaj M. Jani, Chairman, TOLIC and Head, Baroda Apex Academy, Gandhinagar and the Head, Chief representative, Hindi officer and Hindi in-charge of the Central Government Offices / Banks located at Gandhinagar, were present in this meeting.

• The institute has always been playing an active role in the TOLIC, gandhinagar activities. This year, under the auspices of TOLIC, Gandhinagar, the institute organized an online crosswords competition on 6 August 2019. A total of 33 officers / employees from member offices / banks of TOLIC, Gandhinagar participated in this competition.

• *Hindi Seminar:* One day Hindi Seminar on Technical / Scientific subject was organized by the Official Language Implementation Committee of IPR on May 7, 2019. Total 11 power point presentations on various technical / scientific subjects were presented. On this occasion, the Inter-sectional Official language Running Shield for the excellent work in the field of Official Language for the last Half yearly(July-December, 2018), has been awarded to the Accounts Section. As a result of the efforts of Accounts Section, all the Tally Software vouchers are being generated in Hindi, which is a special achievement.

• *Hindi Pakhwada Celebration:* The Hindi Pakhwada Celebration was celebrated from 3rd September 2019 to 17th September 2019 at the Institute. Total 11 competitions were organized during this period - slogan writing, essay writing, Hindi typing, Noting and translation, Technical/ Administrative article writing, quiz, Chaay par charcha, News reading, Debate, Extempore and Self-composed poem recitation. Total 160 employees participated in these competitions.

• *Hindi Talk*: A talk on the activities of Oil and Natural Gas Corporation Limited (ONGC) was delivered by Dr. Umesh Pandey, General Manager ONGC, Ahmedabad on August 8, 2019.

• *Hindi Inspection*: Hindi Inspection of Administration – III regarding implementation of Official Language policy was done by Hindi Inspection committee on 6th November, 2019 and the review report was submitted to Director.

• *World Hindi Day Celebration*: On the occasion of World Hindi Day Celebration, Dr. BS Munjal, Scientist/Engineer, Space Application Centre, ISRO, Ahmedabad was invited for Hindi Speech on January 10, 2020. Dr. BS Munja expressed his views on "Hindi ki duniya - Ek kavi, shaayar aur kalakaar ke andaaz me…" After the talk, a Hindi quiz competition was organized for the members of the institute.

• *ATOLIS incentive scheme*: Under the ATOLIS incentive scheme of the DAE, all the three incentive schemes has been implemented in Institute from 1st April, 2019. Employees/ officers are enthusiastically participating in this incentive scheme for doing official work in Hindi and are receiving cash prizes.

• *Hindi Training*: The Institute puts sincere efforts towards Hindi training of the employees. During the financial year 4 candidates qualified Hindi Pragya exam and two employees qualified for Hindi Typing exam under Hindi Teaching Scheme, Ahmedabad.

• *Hindi Workshop*: During this year, in every quarter a Hindi workshop was organized to train employees to work in Hindi. The employees were introduced to the constitutional

provisions related to the Official Language Policy, Official Language Rules etc. Training was given for working in Hindi on computer and also made them familiar about Hindi software, voice typing, text to speech tools etc. Desktop to desktop workshops were also conducted. The Hindi language was activated in the newly installed computers and the employees were introduced to Hindi e-tools of the Department of Official Language.

• *Hindi Magazine*: The 27th issue of Plasma Jyoti, Hindi home magazine of the institute was published in this financial year.

• *Translation work:* Translation work of annual reports, activity reports, contents received from DAE, documents, letters, forms etc. received from different sections were completed.

• Hindi Officer participated in training program conducted by DAE at AMD, Hyderabad from 16th November– 18th November, 2019.

• During 27 - 31 January 2020 a Faculty Development Program for Hindi Officers of various units was organized by Administrative Training Institute (ATI), Department of Atomic Energy, Mumbai, in which as an invited speaker Dr. Suryakant Gupta Scientific Officer-G, IPR, delivered a talk on IPR activities and later discussed in detail.

• National Science Day: On the occasion of Vikram Sarabhai National Science Day on February 1 & 2, 2020 various competitions like Science skit, Science model, quiz, essay writing, speech, posters etc. were conducted for all over Gujarat state school students in English, Hindi and Gujarati languages.

• National Safety Week: During the National Safety Week held in March 2020, the slogan writing and essay writing competition was conducted in Hindi also.

• Achievements:

Achievements at TOLIC, Gandhinagar level: Institute for Plasma Research was awarded first prize with shield & certificates for the year 2018 for best performance in the field of Official Language at the 12th half yearly meeting of TOLIC, Gandhinagar, held on April 26, 2019 at Baroda Apex Academy, Gandhinagar. Ms. Pratibha Gupta, Scientific Officer-F has been awarded 1st prize (Rs. 5,000) & Mrs. Shilpa Khandkar, Scientific Assistant - C has been awarded 2nd prize (Rs.2,500) in Essay Competition organized by NIFT, Gandhinagar under the auspices of TOLIC, Gandhinagar. Mr. Vrishank Mehta, Scientific Officer-D was awarded 2nd prize and Mr. Himanshu Tyagi, Scientific Officer-D was awarded with Consolation prize in GK quiz competition organized by Directorate of Census, Gandhinagar. Ms. Hiral Joshi bagged 2nd prize in Hindi Extempore competition organized on 10 July 2019 by Headquarters Coast Guard Region. Ms. Jyoti Agarwal has been awarded 2nd prize in online crosswords competition organized by Institute under the auspices of TOLIC, Gandhinagar. Mr. Kaushalendra Singh has bagged 2nd prize for the poetry competition organized on 25th September 2019 by Kendriya Vidyalaya Sangathan, Gandhinagar. Mr. Anuj Kumar Garg has bagged First prize & Mr. Rajinikant Bhatasana bagged Consolation prize in Official Language Policy Hindi Quiz Competition organized on 27 September 2019 by Headquarters Coast Guard Region.

• For promoting Rajbhasha in official work, IPR has been presented the following awards by the DAE at the 20th DAE All India Official Language meet held at Atomic Minerals Directorate for Exploration and Research (AMD), Hyderabad on 15th November, 2019.

1. Official Language Shield (Runner Up) in Aided Institute Category of DAE for the year 2018-19.

2. Best Official Language Magazine Award in Aided Institute Category of DAE for the year 2018-19

3. Dr. Praveen Kumar Atrey, Dean (R & D) & Scientific Officer – H and Shri Harish Chandra Khanduri, Administrative Officer-1 have been awarded with Hindi Sevi Sammaan Puraskar for the year 2018-19 with a memento by the Department of Atomic Energy for their excellent and creative contribution in the propagation of Hindi.

• IPR Science skit 'Vigyan Manthan' received Best Entertainment skit award in science skit competition in Hindi held among various units of Department of Atomic Energy at Anushaktinagar, Mumbai during All India Hindi Vigyan Sammelan organized by Hindi Vigyan Sahitya Parishad, Bhabha Atomic Research Center, Mumbai from 28-30 November 2019.

The Institute is thus continuously making efforts for promoting the use of Hindi language among its staff members

and in communication with other institutes/offices.

F.3 Right To Information

During the report period 2019-20, a total of 63 RTI applications were received, out of which 53 were of new RTI Application, while the other 10 were of Appeal nature. All of them have been disposed off by the Public Information Officer and Appellate Authority concerned within the prescribed time-limit.

F4 Other Activities at Campus

Yoga Day @ IPR

International Day of Yoga, or commonly and unofficially referred to as Yoga Day, is celebrated annually on 21 June since its inception in 2015. IPR celebrated this event on 21 June 2019 by organizing a yoga session in the lawns of IPR campus. Many of the IPR staff participated in the event where a yoga expert Mr. Vivek Sharma (Art of Living) conducted the session for the benefit of IPR staff.

"Swachhta Hi Seva" (SHS) Campaign-2019 @ IPR

"Swachhta Hi Seva (SHS) Campaign, 2019 was observed at IPR and its different campuses during 11th September to 2nd October 2019 with great zeal and enthusiasm. This initiative is a program of the Government of India to promote cleanliness. As part of this drive, IPR staff were motivated to clean their offices and laboratory spaces and also clear away plastic and other unwanted materials. All employees of IPR were effectively involved in mass cleaning activities during this campaign. Extensive drive has been done for cleaning of all the offices, laboratories, canteens, guest houses, kitchens, and lavatories for the removal of unwanted items (plastic, paper, metal, non-metal, and different other waste). Various posters, banners, slogans were displayed on notice boards and in various other location of IPR, showing importance of cleanliness during this campaign. A seminar on "Swachhata Hi Seva (SHS) Campaign - 2019" also has been conducted at IPR. Several action plans also have been undertaken to continue this Swachhta Hi Seva (SHS) Campaign, 2019

Vigilance Awareness Week 2019

As a part of observance of Vigilance Awareness Week 2019 (28th October – 2nd November 2019), the Integrity Pledge was taken by IPR staff on 30th October 2019 at 11.00 AM, with Dr. Shashank Chaturvedi, Director, and Dr. Anita V.P. CVO leading the pledge. Shri Niranjan Kumar, Integrated Finance Adviser, Indian Defence Accounts Service (IDAS), HQ Southern Command, Pune, gave a talk on the theme "Integrity - a way of life" on 1st November 2019 at Seminar Hall, IPR. Shri A. E. Harvey gave a talk on "Vigilance, Integrity and Conduct Rules" at IPR on 6th November 2019 followed by a Quiz Competition. A small video demonstration also was presented by the CVO, IPR.

49th National Safety Week – 2020 @ IPR

The 49th National Safety Week was celebrated at IPR from 4-10 March 2020. The institute organized various competitions during this week to create safety awareness among its employees. Competitions were organized on Slogan in Gujarati, Hindi & English, Safety Poster, Quiz and Essay Writing in Gujarati, Hindi & English based on decided themes for the employees of IPR, FCIPT & ITER-India. Demonstration of various fire fighting equipment was conducted for employees as well as security personnel at IPR. Overwhelming response was received from the employees for various competitions. Concluding Session organised on 9th March. Shri Devendra Modi gave the welcome address which was followed by a talk on "Effect of RF and Microwave Radiations on Human Body- Facts and Fictions" by Shri Raj Singh. Dr. P.K. Atrey, Dean (R&D) read out the Safety Message on behalf of Director, IPR. It emphasised that individual contributions are needed to take care of your own safety that of your colleagues and other stake holders. He highlighted that safety is about doing the right thing, even if no one is looking. He also congratulated the winners of various competitions as well as best safety coordinators of IPR. Prizes were also distributed to them. Dean (R&D) also administered the Safety Pledge. Shri D. Modi conducted a Safety Quiz for audience. Shri Sunil Kumar, Chairman-Safety Committee gave the vote of thanks.

Observance of Swachhta-Pakhwada @ IPR

"Swachhta-Pakhwada" was observed at IPR during 16-28 February, 2020. This is observed by all Government establishments including all DAE establishments. As part of this drive, All IPR staff members were actively participated in this drive. Activities carried out during the Swachhta Pakhwada include;

• Removal of all unwanted waste items collected from offices, laboratories and various open spaces of the institute, segregated and disposed off them properly.
• Survey of all the offices, laboratories, canteens, guest houses, kitchens, and lavatories to check proper cleaning and waste disposal.

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Audited Statements of Accounts as on 31st March 2020

INSTITUTE FOR PLASMA RESEARCH

Registration No.GUJ/88/GANDHINAGAR

CA N. B. SHAH, B. Com., F.C.A.
CA T. N. SHAH, B. Com., F.C.A., DISA

T. N. Shah & Co.
CHARTERED ACCOUNTANTS
PHONE : +91 079 23222152
Fax : +91 079 23241432
Firm Reg. No. 109802/w
C. & A. G. Reg. No. WR/0534
Email : tnshahincometax@gmail.com

INDEPENDENT AUDITOR'S REPORT

Report on the Financial Statements

1. We have audited the attached Balance Sheet of **INSTITUTE FOR PLASMA RESEARCH, BHAT, GANDHINAGAR – 382 428** as at 31st March 2020, Income & Expenditure Account and also Receipts and Payments Account for the year ended on that date thereto.

Management's Responsibility for the Financial Statements

2. These Financial Statements are the responsibility of the Institute's management. This responsibility includes the design, implementation and maintenance of internal control relevant to the preparation and presentation of the financial statements that give a true and fair view and free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

3. Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirement and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement. An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the Institute's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by management, as well as evaluating the overall presentation of the financial statements. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Opinion

4. In our opinion and to the best of our information and according to the explanations given to us, the financial statement give the information required by the Act in the manner so required and give a true and fair view in conformity with the accounting principles generally accepted in India:

   (a) In the case of Balance Sheet, of the state of affairs of the Institute as at 31st March, 2020;

   (b) In the case of the Income & Expenditure Account, of the excess of Income overExpenditure for the year ended on that date;

   (c) In the case of the Receipts and Payments Account, of the receipt and payments for the year ended on that date.

For T.N.Shah& Co.,
Chartered Accountants
Firm Registration No.109802/W

(TusharN.Shah)
Partner
Membership No.042748
UDIN :20042748AAAAIT9815

Place: Gandhinagar
Date:21/08/2020

T. N. SHAH & CO. GANDHINAGAR T. N. SHAH CHARTERED ACCOUNTANTS M.NO. 42748

INSTITUTE FOR PLASMA RESEARCH,
BHAT, GANDHINAGAR- 382 428
(Sponsored by Dept. of Atomic Energy, Govt. of India, Mumbai)
Registration No.GUJ/88/GANDHINAGAR

CONSOLIDATED BALANCE SHEET AS AT 31ST MARCH, 2020

CORPUS/CAPITAL FUND AND LIABILITIES	SCH.	2019-2020	2018-2019
CORPUS/CAPITAL FUND	1	6,81,51,49,605.00	5,99,27,03,773.00
RESERVES AND SURPLUS	2	21,13,18,18,650.00	18,41,89,10,816.00
EARMARKED/ ENDOWMENT FUNDS	3	41,26,17,103.00	38,22,51,748.00
CURRENT LIABILITIES AND PROVISIONS	4	4,52,97,59,463.00	2,97,52,74,041.00
TOTAL		**32,88,93,44,821.00**	**27,76,91,40,378.00**

ASSETS			
FIXED ASSETS	5	10,51,14,54,405.00	10,03,26,27,977.00
CURRENT ASSETS, LOANS, ADVANCES ETC.	6	22,37,78,90,416.00	17,73,65,12,401.00
TOTAL		**32,88,93,44,821.00**	**27,76,91,40,378.00**
Excess of Income over Expenditure		-	-
SIGNIFICANT ACCOUNTING POLICIES	13		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	14		

As per our report of even date attached.

For T N Shah & Co
Chartered Accountants
Firm Registration No.109802/W

-Sd-	-Sd-	-Sd-	-Sd-
(Dr.Shashank Chaturvedi)	**(Dr. Shishir Deshpande)**	**(Falguni Shah)**	**(Tushar N Shah)**
Director	Dean	Accounts Officer-I	Partner
			Membership No.042748

Place : Gandhinagar
Date :17/08/2020

INSTITUTE FOR PLASMA RESEARCH,
BHAT, GANDHINAGAR- 382 428
(Sponsored by Dept. of Atomic Energy, Govt. of India, Mumbai)
Registration No.GUJ/88/GANDHINAGAR

INCOME AND EXPENDITURE ACCOUNT FOR THE PERIOD ENDED ON 31ST MARCH, 2020

A.INCOME	**SCH.**	**2019-2020**	**2018-2019**
Grants- Department of Atomic Energy, Govt. of India	7	8,40,20,00,000.00	6,74,79,00,000.00
Interest Earned	8	12,74,22,420.00	16,79,17,587.00
Other Income	9	19,40,092.00	72,90,203.00
Profit on sale of Assets		-	-
TOTAL (A)		**8,53,13,62,512.00**	**6,92,31,07,790.00**
B. EXPENDITURE			
Establishment Expenses (Including Retirement Benefit Provision)	10	3,02,84,86,460.00	1,57,61,90,877.00
Other Administrative Expenses	11	66,20,02,437.00	76,18,07,199.00
Depreciation & Ammortisation of Intengible Assets	12	49,67,02,900.00	44,88,47,645.00
Less : Transfer from Corpus/Capital Fund		-49,67,02,900.00	-44,88,47,645.00
Loss on Disposal of Capital Assets/ Write off		35,65,634.00	-14,18,606.00
Cash Contribution to ITER IO		46,46,14,840.00	97,08,90,000.00
TOTAL (B)		**4,15,86,69,371.00**	**3,30,74,69,470.00**
Balance being excess of Income over Expenditure/ (Excess of Expenditure over Income)		4,37,26,93,141.00	3,61,56,38,320.00
Transfer to Corpus Fund for addition to Movable & Immovable Properties		1,32,32,79,396.00	45,76,83,113.00
Transfer From Corpus Fund for w/off to Movable & Immovable Properties		41,30,664.00	39,74,256.00
Transfer to Iter-India Fund (Interest Earned)		4,32,81,471.00	6,08,94,113.00
Transfer to/from unspent Grant A/c		3,01,02,62,938.00	3,10,10,35,350.00
SIGNIFICANT ACCOUNTING POLICIES	13		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	14		

As per our report of even date attached.
For T N Shah & Co
Chartered Accountants
Firm Registration No.109802/W

-Sd-	-Sd-	-Sd-	-Sd-
(Dr.Shashank Chaturvedi)	**(Dr. Shishir Deshpande)**	**(Falguni Shah)**	**(Tushar N Shah)**
Director	Dean	Accounts Officer	Partner
			Membership No.042748

Place : Gandhinagar
Date :17/08/2020

INSTITUTE FOR PLASMA RESEARCH, (Conso)

BHAT, GANDHINAGAR- 382 428

(Sponsored by Dept. of Atomic Energy, Govt. of India, Mumbai)

Registration No.GUJ/88/GANDHINAGAR

RECEIPTS AND PAYMENTS FOR THE PERIOD ENDED ON 31ST MARCH, 2020

RECEIPTS	2019-20	2018-19	PAYMENTS	2019-20	2018-19
I. Opening Balances			**I. Expenses**		
a) Cash in hand	15,894.00	66,033.00	a) Establishment Expenses	1,43,86,59,262.00	1,24,82,75,638.00
b) Bank Balances			b) Administrative Expenses	66,20,43,124.00	76,07,43,734.00
i) In Current accounts	21,15,85,658.00	2,14,07,518.00	c) Interest earned transferred to DAE	33,69,01,575.00	1,04,69,70,250.00
ii) In deposit accounts	1,69,74,85,386.00	3,33,88,40,403.00	d) Cash Contribution to ITER-IO	46,46,14,840.00	97,08,90,000.00
iii) Savings accounts	1,75,92,111.00	2,49,73,430.00			
II. Grant Received			**II. Exp. on Fixed Assets, Cap. WIP & Others**		
a) From Govt. of India- DAE	8,40,20,00,000.00	6,74,79,00,000.00	a) Purchase of Fixed Assets & other exp.	55,33,78,456.00	42,32,23,712.00
			b) Expenditure on Capital WIP	42,62,81,541.00	14,95,96,614.00
III. Interest Received			**III. Refund of Surplus money/Loans**		
a) On Bank Deposits	12,46,41,702.00	17,51,68,715.00	a) Deposits with Government Auth. & Suppliers/Security Deposits	55,13,458.00	36,54,413.00
b) Loans, Advances etc.	13,78,554.00	8,88,001.00	b) Payments against Earmarked Funds	8,02,35,583.00	9,73,83,094.00
c) Int on I.T Refund	26,194.00	1,57,187.00			
IV. Other Income			**IV. Other Payments (Specify)**		
Misc Income	12,23,882.00	31,15,278.00	a) Advances to Contractors & Suppliers (Including Adv. for Capital Works)	5,29,52,33,592.00	3,64,76,46,005.00
Royalty & Transfer Fee Income	7,10,528.00	41,74,925.00	b) Deposits with Government Auth.		-
		-	& Suppliers / Security Deposits		
			c) Stock (Change in closing Bal.)	-	10,86,326.00
			d) Security Deposits	4,04,39,683.00	-
V. Any Other receipts			e) Payment of LT Advances to Empl.	65,57,685.00	1,75,000.00
Amount received for Earmarked/Endowment Funds	9,35,91,269.00	10,39,63,999.00	f) Others	1,30,18,316.00	63,77,65,588.00
Stock (Change in closing Bal.)	30,56,291.00	-			
Security Deposits	1,59,16,391.00	2,56,06,370.00	a) Cash in hand	69,740.00	15,894.00
Others	1,00,45,275.00	46,63,98,638.00	b) Bank Balances		
Receipt of LT Advances to Empl.	24,83,800.00	13,83,775.00	i) In Current accounts	6,87,69,515.00	21,15,85,658.00
Sale of Capital Assets	5,40,276.00	45,151.00	ii) In deposit accounts	1,18,77,41,891.00	1,69,74,85,386.00
			iii) Savings accounts	28,34,950.00	1,75,92,111.00
TOTAL	**10,58,22,93,211.00**	**10,91,40,89,423.00**	**TOTAL**	**10,58,22,93,211.00**	**10,91,40,89,423.00**
				-	-

As per our report of even date attached.

For T N Shah & Co.,
Chartered Accountants
Firm Registration No.109802/W

-Sd-	-Sd-	-Sd-	-Sd-
(Dr.Shashank Chaturvedi)	**(Dr. Shishir Deshpande)**	**(Falguni Shah)**	**(Tushar N Shah)**
Director	Dean	Accounts Officer-I	Partner
			Membership No.042748

Place : Gandhinagar
Date :17/08/2020

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2020

PARTICULARS	2019-20		2018-19	
SCHEDULE 1 - CORPUS/CAPITAL FUND :				
Balance as at the beginning of the year		5,99,27,03,773.00		5,98,78,42,561.00
Add : Contribution towards Corpus/Capital Fund	1,32,32,79,396.00		45,76,83,113.00	
Less : Adjustement to Fixed Assets In-Kind Support from External Agencies/Adjustment to Unspent Grant			-	
Adjustment to Unspent Grant			-	
(Deduct) : Depreciation & Ammortisation charged on Capital Assets for FY 2017-18 transferred to Income & Expenditure A/c	(49,67,02,900.00)		44,88,47,645.00	
			-	
Addition/Deduction in Fixed Assets during the year (transfer to/from I & E Account)	41,30,664.00	82,24,45,832.00	39,74,256.00	48,61,212.00
BALANCE AS AT 31ST MARCH, 2020		**6,81,51,49,605.00**		**5,99,27,03,773.00**
SCHEDULE 2 - RESERVE AND SURPLUS :				
1. Unspent Grant : *				
a) As per last Account	18,35,80,16,703.00		15,54,83,81,353.00	
Add : Adjustment from Corpus Fund			-	
Addition/Deduction during the year (transfer to/from I & E A/c)	3,01,02,62,938.00		3,10,10,35,350.00	
Addition/Deduction during the year (transfer to/fromCorpus Fund)	(37,35,000.00)		(29,14,00,000.00)	
Less : Previous year interest income traf to DAE	(27,60,07,462.00)	21,08,85,37,179.00		18,35,80,16,703.00
2. Interest earned on Unspent Grant (ITER INDIA FUND):				
As per last Account	6,08,94,113.00		1,04,69,70,252.00	
Addition during the year (transfer from I & E A/c)	4,32,81,471.00		6,08,94,113.00	-
Deduction during the year (Balance of Interest Earned Transferred to DAE)	6,08,94,113.00	4,32,81,471.00	1,04,69,70,252.00	6,08,94,113.00
BALANCE AS AT 31ST MARCH, 2020		**21,13,18,18,650.00**		**18,41,89,10,816.00**

* Note:
Against Unspent Grant of Rs.2108.85 Crore at year end contain Advance to Suppliers towards ITER - India Projects Rs.2078.84 Crore

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2020

SCHEDULE-3A - ENDOWMENT FUND

Dr.Parvez Guzdar Memorial Endowment Fund	**2019-2020**	**2018-2019**
a) Opening Balance of the fund	6,01,116	6,20,580
b) Additions to the Funds		
i. Donation/Grants		
ii. Income from Investments made on account of fund	12,325	30,536
iii. Other additions		
TOTAL (a+b)	**6,13,441**	**6,51,116**
c) **Utilisation/Expenditure towards objectives of the fund**		
i. Revenue Expenditure		
Dr.Parvez Guzdar Memorial award for Plasma physics	50,000	50,000
ii. Capital Expenditure		
TOTAL (c)	**50,000**	**50,000**
NET BALANCE AS AT THE YEAR END (a+b-c)	**5,63,441**	**6,01,116**

Represented by

Cash And Bank Balance	13,441	1,116
Investments - FD with SBI	6,00,000	6,00,000
Interest Accrued but not due	-	-
	6,13,441	**6,01,116**
CURRENT YEAR (2019-2020)	-50,000.00	-

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2020

		SCHEDULE 3B - EARMARKED/ ENDOWMENT FUNDS :	a) Opening Balance of the fund 01-04-2019	b) Additions to the Funds	TOTAL (a+b)	c)Utilisation/ Expenditure towards objectives of funds	NET BALANCE AS AT 31ST MARCH, 2020 (a+b-c)	NET BALANCE AS AT 31ST MARCH, 2019
		FUND-WISE BREAK UP						
		Earmarked Fund						
1	9981	Plasma Processing Fund	2,73,61,721.00	-	2,73,61,721.00	2,73,61,721.00	-	2,73,61,721.00
2	ITER	Iter India Fund - Surplus On Task	35,21,49,526.00	1,78,68,225.00	37,00,17,751.00	-	37,00,17,751.00	35,21,49,526.00
		Sub Total (a)	**37,95,11,247.00**	**1,78,68,225.00**	**39,73,79,472.00**	**2,73,61,721.00**	**37,00,17,751.00**	**37,95,11,247.00**
		Sponsored Projects						
1	9106	BRNS - EPIA - AD	38,876.00		38,876.00	-	38,876.00	38,876.00
2	9109	TIFAC - EMF	3,20,782.00	-	3,20,782.00	-	3,20,782.00	3,20,782.00
3	9204	DST - DADD	96,097.00	-	96,097.00	-	96,097.00	96,097.00
4	9213	SPACE-DEBRIS Research	2,498.00	-	2,498.00	-	2,498.00	2,498.00
5	9222	BRNS-SRC-OIA-SP	30,01,566.00	-	30,01,566.00	-	30,01,566.00	30,01,566.00
6	9224	INSA Senior Scientist Position	(2,915.00)	5,75,960.00	5,73,045.00	4,39,741.00	1,33,304.00	(2,915.00)
7	9226	IPR-DDT-TBRL	6,50,198.00	40,452.00	6,90,650.00	6,80,140.00	10,510.00	6,50,198.00
8	9308	FCIPT-SPIX-II	17,15,624.00	-	17,15,624.00	17,15,624.00	-	17,15,624.00
9	9309	FCIPT-DU-CDPS	1,11,345.00	-	1,11,345.00	-	1,11,345.00	1,11,345.00
10	9310	FCIPT-DU-PPNS	5,15,047.00	-	5,15,047.00	4,00,857.00	1,14,190.00	5,15,047.00
11	9311	FCIPT-DU-WGPS	8,16,921.00	-	8,16,921.00	-	8,16,921.00	8,16,921.00
12	9320	FCIPT-EXCEL	1,89,787.00	-	1,89,787.00	-	1,89,787.00	1,89,787.00
13	9335	FCIPT MOEF	3,61,582.00	-	3,61,582.00	2,200.00	3,59,382.00	3,61,582.00
14	9339	VSSC-MoU-IPR	89,083.00	-	89,083.00	-	89,083.00	89,083.00
15	9340	FCIPT-IIT-Indore	2,01,415.00	-	2,01,415.00	-	2,01,415.00	2,01,415.00
16	9345	FCIPT-DST-RAD	19,647.00	589.00	20,236.00	-	20,236.00	19,647.00
17	9347	FCIPT-DST-TEX	2,92,234.00	-	2,92,234.00	92,800.00	1,99,434.00	2,92,234.00
18	9348	FCIPT-AMRITA	3,73,504.00	-	3,73,504.00	1,02,119.00	2,71,385.00	3,73,504.00
19	9349	FCIPT-NPN	43,95,258.00	72,411.00	44,67,669.00	20,43,685.00	24,23,984.00	43,95,258.00
20	9350	FCIPT-MSU	1,82,980.00	-	1,82,980.00	-	1,82,980.00	1,82,980.00
21	9352	FCIPT-IISUPNS	38,93,289.00	-	38,93,289.00	22,90,137.00	16,03,152.00	38,93,289.00
22	9355	FCIPT-LXM	2,55,885.00	-	2,55,885.00	-	2,55,885.00	2,55,885.00
23	9357	FCIPT-AAU-DBD	3,39,563.00	-	3,39,563.00	-	3,39,563.00	3,39,563.00
24	9358	FCIPT-ABREF	1,00,847.00	-	1,00,847.00	7,316.00	93,531.00	1,00,847.00
25	9359	FCIPT - APPJIITK	70,473.00	45,000.00	1,15,473.00	18,090.00	97,383.00	70,473.00
26	9361	FCIPT-VEGPL	12,773.00	-	12,773.00	-	12,773.00	12,773.00
27	9362	FCIPT-DST-SOLVENT	1,21,999.00	3,660.00	1,25,659.00	-	1,25,659.00	1,21,999.00
28	9363	FCIPT-NPCIL	43,068.00	3,00,000.00	3,43,068.00	46,321.00	2,96,747.00	43,068.00
29	9364	FCIPT-IITGN-INP	8,73,113.00	-	8,73,113.00	1,79,547.00	6,93,566.00	8,73,113.00
30	9365	FCIPT-PSED-SERB-CZTS	23,43,030.00	5,85,027.00	29,28,057.00	27,08,632.00	2,19,425.00	23,43,030.00
31	9366	Dr. Ashish Adak-SERB	-2,24,031.00	8,34,389.00	6,10,358.00	4,29,000.00	1,81,358.00	(2,24,031.00)
32	9367	FCIPT CIPET	20,52,034.00	-	20,52,034.00	10,62,590.00	9,89,444.00	20,52,034.00
33	9368	Dr. Amreen Ara Hussain-DST Inspire	14,12,802.00	25,22,378.00	39,35,180.00	16,49,704.00	22,85,476.00	14,12,802.00
34	9369	AOARD	16,16,960.00	21,09,510.00	37,26,470.00	14,92,164.00	22,34,306.00	16,16,960.00
35	9370	CPIS-SAC-CP	-	30,18,043.00	30,18,043.00	7,56,487.00	22,61,556.00	-
36	9371	ARMREB-DRDO	13,20,961.00	2,58,981.00	15,79,942.00	1,13,270.00	14,66,672.00	13,20,961.00
37	9372	FCIPT-PSED-SU	4,10,000.00	4,10,540.00	8,20,540.00	5,44,833.00	2,75,707.00	4,10,000.00
38	9373	FCIPT-PSED-NU	1,35,393.00	-	1,35,393.00	10,705.00	1,24,688.00	1,35,393.00
39	9375	IPR-AAU-VS	-	4,35,000.00	4,35,000.00	3,28,177.00	1,06,823.00	-
40	9376	FCIPT-SPIX-III	-	1,51,65,624.00	1,51,65,624.00	1,80,738.00	1,49,84,886.00	-
41	9377	FCIPT-VSSC	-	45,00,000.00	45,00,000.00	28,910.00	44,71,090.00	-
42	9379	FCIPT-APD-NSSPL	-	3,25,000.00	3,25,000.00	-	3,25,000.00	-
43	9380	FCIPT-APD-BN	-	18,50,000.00	18,50,000.00	-	18,50,000.00	-
44	9381	SERB-2020	-	1,50,000.00	1,50,000.00	-	1,50,000.00	-
45	9915	DST/PAC	5,40,903.00	-	5,40,903.00	-	5,40,903.00	5,40,903.00
46	-	DAE-LIGO	99,60,043.00	2,20,00,000.00	3,19,60,043.00	19,79,939.00	2,99,80,104.00	99,60,043.00
47	-	DST-LIGO	1,08,05,470.00	-	1,08,05,470.00	21,87,486.00	86,17,984.00	1,08,05,470.00
48	-	UGC-DAE-CSR	45,000.00	-	45,000.00	-	45,000.00	45,000.00
49		IO-TA-C26TD12FI_CCWS2	17,53,092.00	32,76,320.00	50,29,412.00	50,29,412.00	-	17,53,092.00
50		IO-TA-C26TD14FI_CCWS3		45,20,203.00	45,20,203.00	45,20,203.00	-	-
51		IO-TA-C26TD16FI_CCWS4		16,31,100.00	16,31,100.00	21,901.00	16,09,199.00	-
52		IO-TA-C74TD22FI_Sjakhar		83,18,610.00	83,18,610.00	83,18,610.00	-	-
53		IPA RECEIPTS		1,81,20,673.00	1,81,20,673.00	60,56,014.00	1,20,64,659.00	-
54	9354	FEC-2018	-	11,72,244.00	11,72,244.00	11,72,244.00	-	-
		Sub Total (b)	**5,12,54,196.00**	**9,22,41,714.00**	**14,34,95,910.00**	**4,66,09,596.00**	**9,68,86,314.00**	**5,12,54,196.00**

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2020

		SCHEDULE 3B - EARMARKED/ ENDOWMENT FUNDS :	a) Opening Balance of the fund 01-04-2019	b) Additions to the Funds	TOTAL (a+b)	c)Utilisation/ Expenditure towards objectives of funds	NET BALANCE AS AT 31ST MARCH, 2020 (a+b-c)	NET BALANCE AS AT 31ST MARCH, 2019
1	9069	F.C.I.P.T. - DST - UP	(8,20,592.00)	-	(8,20,592.00)	-	(8,20,592.00)	(8,20,592.00)
2	9081	F.C.I.P.T. - RHVPS	(2,23,35,127.00)	-	(2,23,35,127.00)	-	(2,23,35,127.00)	(2,23,35,127.00)
3	9095	F.C.I.P.T. - DST2	(55,69,425.00)	-	(55,69,425.00)	-	(55,69,425.00)	(55,69,425.00)
4	9164	BARC - EED - Project	(15,50,420.00)	-	(15,50,420.00)	-	(15,50,420.00)	(15,50,420.00)
5	9203	DST - TSG- GYRO- RF	(22,17,752.00)		(22,17,752.00)	-	(22,17,752.00)	(22,17,752.00)
6	9211	DGFS-PhD	(1,38,34,107.00)	-	(1,38,34,107.00)	47,90,100.00	(1,86,24,207.00)	(1,38,34,107.00)
7	9215	DST-WOSA	(6,68,809.00)	-	(6,68,809.00)	-	(6,68,809.00)	(6,68,809.00)
8	9216	DST-INSPIRE	(60,009.00)	-	(60,009.00)	-	(60,009.00)	(60,009.00)
9	9227	APD-CEBS	(1,96,310.00)	-	(1,96,310.00)	7,35,385.00	(9,31,695.00)	(1,96,310.00)
10	9306	FCIPT-DST-IPT	(90,254.00)	-	(90,254.00)	-	(90,254.00)	(90,254.00)
11	9312	FCIPT-DU-SEPS	(3,47,161.00)	-	(3,47,161.00)	-	(3,47,161.00)	(3,47,161.00)
12	9331	LPSC THUSTER	81,567.00	-	81,567.00	1,03,981.00	(22,414.00)	81,567.00
13	9334	FCIPT-DST INT ITALY	(3,57,849.00)	-	(3,57,849.00)	-	(3,57,849.00)	(3,57,849.00)
14	9337	FCIPT-CSMCRI-MoU	(14,125.00)	-	(14,125.00)	-	(14,125.00)	(14,125.00)
15	9343	DST-PKK-GITA	(3,17,725.00)	-	(3,17,725.00)	-	(3,17,725.00)	(3,17,725.00)
16	9353	FCIPT-PERD	(2,15,598.00)	-	(2,15,598.00)	-	(2,15,598.00)	(2,15,598.00)
17	9374	IPR-TBRL-CGN	-	5,41,000.00	5,41,000.00	6,34,800.00	(93,800.00)	-
Sub Total (c)			**(4,85,13,696.00)**	**5,41,000.00**	**(4,79,72,696.00)**	**62,64,266.00**	**(5,42,36,962.00)**	**(4,85,13,696.00)**
		Dr. Parvez Guzdar Fund (3a)	-	(50,000.00)	(50,000.00)	-	(50,000.00)	-
BALANCE FOR YEAR 2019-20 (3a + 3b)			**38,22,51,747.00**	**11,07,00,939.00**	**49,29,52,686.00**	**8,02,35,583.00**	**41,26,17,103.00**	**38,22,51,747.00**

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2020

PARTICULARS	2019-20	2018-2019
SCHEDULE 4 - CURRENT LIABILITIES AND PROVISIONS:		
A. CURRENT LIABILITIES :		
1. Sundry Creditors		
a) For Goods	35,70,211.00	44,84,052.00
b) Others	8,43,339.00	11,59,181.00
2. Other Current Liabilities		-
a) Security Deposits	2,73,51,315.00	5,73,89,565.00
b) Other Liabilities	21,07,276.00	36,53,320.00
c) Outstanding Expenses	2,97,22,597.00	1,76,43,201.00
3) Divisions		-
a) Iter-India/IPR	-	1,05,33,938.00
TOTAL (A)	**6,35,94,738.00**	**9,48,63,257.00**
B. PROVISIONS		
1. Gratuity	40,28,07,681.00	34,83,82,275.00
2. Superannuating/Pension	3,64,82,00,957.00	2,18,59,10,527.00
3. Accumulated Leave Encashment	41,51,56,086.00	34,61,17,982.00
TOTAL (B)	**4,46,61,64,724.00**	**2,88,04,10,784.00**
TOTAL (A+B)	**4,52,97,59,462.00**	**2,97,52,74,041.00**

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2020

SCHEDULE 5 - FIXED ASSETS		Rate	GROSS BLOCK				DEPRICIATION				NET BLOCK	
	DESCRIPTION		Cost as at beginning of the year	Addition during the year	Ded./Adj during the year	Cost as at the year end	Up-to beginning of the year	for the year	on deductions/Adj	Total up to the year end	As at the Current year - end	As at the Previous year - end
A.	**FIXED ASSETS:**											
1	LAND:											
	a) Freehold		4,36,440.00		-	4,36,440.00		-	-	-	4,36,440.00	4,36,440.00
	1. Bhat Land	-	56,75,519.00		-	56,75,519.00		-	-	-	56,75,519.00	56,75,519.00
	2.GIDC Land	-	83,52,433.00		-	83,52,433.00		-	-	-	83,52,433.00	83,52,433.00
2	BUILDINGS :				-	-				-	-	
	On Freehold Land				-	-				-	-	
	a) Bhat Main Building/ITER Lab	1.63%	46,64,94,380.00		-	46,64,94,380.00	10,29,58,198.00	76,97,033.00		11,06,55,231.00	35,58,39,149.00	36,35,36,182.00
	b) Guest House/Hostel Building	1.63%	6,34,10,013.00		-	6,34,10,013.00	90,07,990.00	10,54,058.00		1,00,62,048.00	5,33,47,965.00	5,44,02,023.00
	c) Staff quarters	1.63%	28,55,711.00		-	28,55,711.00	16,52,454.00	46,548.00		16,99,002.00	11,56,709.00	12,03,257.00
	d) FCIPT Building	1.63%	8,66,64,329.00	2,26,253.00	-	8,68,90,582.00	1,02,15,236.00	14,14,473.00		1,16,29,709.00	7,52,60,873.00	7,64,49,093.00
	e) Additional Building	1.63%	9,29,41,236.00		-	9,29,41,236.00	66,68,708.00	15,14,943.00		81,83,651.00	8,47,57,585.00	8,62,72,528.00
	f) Laboratory & Auxi. Building	1.63%	2,85,28,954.00	76,88,77,366.00	-	79,74,06,320.00	1,23,84,979.00	69,39,510.00		1,93,24,489.00	77,80,81,831.00	1,61,43,975.00
	g) HVAC Building	1.63%	1,13,43,788.00	8,33,264.00	-	1,21,77,052.00	6,47,163.00	1,91,694.00		8,38,857.00	1,13,38,195.00	1,06,96,625.00
	h) MSH Building	1.63%	1,76,23,290.00		-	1,76,23,290.00	12,83,894.00	2,87,260.00		15,71,154.00	1,60,52,136.00	1,63,39,396.00
	i) Pre Feb Building/Apporach Road		1,72,93,315.00	1,97,862.00	-	1,74,91,177.00	10,48,785.00	2,83,495.00		13,32,280.00	1,61,58,897.00	1,62,44,530.00
3	PLANT MACHINERY & EQUIPMENTS					-						
	a) Scientific Equipments	4.75%	7,62,93,77,645.00	19,13,18,888.00	1,46,18,603.00	7,80,60,77,930.00	2,99,12,22,897.00	35,00,81,296.00	1,14,40,369.00	3,32,98,63,824.00	4,47,62,14,106.00	4,63,81,54,748.00
	c) Workshop Equipments/CPP Machinery & Equip.	4.75%	1,96,39,164.00	72,879.00	8,27,358.00	1,88,84,685.00	1,36,89,844.00	4,18,428.00	7,49,747.00	1,33,58,525.00	55,26,160.00	59,49,320.00
	d) Workshop Tools (CPP Mechanical Works)	4.75%	5,66,483.00		-	5,66,483.00	4,85,173.00	22,009.00	-	5,07,182.00	59,301.00	81,310.00
4	FURNITURE, FIXTURES	6.33%	10,75,90,825.00	31,15,465.00	4,997.00	11,07,01,293.00	5,79,83,721.00	57,59,257.00	4,997.00	6,37,37,981.00	4,69,63,312.00	4,96,07,104.00
5	OFFICE/GEN. EQUIPMENTS	4.75%	7,55,54,876.00	28,24,115.00	11,06,381.00	7,72,72,610.00	3,15,27,558.00	29,87,615.00	4,84,468.00	3,40,30,705.00	4,32,41,905.00	4,40,27,319.00
6	COMPUTER / PERIPHERALS*	16.21%	54,61,88,602.00	29,76,90,865.00	43,96,216.00	83,94,83,251.00	40,41,44,298.00	7,32,87,871.00	41,43,310.00	47,32,88,859.00	36,61,94,392.00	14,20,44,303.00
7	ELECTRIC INSTALLATION	4.75%	2,17,92,043.00	2,89,99,497.00		5,07,91,540.00	1,12,59,398.00	27,11,559.00		1,39,70,957.00	3,68,20,583.00	1,05,32,645.00
8	LIBRARY BOOKS/ JOURNALS	4.75%	33,34,81,146.00	2,43,26,997.00		35,78,08,143.00	14,27,81,383.00	1,41,54,781.00		15,69,36,164.00	20,08,71,979.00	19,06,99,763.00
CURRENT YEAR			**9,53,58,10,192.00**	**1,31,84,83,451.00**	**2,09,53,555.00**	**10,83,33,40,088.00**	**3,79,89,61,679.00**	**46,88,51,830.00**	**1,68,22,891.00**	**4,25,09,90,618.00**	**6,58,23,49,470.00**	**5,73,68,48,513.00**
B.	**INTENGIBLE ASSETS**											
1	Computer Softwares*		19,38,08,528.00	47,95,945.00		19,86,04,473.00	16,02,21,359.00	1,49,84,809.00		17,52,06,168.00	2,33,98,305.00	3,35,87,169.00
2	Patents		81,380.00		-	81,380.00	81,380.00			81,380.00	-	-
									-			
CURRENT YEAR			**19,38,89,908.00**	**47,95,945.00**	**-**	**19,86,85,853.00**	**16,03,02,739.00**	**1,49,84,809.00**	**-**	**17,52,87,548.00**	**2,33,98,305.00**	**3,35,87,169.00**
C.	**ASSETS AT IGCAR**											
1	Building	1.63%	3,35,67,457.00	-	-	3,35,67,457.00	32,83,931.00	5,47,149.00		38,31,080.00	2,97,36,377.00	3,02,83,526.00
2	Office & General Equipment	4.75%	1,92,46,116.00	-	-	1,92,46,116.00	48,63,971.00	9,14,190.00		57,78,161.00	1,34,67,955.00	1,43,82,145.00
3	Computers & Furniture	16.21%	1,67,738.00	-	-	1,67,738.00	81,570.00	27,190.00		1,08,760.00	58,978.00	86,168.00
4	Office Furniture at IGCAR	4.75%	4,84,673.00		-	4,84,673.00	69,729.00	30,680.00		1,00,409.00	3,84,264.00	4,14,944.00
5	Scientific Equipments at IGCAR	4.75%	20,49,08,977.00		-	20,49,08,977.00	4,89,14,020.00	97,33,065.00		5,86,47,085.00	14,62,61,892.00	15,59,94,957.00
CURRENT YEAR			**25,83,74,961.00**	**-**	**-**	**25,83,74,961.00**	**5,72,13,221.00**	**1,12,52,274.00**	**-**	**6,84,65,495.00**	**18,99,09,466.00**	**20,11,61,740.00**
D.	**ASSETS -External Projects**											
	COMPUTER / PERIPHERALS*	16.21%	26,35,247.00	-	-	26,35,247.00	25,16,031.00		16,806.00	24,99,225.00	1,36,022.00	1,19,216.00
	Computer Softwares*	16.67%	4,53,965.00	-	-	4,53,965.00	4,53,965.00			4,53,965.00	-	-
	OFFICE/GEN. EQUIPMENTS	4.75%	4,71,106.00	-	-	4,71,106.00	2,22,577.00	22,262.00		2,44,839.00	2,26,267.00	2,48,529.00
	FURNITURE, FIXTURES	6.33%	5,04,198.00	-	-	5,04,198.00	4,49,637.00	5,916.00		4,55,553.00	48,645.00	54,561.00
	Scientific Equipments	4.75%	3,37,82,937.00	-	-	3,37,82,937.00	1,30,98,894.00	16,02,615.00		1,47,01,509.00	1,90,81,428.00	2,06,84,043.00
CURRENT YEAR			**3,78,47,453.00**	**-**	**-**	**3,78,47,453.00**	**1,67,41,104.00**	**16,30,793.00**	**16,806.00**	**1,83,55,091.00**	**1,94,92,362.00**	**2,11,06,349.00**
D.	**CAPITAL WORK-IN-PROGRESS**		4,03,99,24,207.00	2,36,42,89,576.00	2,70,79,08,975.00	3,69,63,04,808.00	-	-	-	-	3,69,63,04,808.00	4,03,99,24,207.00
	TOTAL		**14,06,58,46,721.00**	**3,68,75,68,972.00**	**2,72,88,62,530.00**	**15,02,45,53,163.00**	**4,03,32,18,743.00**	**49,67,19,706.00**	**1,68,39,697.00**	**4,51,30,98,752.00**	**10,51,14,54,411.00**	**10,03,26,27,978.00**
PREVIOUS YEAR			**13,49,76,55,679.00**	**61,00,47,727.00**	**4,18,56,685.00**	**14,06,58,46,721.00**	**3,58,43,71,098.00**	**44,94,16,543.00**	**5,68,898.00**	**3,98,41,53,424.00**	**10,03,26,27,978.00**	

SCHEDULE FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2020

PARTICULARS	2019-20	2018-19
SCHEDULE 6 - CURRENT ASSETS, LOANS, ADVANCES ETC:		
A. CURRENT ASSETS :		
1. Inventories:		
a) Stores and spares	55,74,383.00	86,30,674.00
2. Sundry Debtors:		
a) Debts outstanding for a period exceeding six months	36,48,802.00	2,19,342.00
b) Debts outstanding for a period less then six months	99,45,210.00	
c) Others	-	
3. Cash balances in hand (including cheques/drafts and imprest)	69,740.00	15,894.00
4. Bank Balances:		
a) With Scheduled Banks:		
- On Current Accounts		
State Bank of India, IPR.Branch, Ahemdabad A/c.30185519770	1,10,27,053.00	(14,20,53,796.00)
State Bank of India, IPR.Branch, Ahemdabad A/c.30360884053	22,24,617.00	10,17,64,925.00
State Bank of India, Naroda Branch, Ahemdabad A/c.10159920115	70,41,597.00	25,09,45,047.00
State Bank of India, Naroda Branch, Ahemdabad A/c.30360272380	10,28,518.00	9,29,482.00
State Bank of India, A/c. 35052592927	8,28,681.00	46,161.00
- On Deposit Accounts		
State Bank of India	1,18,77,41,891.00	1,69,74,85,386.00
- On Savings Accounts		
State Bank of India, A/c No. 30767137485	20,06,269.00	1,47,191.00
State Bank of India, IPR-FEC/CPP A/c No. 37553565059	4,74,47,730.00	1,73,98,759.00
Money Margin With Bank		
State Bank of India, A/c No.33906582576		
TOTAL (A)	**1,27,85,84,491.00**	**1,93,55,29,065.00**
B. LOANS, ADVANCES AND OTHER ASSETS :		
1. Loans:		
a) Staff		
House Building Advance (Including accrued interest)	2,08,08,281.00	1,69,57,805.00
Computer Advance (Including accrued interest)	54,93,591.00	66,18,283.00
Vehicle Advance (Including accrued interest)	20,27,469.00	23,34,074.00
2. Advances and amounts recoverable in cash or in kind or for value to be received:		
a) Advances to Non Govt. Contractors & Suppliers (Including adv. *for Capital Works)*	20,65,44,83,756.00	15,34,56,04,663.00
b) Advances to Govt.Institutions/Organisations *(Refer Note 5 of Schedule-14)*	35,42,29,415.00	36,78,74,912.00
c) Deposit with Government Authorities	1,68,88,835.00	1,69,25,267.00
d) Deposit with Others	1,00,11,295.00	99,76,363.00
e) TDS Receivable	11,42,861.00	12,92,551.00
f) Patents Applied for	3,96,600.00	3,87,720.00
g) Advance for Travelling Expenses	60,11,637.00	32,30,741.00
h) General Advance	2,93,451.00	3,08,398.00
i) Project Leader Imprest Advance	1,64,470.00	-
j) LTC Advance	9,37,275.00	4,77,647.00
k) Medical Recovery	-	21,794.00
l) CPP-NPS	5,01,654.00	
m) Prepaid Expenses	55,10,168.00	12,34,420.00
n) GST Receivable	23,31,717.00	21,37,474.00
o) RCM CGST Receivable	2,56,735.00	-
p) RCM SGST Receivable	2,56,735.00	-
q) TDS of CGST	3,12,577.00	-
r)TDS of SGST	3,12,585.00	-
3. Income Accrued:		
a) On Bank Fixed Deposits	1,69,34,818.00	1,50,67,286.00
TOTAL (B)	**21,09,93,05,925.00**	**15,80,09,83,336.00**
TOTAL (A+B)	**22,37,78,90,416.00**	**17,73,65,12,401.00**

SCHEDULE FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH, 2020

PARTICULARS	2019-20	2018-19
SCHEDULE 7 - GRANTS/SUBSIDIES :		
(Irrevocable Grants & Subsidies Received)		
1) Central Government (Dept. of Atomic Energy, Govt. of India)	8,40,20,00,000.00	6,74,79,00,000.00
TOTAL	**8,40,20,00,000.00**	**6,74,79,00,000.00**
SCHEDULE 8 - INTEREST EARNED :		
1) On Term Deposits & Savings Deposits:		
a) With Scheduled Banks- State bank of India	12,65,09,234.00	16,68,72,399.00
2) On Loans:		
a) Employees/Staff		
- On Vehicle Advance	54,694.00	1,03,254.00
- On Computer Advance	1,35,441.00	1,62,872.00
- On House Building Advance	6,96,857.00	6,21,875.00
3) Interest on TDS refund	26,194.00	1,57,187.00
TOTAL	**12,74,22,420.00**	**16,79,17,587.00**
SCHEDULE 9 - OTHER INCOME :		
1) Miscellaneous Income	5,65,016.00	26,25,941.00
2) Rent	6,47,266.00	4,89,337.00
3) Royalty & Technology Tranfer Fee Income	11,600.00	500.00
4) Other receipts for Facility utilisation	7,10,528.00	41,74,425.00
5) Surplus on Sale of Asset	5,682.00	-
TOTAL	**19,40,092.00**	**72,90,203.00**

SCHEDULE FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH, 2020

PARTICULARS	2019-2020	2018-19
SCHEDULE 10 - ESTABLISHMENT EXPENSES :		
a) Salaries and Wages	77,47,63,737.00	70,87,52,159.00
b) Allowances and Bonus	58,81,08,819.00	49,28,52,928.00
c) Contribution to Provident Fund (Including NPS Contribution)	5,23,52,532.00	3,02,57,140.00
d) Staff Welfare Expenses	19,55,716.00	16,57,302.00
e) Expenses on Employees' Retirement and Terminal Benefits	1,59,17,96,430.00	34,14,86,973.00
f) NPS charges	68,725.00	68,797.00
g) Medical Expenses	2,35,68,584.00	2,34,34,720.00
Less: PF Contribution Receipt for PF Trust on Option change CPF to GPF	(41,28,083.00)	-
TOTAL	**3,02,84,86,460.00**	**1,57,61,90,877.00**
SCHEDULE 11 - OTHER ADMINISTRATIVE EXPENSES ETC. :		
a) Purchases- Consumable Stores & Spares	19,52,68,917.00	18,62,14,262.00
b) Electricity and Power	11,43,11,591.00	9,47,26,357.00
c) Repairs and Maintenance	8,96,26,674.00	9,10,91,566.00
d) Rent, Rates and taxes	3,68,56,013.00	3,89,81,855.00
e) Transport Hire Charges	1,78,36,305.00	1,65,20,381.00
f) Postage & Telegraph	3,99,142.00	7,05,544.00
g) Telephone and Trunck	42,15,467.00	48,99,649.00
h) Printing and Stationary	33,33,154.00	35,47,559.00
i) Travelling and conveyance Expenses	2,39,32,760.00	2,14,58,310.00
j) Travelling Expenses-International	1,77,94,101.00	2,52,45,191.00
k) Expenses on Seminar/Workshops	58,87,966.00	4,32,44,209.00
l) Membership	31,464.00	32,691.00
m) Auditors Remuneration - Internal	1,88,800.00	1,77,000.00
n) Auditors Remuneration - Statutory	2,36,000.00	2,36,000.00
o) Professional/Legal Charges	19,84,020.00	29,37,323.00
p) Security Expenses	5,52,12,668.00	4,39,02,754.00
q) Visiting Scientist Expenses	37,00,805.00	23,01,168.00
r) Advertisement and Publicity	18,58,349.00	17,14,298.00
s) Admin/Office Exp	2,24,592.00	2,00,824.00
t) Expenses on Acedemic Programmes	37,48,135.00	41,93,907.00
u) Honorarium	11,38,682.00	16,15,215.00
v) Bank Charges	6,17,235.00	13,28,950.00
w Remuneration & Wages	4,03,01,239.00	3,89,45,436.00
x) Canteen Subsidy	46,45,857.00	28,68,975.00
y) Collobrative Research Expenses	71,81,698.00	6,29,34,273.00
z) Technical & Professional Consultancy	12,30,814.00	2,40,657.00
aa) TA to Candidate	(6,51,054.00)	23,270.00
ab) Freight & Cartage Expenses	3,20,763.00	1,33,277.00
ac) Reimbursement of Exp. To IO	3,05,70,280.00	4,90,67,156.00
TOTAL	**66,20,02,437.00**	**76,18,07,199.00**
TOTAL EXPENSES	**3,69,04,88,897.00**	**2,33,79,98,076.00**

SCHEDULE FORMING PART OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH, 2020

PARTICULARS	2019-2020	2018-19
SCHEDULE 12 - DEPRECIATION ON FIXED ASSETS:		
a) Main Building/Lab Buidling	83,70,192.00	84,17,041.00
b) Guest House / Hostel Building	10,54,058.00	9,94,685.00
c) Staff Quarters Building	46,548.00	46,548.00
d) FCIPT Building	14,14,473.00	14,12,629.00
e) Additional Office Building	15,14,943.00	15,14,943.00
f) HVAC Building/Lab & Aux. Building	64,58,045.00	1,84,903.00
g) MSH Building	2,87,260.00	2,87,260.00
h) Scientific Equipments	35,00,81,296.00	34,19,62,615.00
i) Workshop Equipments	4,18,428.00	3,03,838.00
j) Workshop Tools	22,009.00	22,009.00
k) Furniture & Fixture	57,59,257.00	56,28,090.00
l) Office/General Equipments	29,87,615.00	32,92,545.00
m) Computers/Peripherals	7,32,87,871.00	4,20,22,897.00
n) Electric Installations / Loss on sale of Assets (ITER)	27,11,559.00	6,75,196.00
o) Library Books/Journals	1,41,54,781.00	1,35,38,249.00
p) Pre-Fab Building / Approach Road	2,83,495.00	2,17,870.00
TOTAL (A)	**46,88,51,830.00**	**42,05,21,318.00**
AMMORTISATION ON INTENGIBLE ASSETS :		
a) Computer Softwares	1,49,84,809.00	1,53,63,015.00
b) Patents	-	-
TOTAL (B)	**1,49,84,809.00**	**1,53,63,015.00**
ASSETS AT IGCAR		
a) Building	5,47,149.00	5,47,149.00
b) Office & General Equipment	9,14,190.00	9,14,190.00
c) Computer & Furniture	27,190.00	27,190.00
d) Office Furniture at IGCAR	30,680.00	30,680.00
e) Scientific Equipments	97,33,065.00	97,30,756.00
TOTAL (C)	**1,12,52,274.00**	**1,12,49,965.00**
ASSETS -External Projects		
a) Computer	(16,806.00)	80,747.00
b) Office Equipment	22,262.00	22,377.00
c) Office Furniture	5,916.00	5,916.00
d) Scientific Equipments	16,02,615.00	16,04,307.00
TOTAL (D)	**16,13,987.00**	**17,13,347.00**
TOTAL (A+B)	**49,67,02,900.00**	**44,88,47,645.00**

SIGNIFICANT ACCOUNTING POLICIES

SCHEDULE- 13:

1. BASIS FOR PREPARATION OF ACCOUNTS

The Financial statements are prepared on the historical cost convention, and on accrual method of Accounting, unless otherwise stated and on going concern basis.

2. INVENTORY VALUATION

Stores & spares are valued at the weighted average cost.

3. INVESTMENT

Investments are valued at cost.

4. FIXED ASSETS

a) Fixed Assets are recorded at cost which includes incidental expenses incurred up to the date of Commissioning of assets, net of liquidated damages/other recoveries prior to /post commissioning of the assets.

b) **Intengible Assets**

i) Softwares are recorded at cost which includes incidental expenses incurred up to the date of Commissioning.

ii) Patents are recorded at legal cost in the year in which granted. Legal cost includes Governemnet fees and lawyer's fees etc., incurred on getting patents.

5. DEPRECIATION

i) Depreciation is provided on Straight Line Basis at the following rates:

Sr	*Particular*	Rate of Depreciation
1	Building	1.63%
2	Plant Machinery & Equipments	4.75%
3	Furniture & Fixtures	6.33%
4	Office / Gen.Equipments	4.75%
5	Computers / Peripherals	16.21%
6	Electric Installation	4.75%
7	Library Books / Journals	4.75%

ii) Asset Costing Rs.5000.00 or less each are fully depreciated.

iii) Depreciation on additions to Assets other than Buildings and Library Books/Journals is provided on prorata basis from the month of addition.Depreciation on additions to Buildings and Library Books/Journals is provided at 50% of the applicable rate.

6. AMMORTISATION

i) Computer Softwares are ammortised during the period of six (6) years.

ii) Patents are ammortised during the period of 10 years from the date of application.

7. GOVERNMENT GRANTS

Government Grants are accounted for on the basis of the Income Approach on receipt basis.Grants received in respect of Fixed Assets are transferred to the Corpus Fund through the Income & Expenditure Account at the time of acquisition of Fixed Assets.

8. FOREIGN CURRENCY TRANSACTION

i) Foreign currency transactions during the year are recorded at rates of exchange prevailing on the date of transactions.

ii) Foreign Currency Assets and Liabilities are not translated into rupees at the rates of exchange prevailing on Balance-Sheet date, since this would have notional impact on unspent grant. Impact of not translation as above is not quantified.

9. CONTRIBUTIONS TO PROJECTS

Contributions to collaborative projects are accounted on the basis of the respective project agreements/Project Memorandum of Understanding. Further accounting for utilization of contribution given for collaborative projects is done on the basis of information regarding utilization received from partner organization.

10. EXTERNALLY FUNDED PROJECTS

Receipts & utilization for Externally Funded Projects are being accounted in a specific project account. On closure, surplus/deficit is being transferred to Plasma Processing Fund.

11. INTEREST EARNED ON PROJECT FUNDS

In accordance with Rule 230 (8) of General Financial Rules, 2017 interest earned during the F.Y. 2018-2019 on the deposits made out of unspent grant and other funds of ITER India was amounting Rs.60894113.00 was remitted to Consolidated Fund of India immediately after finalisation of the accounts.

12. RESEARCH & DEVELOPMENT

Revenue expenditure on research and development is charged against the grant of the year in which it incurred, Capital expenditure on research and development is shown as an addition to fixed assets. Expenditure on research and development resulting into tangible asset is accounted as fixed asset or intengible assets as the case may be.

13. RETIREMENT BENEFITS

Liability for all Retirement benefits like Pension, Gratuity, Leave Encashment are accounted for on actuarial valuation basis.

As per our report of even date attached.

Institute for Plasma Research
Bhat, Gandhinagar

For T.N.Shah & Co.,
Chartered Accountants
Firm Registration No.109802/W

-Sd-	-Sd-	-Sd-	-Sd-
(Dr.Shashank Chaturvedi)	**(Dr. Shishir Deshpande)**	**(Falguni Shah)**	**(Tushar N Shah)**
Director	Dean	Accounts Officer-I	Partner
			Membership No. 042748

Place : Gandhinagar
Date :17/08/2020

INSTITUTE FOR PLASMA RESEARCH
BHAT, GANDHINAGAR – 382 428

(Sponsored by Dept. of Atomic Energy, Govt. of India, Mumbai)
Registration No. GUJ/88/GANDHINAGAR

NOTES TO THE ACCOUNTS

SCHEDULE- 14:

1 a Hitherto, as per rules of ITER India Empowered Board, separate set of accounts & records were to be maintained and separate Audited Statement of Accounts were to be presented for the ITER-India Project w.e.f. April 1,2008. Howeverm in accordance with Department of Atomic Energy directive vide their letter No.18/1/2010-R&D-II/9309 Dated October 5,2010, Audited Statements of Accounts for ITER-India Project are to be presented on branch accounting concept.

2 CONTINGENT LIABILITIES :

(i) Contingent Liabilities in respect of claims against the IPR not acknowledged as debts Rs.--NIL-- (Previous year - Rs.NIL).

(ii) Guarantees and Letter of Credits given by Bank on behalf of the Institute for Plasma Research is Rs.190.36 Crore (Previous Year Rs.249.87 crore).

3 CAPITAL COMMITMENTS

Estimated value of Contracts remaining to be executed on Capital Account and not provided for Rs.1091.093 Crore (Previous Year Rs.1368.08 crore).

4 DEPRECIATION

Depreciation for the year 2019-2020 Rs.49,67,02,900.00 (Previous Year Rs. 44,88,47,645.00 has been debited to the Income & Expenditure Account and the like amount has been transferred from the Corpus Fund to the Income & Expenditure Account

5 ACCOUNTING OF PROJECT ASSETS

Fixed Assets set out in the Schedule-5 do not include Scientific Equipment of Rs.3,98,56,235.00 (Previous Year Rs. 3,98,56,235.00 as on 31.03.2020 purchased out of funds of closed sponsered projects as on 31.03.2020, held and used by Institute, as Project sanctions include stipulations that all such assets puchased out of the project funds will remain the property of the sponsors.

6 FOREIGN CURRENCY TRANSACTION

	2019-2020	**2018-2019**
i) Value of Imports Calculated on C.I.F. Basis :		
- Capital Goods	36,22,98,217.00	9,96,00,122.00
- Consumables & Spares	3,95,65,353.00	5,17,18,576.00
ii) Expenditure in foreign currency :		
- Travel	1,08,06,750.00	1,68,70,021.00
- Cash Contribution to ITER-Organisation	49,51,85,120.00	-
- Technical Consultancy	-	3,78,996.00
iii) Earnings :		
- Value of Exports on F.O.B. basis	Nil	Nil

7 Advance to Govt.Institutions / Organaisation stated in Schedule - 6B.2.b) includes:

An amount of Rs. 4.02 Crore (Previous year Rs. 4.02 Crore) has been paid to Indira Gandhi Centre for Advance Atomic Research for colloborative research on Development of ITER Test Blanket Modules which is pending for adjustment in absence of information regarding its utilisation.

INSTITUTE FOR PLASMA RESEARCH
BHAT, GANDHINAGAR – 382 428
(Sponsored by Dept. of Atomic Energy, Govt. of India, Mumbai)
Registration No. GUJ/88/GANDHINAGAR

8 Total demand outstaning of In-Cash Contribution to ITER Organisation as on 31/03/2020 is Euro 128827752.28 (Approx. Rs.1098/- Crores taking SBI TT Selling rate Rs.85.18 per Euro)

9

a One reactor for aprox. Rs. 8.00 Lacs (Rupees Eight Lacs) included in present value of Assets is lost. No provision is made for loss,as lower court has decided the case in favour of the Institute and the matter is pending before Hon.High Court of Gujarat.

b Since 2011, Iter-India has given advances to contractor aggregating to Rs. 4,84,06,387/- for implemation of SAP software. These advances has been shown under Current Assets (Advances to Non-Govt. Contractors). Last Year a committee consisting of Senior Scientists had been formed by Project Director - Iter-India, to review implementation status of SAP and closure of contracts related thereto. Accounting treatment of above advances will be decided based on and as directed by the final decision of the committee as aforesaid. The decission of the Committee is pending.

10 No Insurance Policy is taken for the Movable & Immovable assets as per the usual practice.

11 Previous year's figures have been regrouped wherever necessary to correspond with the current year's figures.

12 Balances of Suppliers/Contractors are subject to confirmations & adjustment, if any.

As per our report of even date attached.

Institute for Plasma Research
Bhat, Gandhinagar

For T.N.Shah & Co.,
Chartered Accountants
Firm Registration No.109802/W

-Sd-	-Sd-	-Sd-	-Sd-
(Dr.Shashank Chaturvedi)	**(Dr. Shishir Deshpande)**	**(Falguni Shah)**	**(Tushar N Shah)**
Director	Dean	Accounts Officer-I	Partner
			Membership No. 042748

Place : Gandhinagar
Date :17/08/2020

Audited Statements of Accounts as on 31st March 2020

INSTITUTE FOR PLASMA RESEARCH

Employees Provident Fund

IPR EMPLOYEE'S PROVIDENT FUND.

BALANCE SHEET AS AT 31ST MARCH, 2020

2018-19		CORPUS/CAPITAL FUND AND LIABILITIES	2019-20	
		MEMBERS PF SUBSCRIPTION :		
		(Net of Loans & including Interest on Subscription)		
37,24,81,442.30		Balance as on 1st April 2019	42,26,65,269.30	
7,53,29,294.00		Addition During the year	7,28,58,340.00	
2,51,45,467.00	**42,26,65,269.30**	**Less :** Debit During the year	3,21,20,227.00	**46,34,03,382.30**
		INSTITUTE'S PF CONTRIBUTION :		
		(Including Interest)		
93,85,540.15		Balance as on 1st April 2019	14,39,909.15	
76,035.00		Addition during the year	30,280.00	
80,21,666.00	**14,39,909.15**	**Less :** Debits during the year	12,89,663.00	**1,80,526.15**
		LAPSE & FORFEITTURE A/c		
16,42,343.49		Balance as on 1st April 2019	16,42,343.49	
-	**16,42,343.49**	Addition during the year	-	**16,42,343.49**
		CURRENT LIABILITIES :		
47,73,657.00	**47,73,657.00**	Sundray Credit Balances.	11,81,166.00	**11,81,166.00**
		INCOME & EXPENDITURE A/c		
4,47,62,007.22		Openig Balance	4,23,14,630.22	
-24,47,377.00	**4,23,14,630.22**	**Add/Less :** Tranfer from Income & Expenditure A/c	-27,28,468.00	**3,95,86,162.22**
	47,28,35,809.16	**TOTAL**		**50,59,93,580.16**
		ASSETS		
	43,03,36,430.00	FIXED DEPOSIT with State Bank Of India / Public Financial Institute.	44,00,28,829.00	
		S/B A/c with :		
	1,01,69,569.03	State Bank Of India	1,34,77,100.03	**45,35,05,929.03**
	3,21,81,514.13	Interest accrued but not due on Fixed Deposits with a Scheduled Bank / Public Financial Institute.	5,23,39,355.13	**5,23,39,355.13**
		Income-Tax Deducted at source :		
1,48,296.00		Balance as on 1st April 2019	1,48,296.00	
-		Addition during the year	-	
-	**1,48,296.00**	**Less :** Refund Received	-	**1,48,296.00**
	47,28,35,809.16	**Total**		**50,59,93,580.16**

Note : Loan transactions are merged with members subscription accounts.**Rs. 9,75,271/-** were given during the year ended as on 31st March 2020, **Rs.70,01,603/-** are outstanding in loan accounts.

Examined and Found correct.
For T.N.Shah & Co.,
Chartered Accountants
FRN.109802/W

-Sd-
(Dr.Shishir Deshpande)
Senior Professor - I
Chairman

-Sd-
(Falguni Shah)
Accounts Officer-I, IPR
Member

-Sd-
(Tushar N.Shah)
Partner
Membership No.042748

Place : Bhat, Gandhinagar
Dated : July 06,2020

IPR EMPLOYEE'S PROVIDENT FUND.

INCOME AND EXPENDITURE ACCOUNT FOR THE PERIOD ENDED ON 31ST MARCH, 2020

2018-19	INCOME	2019-20
3,35,731.00	Interest On Savings Bank Account & Others	**2,14,680.00**
2,69,29,816.00	Interest On Fixed Deposit	**2,98,44,867.00**
24,47,377.00	Excess of Expenditure over Income transferred to Income & Expenditure A/c	**27,28,468.00**
2,97,12,924.00	**TOTAL**	**3,27,88,015.00**
	EXPENDITURE	
2,96,36,889.00	Interest on Members Subscription	**3,28,18,040.00**
76,035.00	Interset on Institute's Contribution	**(30,025.00)**
-	Excess of Income over Expenditure transferred to Income & Expenditure A/c	**-**
2,97,12,924.00	**TOTAL**	**3,27,88,015.00**

Examined and Found correct.
For T.N.Shah & Co.,
Chartered Accountants
FRN.109802/W

-Sd-
(Dr.Shishir Deshpande)
Senior Professor - I
Chairman

-Sd-
(Falguni Shah)
Accounts Officer-I. IPR
Member

-Sd-
(Tushar N.Shah)
Partner
Membership No.042748

Place : Bhat, Gandhinagar
Dated : July 06,2020

अंतर्राष्ट्रीय योग दिवस – 2019

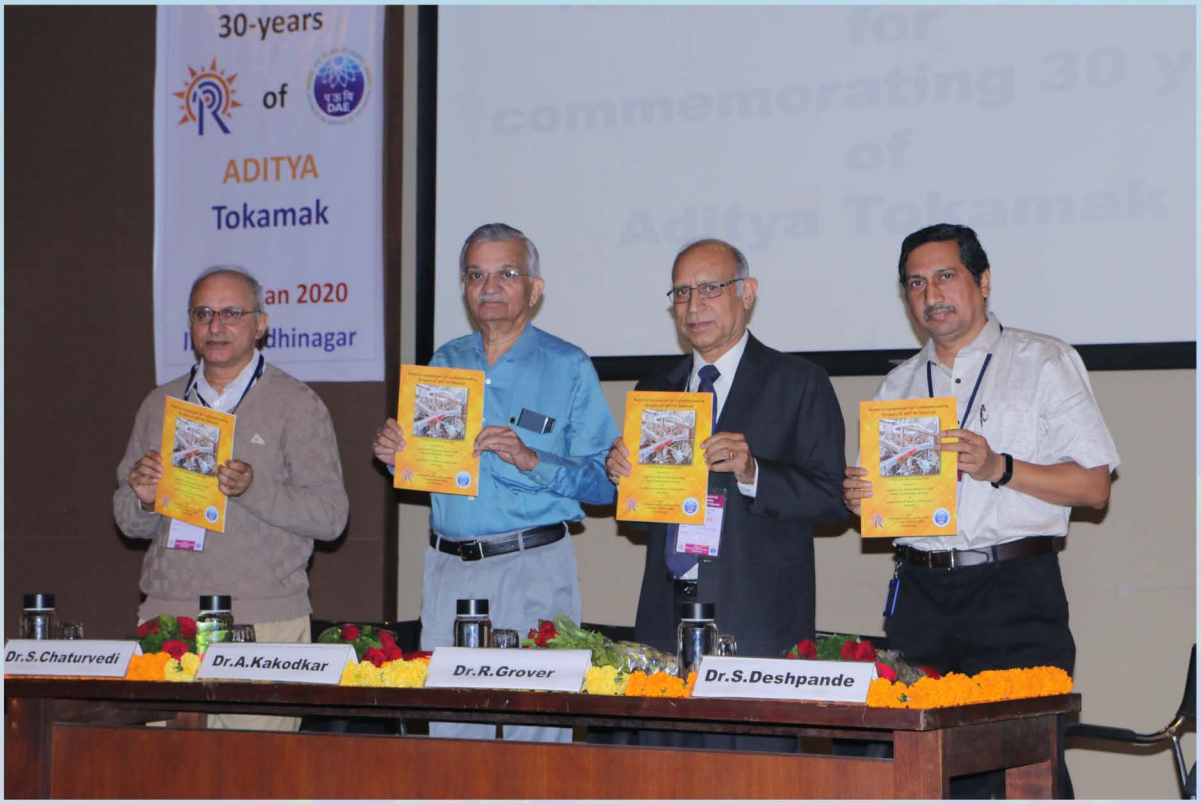
International Yoga Day -2019

विक्रम साराभाई शताब्दी राष्ट्रीय विज्ञान दिवस 2020

Vikram Sarabhai Centenary National Science Day 2020

पऊवि की विभिन्न इकाईयों के बीच हिंदी में आयोजित विज्ञान नाटिका प्रतियोगिता में आईपीआर की प्रतिभागिता

Participation from IPR in Hindi Science Skit Competition held among various DAE units



आदित्य टोकामॅक के 30 वर्ष के स्मरण में आयोजित राष्ट्रीय संगोष्ठी का उद्घाटन सत्र

Inaugural Session of the National Symposium for commemorating 30-years of ADITYA Tokamak

स्वास्थ्य क्षेत्र हेतु प्लाज़्मा प्रौद्योगिकी 2019 पर एक दिवसीय संगोष्ठी का उद्घाटन सत्र

Inaugural Session of the One-Day Seminar on Plasma Technologies for Health Sector 2019

प्लाज़्मा अनुसंधान संस्थान

भाट, गांधीनगर–382 428, गुजरात (भारत)

INSTITUTE FOR **PLASMA RESEARCH**

Bhat, Gandhinagar - 382 428, Gujarat (India)