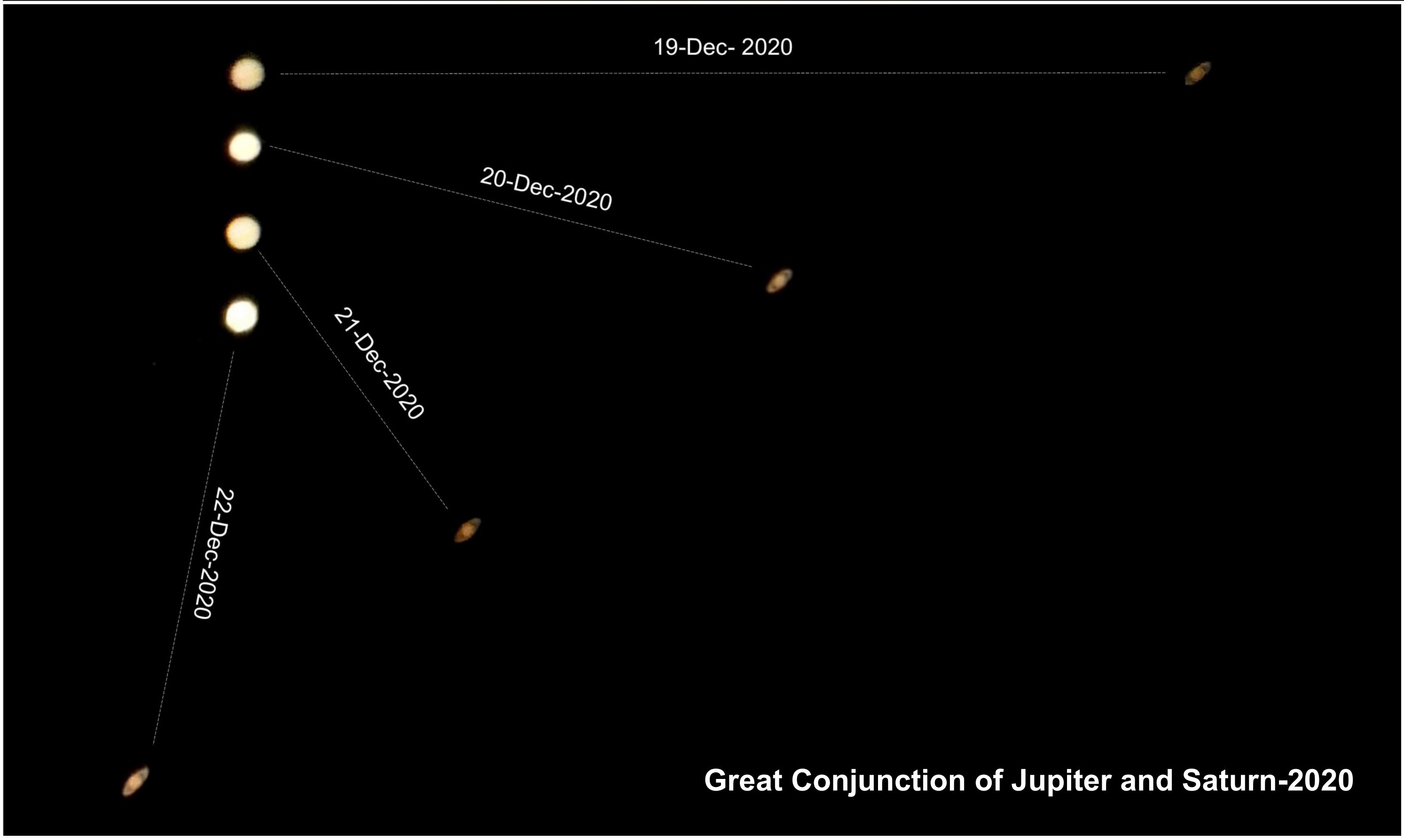
Issue 090

January 2021

The Fourth State

Newsletter of the Institute For Plasma Research, Gandhinagar, Gujarat (India)

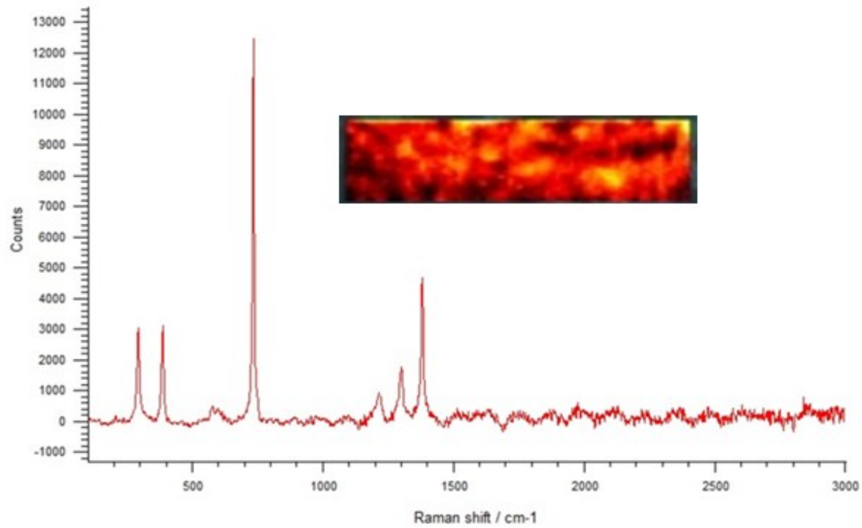


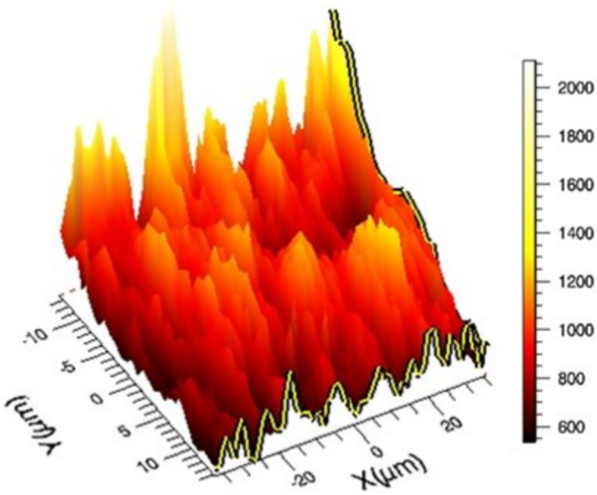
A composited sequence of the Great 2020 Conjunction of Jupiter and Saturn captured at Ahmedabad. The two planets, more than 734 million kms apart, was in such an alignment with earth that they appeared to be very close to each other in what is known as a “Great Conjunction” on 21st December, 2020. It will be the closest the planets have been in 800 years. Visible to naked eye, the planets were separated only by 6.11 minutes arc in the sky. A similar conjunction will not occur until the year 2080. The previous one took place on July 16, 1623. Photo composite by Ravi A V Kumar. (Video Link)

Installation of Scanning Raman Microscope System at FCIPT/IPR

A Confocal Scanning Raman Microscope has been procured at FCIPT/IPR. The system is a two laser system of wavelength 532 nm and 785 nm with different power levels. It has some unique features like Raman Mapping and real time dynamic focusing. The system is was procured for molecular sensing using nano-patterns surfaces.

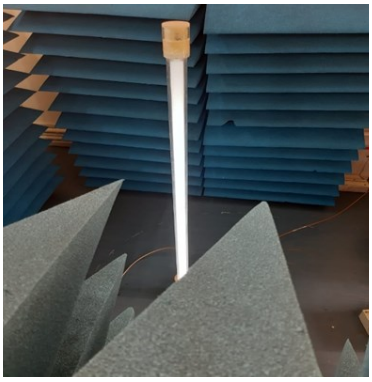
(L) Newly installed Raman Microscope system (R) Training session in progress





Raman spectra of Teflon with mapping in the 30x60 μm range

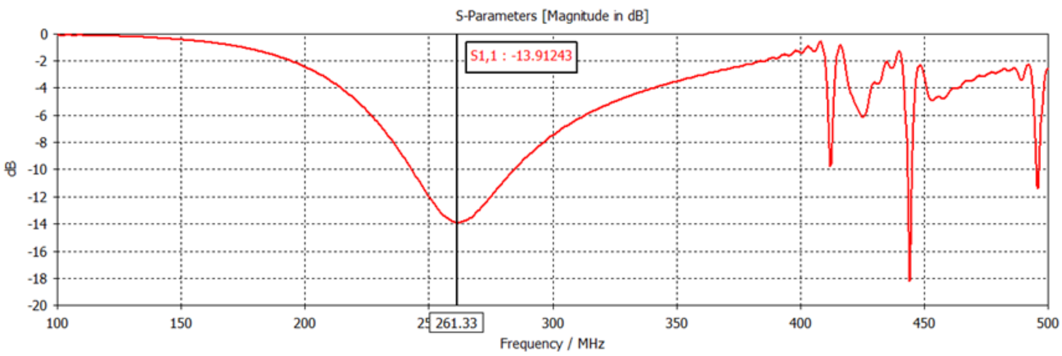
Development of Plasma Antenna @ IPR

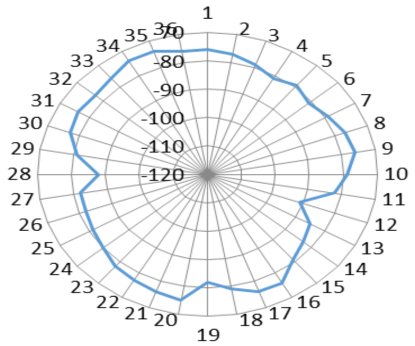


Plasma is well known for its re-configurability and dynamic behavior. Also, plasmas have very high electrical conductivity and hence find several commercial applications. Due to the high electrical conductivity, radio frequency can travel through it and thus a plasma column can act as an antenna to radiate radio waves, or to receive them. Also, the same plasma can be used as a reflector or a lens to guide and focus radio waves from another source.

Plasma antenna is also reconfigurable by varying its basics parameters. Hence, a single plasma antenna can work for many frequencies.

Development of plasma antenna system is currently being carried out at the RPAD lab at IPR. This plasma antenna system can transmit and receive frequencies in the range from 100 MHz to 300 MHz.

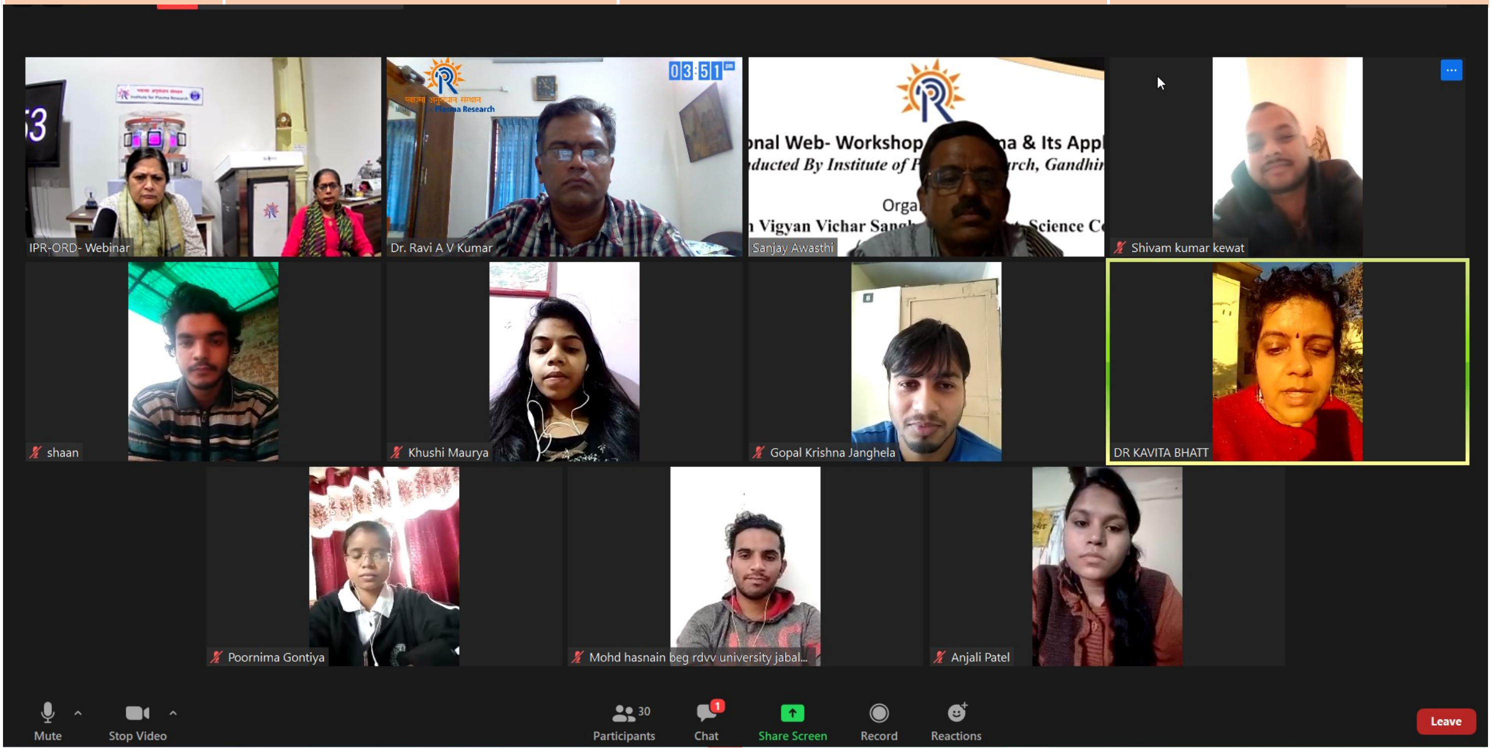


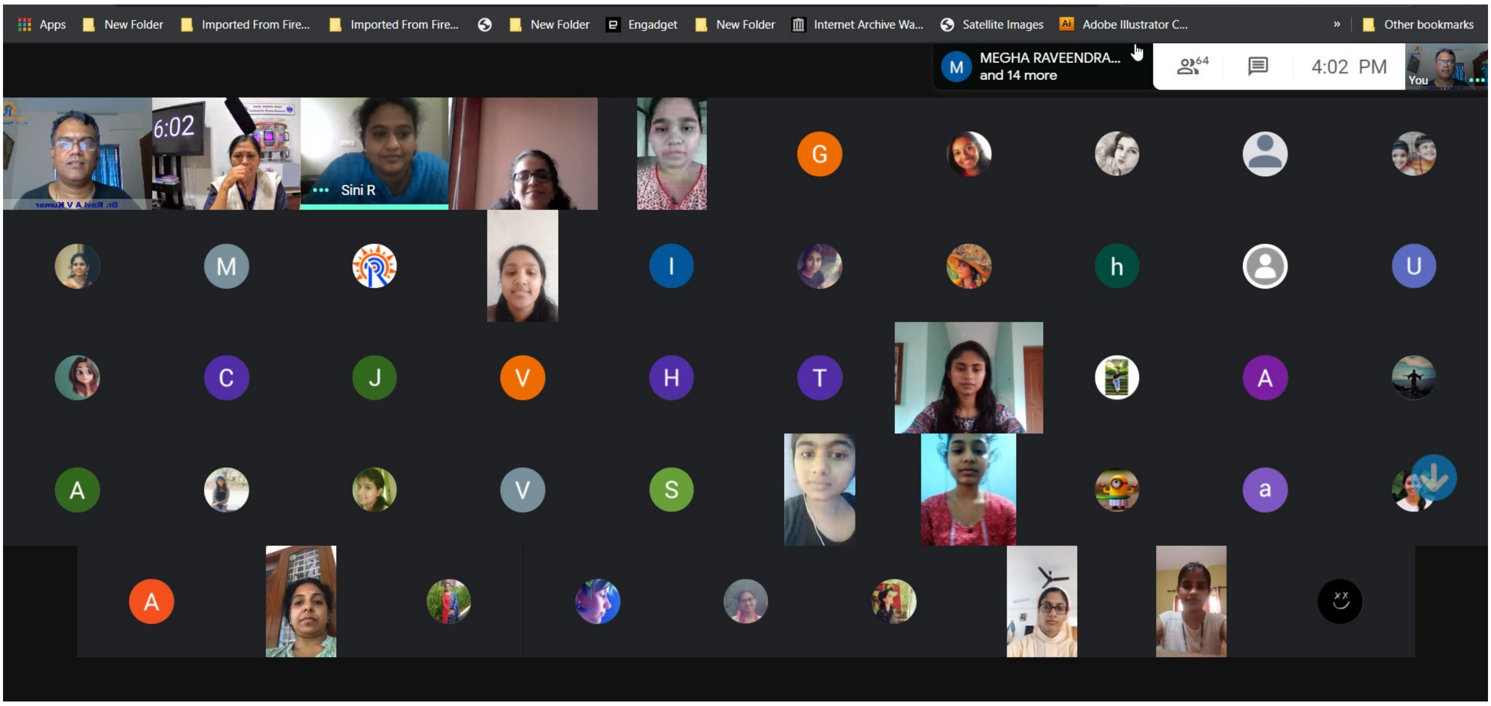


(Top) Photo of the plasma antenna system (Bottom) The simulated S11 parameter and the radiation pattern of the antenna.

Outreach webinar programmes conducted during the month of December 2020

Date	Institution	Programme	Participants
3-4 Dec, 2020	Providence Women's College, Calicut, Kerala	2-day, 4 hour webinar on Plasma & its applications	64 BSc/MSc Physics students of 4 teachers
14-Dec-2020	Unmesh Secondary & Higher Secondary School, Jabalpur	1-day, 2 hour webinar Plasma & its applications	28 students of 9, 10, 11 and 12th standards and 3 teachers
15-Dec-2020	Government Science College, Jabalpur	1-day, 4 hour webinar Plasma & its applications	36 students of BSc/MSc Physics and 3 teachers
21-22 Dec, 2020	Sir Syed College, Taliparamba, Kannur, Kerala	2-day, 4 hour webinar on Plasma & its applications for PG Students and science teachers	64 BSc/MSc Physics students and 2 teachers





Students of (Top) Government Science College, Jabalpur (Bottom) Providence College for Women, Calicut, Kerala, attend-

HPC Corner - Simulation: Understanding Active System (System of Self-Propelled Agents) Using In-house Developed Molecular Dynamics Code

Active (matter) or self-propelled systems are the ones where each entity in the system can be thought of as a self-propelled particle i.e. they propel themselves using an internal source of energy or using energy from an external source but energy injection and dissipation happens at the individual particle level.

There are numerous examples of active systems in nature, in varying scales, ranging from microtubule propelled by motor proteins inside a cell, a group of single-cell bacteria, herds of animals, to human crowd movements. Unlike passive driven systems, active systems consume energy at the smallest possible length scale, i.e., at the individual particle length scale, and exhibit various kinds of complex phenomena e.g., motility-induced phase transitions, large-scale dynamical patterns, and large fluctuations, to name a few.

There has been a great effort in the recent past to produce artificial self-propelled particles from nanoscales to microscales and marcoscales.

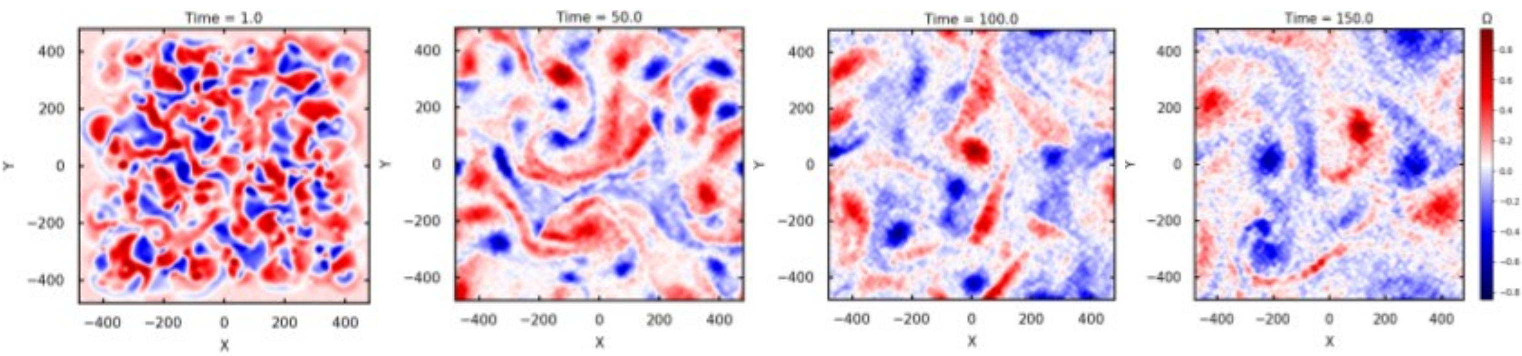
Examples of collective motion in nature (L) Murmuration of birds. (M) Collective motion of school of fish. (R) Experimental image of bacterial colony.

Apart from understanding some of the fundamental questions of nonequilibrium statistical physics, studying active systems could find potential applications in targeted drug delivery, security, and environmental applications, to name a few. With the accessibility of bigger and powerful computing facilities, researchers are being able to explore many unknown areas that are very difficult to study experimentally or analytically due to several constraints.

For our simulation studies, we have considered active systems whose agents or particles are of microscopic scales. They are also known as micromotors or micro-swimmers as they are generally immersed in a background solvent. We have performed a numerical simulation of an agent-based model of micro-flyers (self-propelled particles in a low viscous solvent). Our simulation techniques, are similar to the Brownian dynamics simulation with some minor changes due to the active nature of the particles.

We have upgraded the molecular dynamics code, MPMD to perform our numerical study. Though we have taken only 1936 particles, our simulations were large scale in the sense that a total data of more than three months serial runtime has been generated and analyzed in parallel in the CPU cores of UDAY and ANTYA clusters at IPR's computing facility. Surprisingly enough, our study demonstrates that despite their non-equilibrium nature, the micro-flyers are found to observe equilibrium like Gaussian velocity distributions. We have extracted the equilibrium-like temperature of an inherent non-equilibrium system.

To perform numerical simulation studies for much larger system sizes (for both passive as well as active systems), the code was upgraded using MPI and OpenACC directives to run in multiple GPU devices across compute nodes. We have tested our code with a maximum of 64 million particles across 12 GPU devices using a simple passive Yukawa liquid model in the ANTYA cluster. With minor modifications, it can be pushed to handle a few billion particles with various types of agent-based simulations, e.g. molecular dynamics, Brownian dynamics, Langevin dynamics, to name a few.

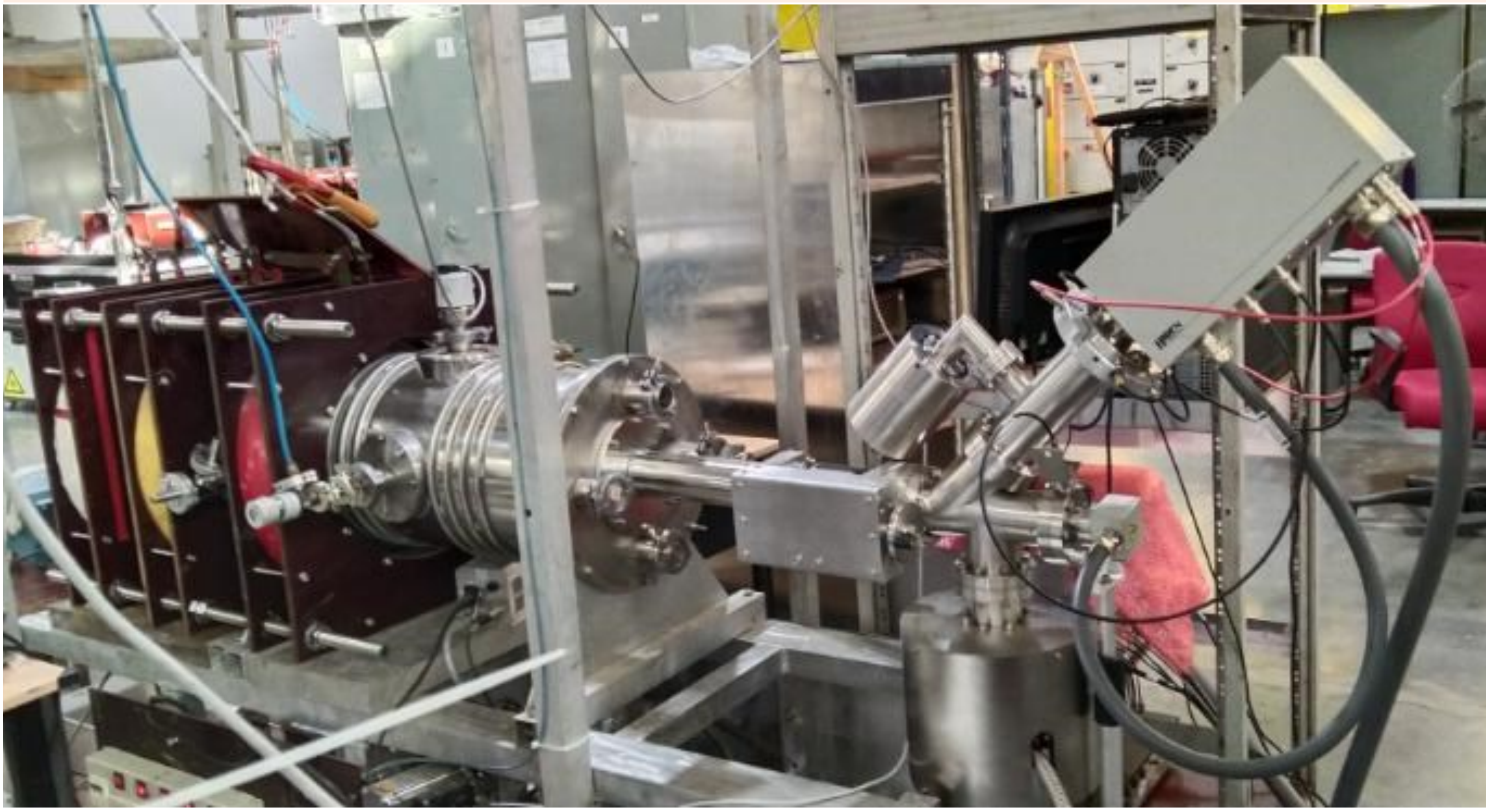


MD simulation of 1 million passive Yukawa particles in two dimensions in a doubly periodic simulation box with our single-GPU MPMD code. Thermally equilibrated configuration is superposed with 500 random vortices with variable strength and size. The system is normalized in Yukawa units with time evolution at t = 1, t = 50, t = 100 and t = 150. Numerical simulations are performed in the ANTYA cluster in a single GPU card and a single CPU core. A single GPU simulation run of our single-GPU MPMD code is roughly 13 times faster that of 31 core MPI run

New Plasma Diagnostic System Commissioned at IPR

The EQP-300 mass-resolve energy analyzer plasma diagnostic system from Hiden Analytical Instruments, U.K; has been commissioned on the BEAM (**B**asic **E**xperiment in **A**xial **M**agnetic field) experimental setup in the Magnetized Plasma Development Laboratory at new R&D building at IPR.

This instrument, which is an advanced plasma diagnostic tool with combined high transmission ion energy analyzer and quadrupole mass spectrometer, acquiring both mass spectra at specified ion energies, can be used for both fundamental plasma research and also provide a testing facility for the characterization of various plasma ions and neutrals from a discharge or ion source.



The mass/energy analyzer diagnostics installed on the BEAM experimental system at IPR

Installation & Commissioning of Gaseous Helium Buffer Tank at ITER-India

A gaseous helium (GHe) buffer tank has been installed and commissioned at the ITER-India cryogenics laboratory, IPR on 17th October 2020.

The capacity of GHe buffer tank is 2 m^3 (2000 liters water volume) with outer shell diameter of 1020 mm and overall height of 3100 mm. The tank has been designed for 16 bar(g) pressure and the operating pressure has been set to 8 bar(g).

The approval from PESO to operate the GHe tank has been obtained. The GHe buffer tank will be used to operate the existing 80 K system in ITER India cryogenics laboratory and perform experiments at 80 K temperature level with helium.

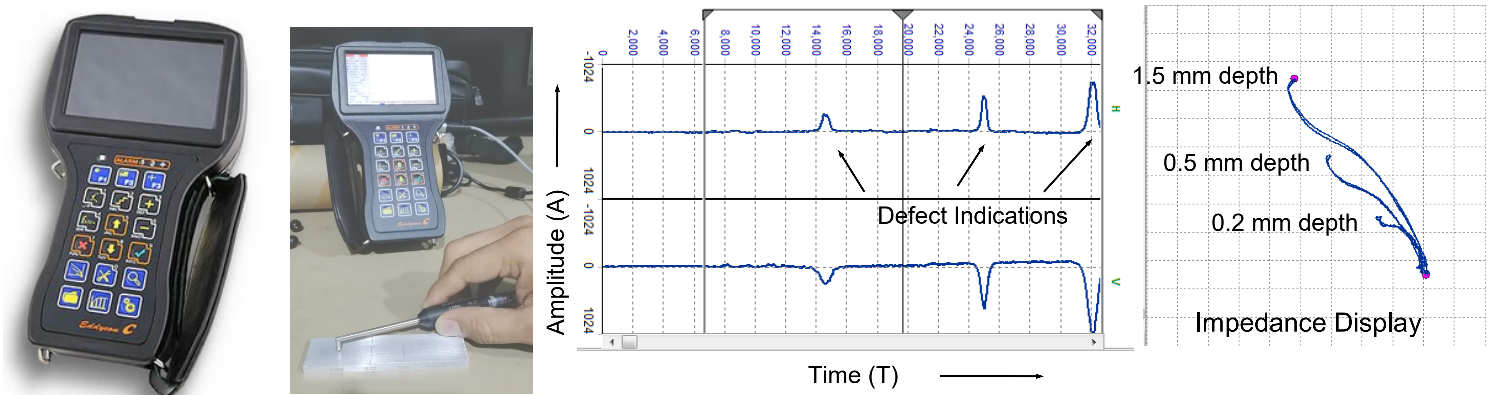
The civil foundation work for the tank was executed by CMS, IPR.

Eddy Current Testing – A Non Destructive Testing Facility @ IPR

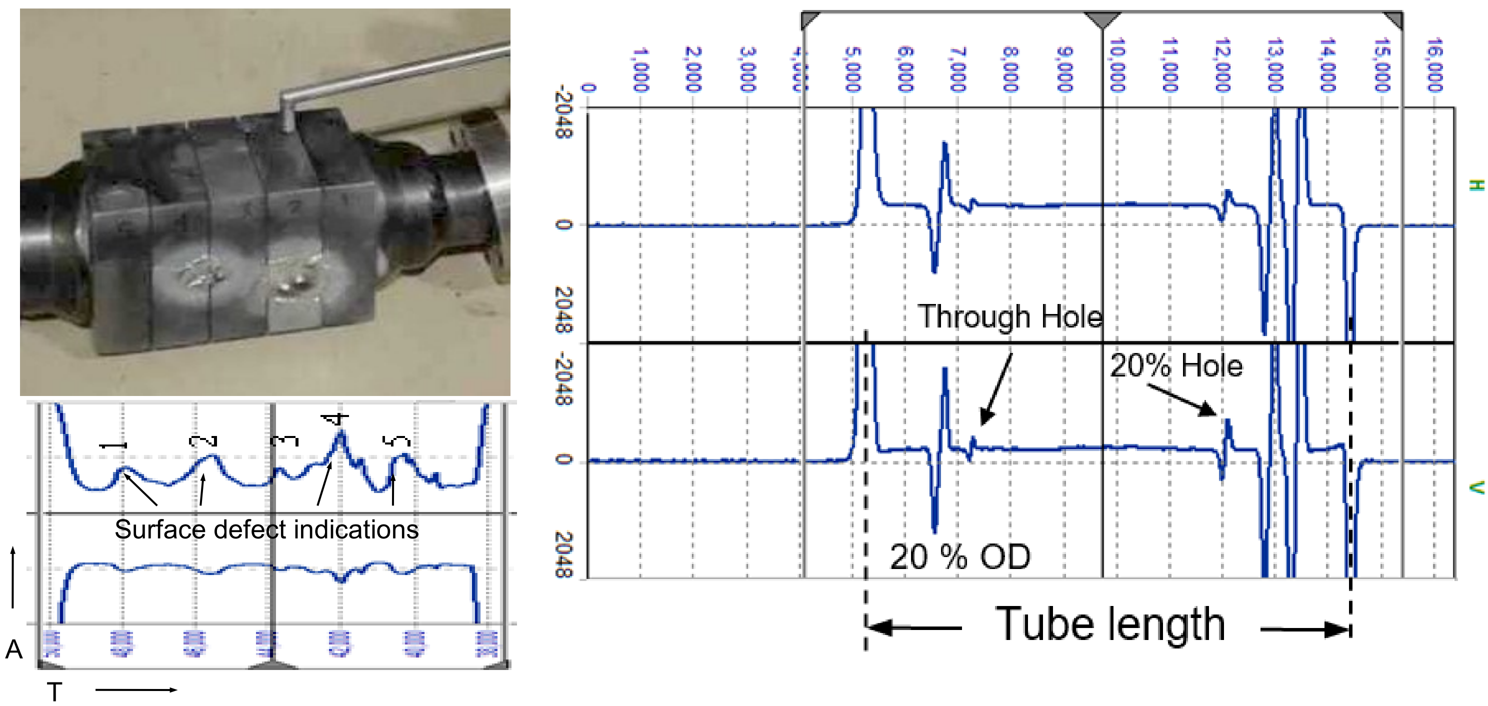
Eddy Current Testing (ECT) is a non-destructive testing method which utilized the principle of electromagnetism to characterize the integrity of electrically conducting structural materials and components. ECT Probe contains an excitation coil carrying current is placed in proximity to the component to be inspected. The coil generates a changing magnetic field using an alternating current, which interacts with the component generating eddy currents. Variations in the phase and magnitude of these currents are monitored either by using a second coil, or by measuring changes to the current flowing in the excitation coil. The presence of any defect/flaw will cause a change in the eddy current field and a corresponding change in the phase and amplitude of the measured signal. A Portable Eddy Current Test System (OKOndt USA) is recently set-up at High Temperature Technologies Division, IPR. This facility have a potential utilization such as (1) to check the surface defects in Divertor plasma facing components at various stages of manufacturing as well as at in-service inspection (2) To evaluate electrical conductivity of material (3) To inspect raw materials, multilayered structures and tubes.

System Features

- Frequency Range up to 16MHz.
- Surface probe for flat/curved surface components and bobbin probe for tube inspection.
- Compatible with encoder and data storage up to 8 GB.
- Non-contact inspection with immediate results.



(L-R) The Eddy current testing device; Calibration on Aluminum block for crack depth measurement; Probe scan showing surface breaks at 0.2, 0.5 and1.5mm depths.



(L) Crack detection in HHF Tested Tungsten Mono block PFC (R) Calibration on SS 304 ASME tube standard for tube inspections.

This system is regularly used to scan the surface of tungsten Mono block PFCs to detect cracks induced due to exposure to the high heat flux source. Inspection of metallic tubes also can be carried out with this system. Characteristics such as wall loss, pits and OD & ID defects are clearly detected.

Eddy current based inspection thus provide reliable, qualitative and quantitative information of defects.

Awards & Accolades

The Cryostat manufacturing and production team of ITER, which includes Shri. Anil Kumar Bharadwaj (Leader, Cryostat Auxiliaries Group) received the "first of a kind" component award which was newly launched by the Director general of ITER in recognition of exemplary work carried out at ITER during the Covid pandemic.

Dr. Shashi Kant Verma, received the ***Young Researcher Award 2020*** from Institute of Scholars (InSc2020), on 6th October 2020 for his publication "*Experimental investigation of effect of spacer single phase turbulent mixing rate on simulated sub channel of AHWR*" published in Annals of Nuclear Energy, December 2017. This work was carried out by him in collaboration with RD&D Group, BARC, Mumbai.

Past Events @ IPR

- *4th Asia Pacific Conference on Plasma Physics (AAPPS-DPP2020 e-Conference), 26-31 October 2020:*
  - ***Dr. Devendra Sharma,*** gave an invited talk on "*Kinetic mode 'cloaking' of nonlinear waves in plasmas*"
  - ***Dr. Lavkesh Lachhvani,*** gave an invited talk on "*Toroidal Electron Plasma Experiment: SMARTEX-C*"
- ***Mr. A. Satyaprasad,*** gave an invited talk on "*SEM and TEM for Surface Morphology*" at National STTP (Online) on "Fostering Instrumental Techniques for Effective Research–2020", Nirma University, 27-31 October 2020
- *62nd Annual Meeting of the APS Division of Plasma Physics (Virtual Meeting), 9-13 November 2020:*
  - ***Dr. Debraj Mandal,*** gave a talk on "*Stochastic webs formation and anomalous chaotic cross-field particle transport in Hall-thruster by E×B electron drift instability*"
  - ***Ms. Devshree Mandal,*** gave a talk on "*Generation of coherent structures in overdense plasma using intense laser pulse*"
- ***Mr. Hitensinh Vaghela,*** gave a talk on "*Development of a test facility for thermo-hydraulic characterization of superconducting cables and small prototype magnets - first functional result of pressure drop measurement*" at Applied Superconductivity Conference-2020, 6th November 2020
- ***Dr. Saravanan A,*** Institute for Plasma Research, Gandhinagar, gave a talk on "*Experiments in DC Dusty Plasma Experimental Setup*' on 26th November 2020
- ***Mr. Ajay Kumar Pandey,*** gave a talk on "*Design of Normal Mode Circularly Polarized Helical Antenna at 5.3 GHz*" at 7th IEEE Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON 2020), organized by MNNIT Allahabad, 28th November 2020
- ***Dr. Prateek Varsheney,*** IIT, Delhi, gave a talk on "*Terahertz Emission Using Laser-Plasma Methods*" on 4th December 2020
- ***Dr. Gayatri Dhamale,*** Institute for Plasma Research, Gandhinagar, gave a talk on "*Theoretical modeling and simulation of DC thermal plasma torches for nanoparticle synthesis*" on 21st December 2020
- ***Dr. Pramod Pandey,*** IIT Kanpur, gave a talk on "*Study of colliding plasmas dynamics and stagnation layer parameters for applications in analytical techniques (LA-ICP-MS)*" on 23rd December 2020

Upcoming Events

- Is There a Common Thread to Layering in Atmospheres, Oceans and Plasmas?, United States, 5-8 January 2021 https://www.kitp.ucsb.edu/activities/staircase-c21
- 24th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 2020), Jeju, Korea, 25-29 January 2021 https://psi2020.kr/
- 2021 European Winter Conference on Plasma Spectrochemistry, Ljubljana, Slovenia, 31 January - 5th February 2021 https://ewcps2021.si/

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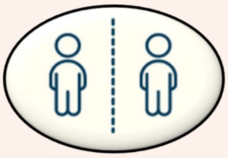
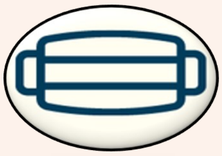
Help Fight The Covid-19 Pandemic

Wash Your Hands With Soap



Ensure Social Distancing



Always Wear Mask

- Avoid touching your eyes, nose and mouth
- If you have fever, cough and difficulty in breathing, seek medical care early
- Stay informed and follow advice given by your healthcare provider
- Inform Office immediately if you or any family member tests positive
- Follow SMS - Social Distancing : Mask : Soap/Sanitizer
- Strictly follow social distancing while outdoors, especially at work.

For your safety and for the safety of your co-workers, ensure that you always use Arogya Setu App

Know Your Colleagues

Dr. Ramkrishna Rane joined IPR as a Scientific Officer-C in May-2004 at FCIPT/IPR. Presently he is working as Scientific Officer-F in Plasma Surface Engineering Division of IPR. He has completed his Ph.D. degree in experimental plasma physics from HBNI in August-2019. He has contributed in development of plasma based reactors for different plasma processing applications. This includes low pressure magnetized DC discharges like magnetron sputtering discharges as well as atmospheric pressure dielectric barrier discharges. He has successfully completed several external projects funded by different government as well as private organisations. He is actively involved in development of plasma based coatings using planar and cylindrical magnetron sputtering technique.

The IPR Newsletter Team

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