

Issue 104  
March 2022

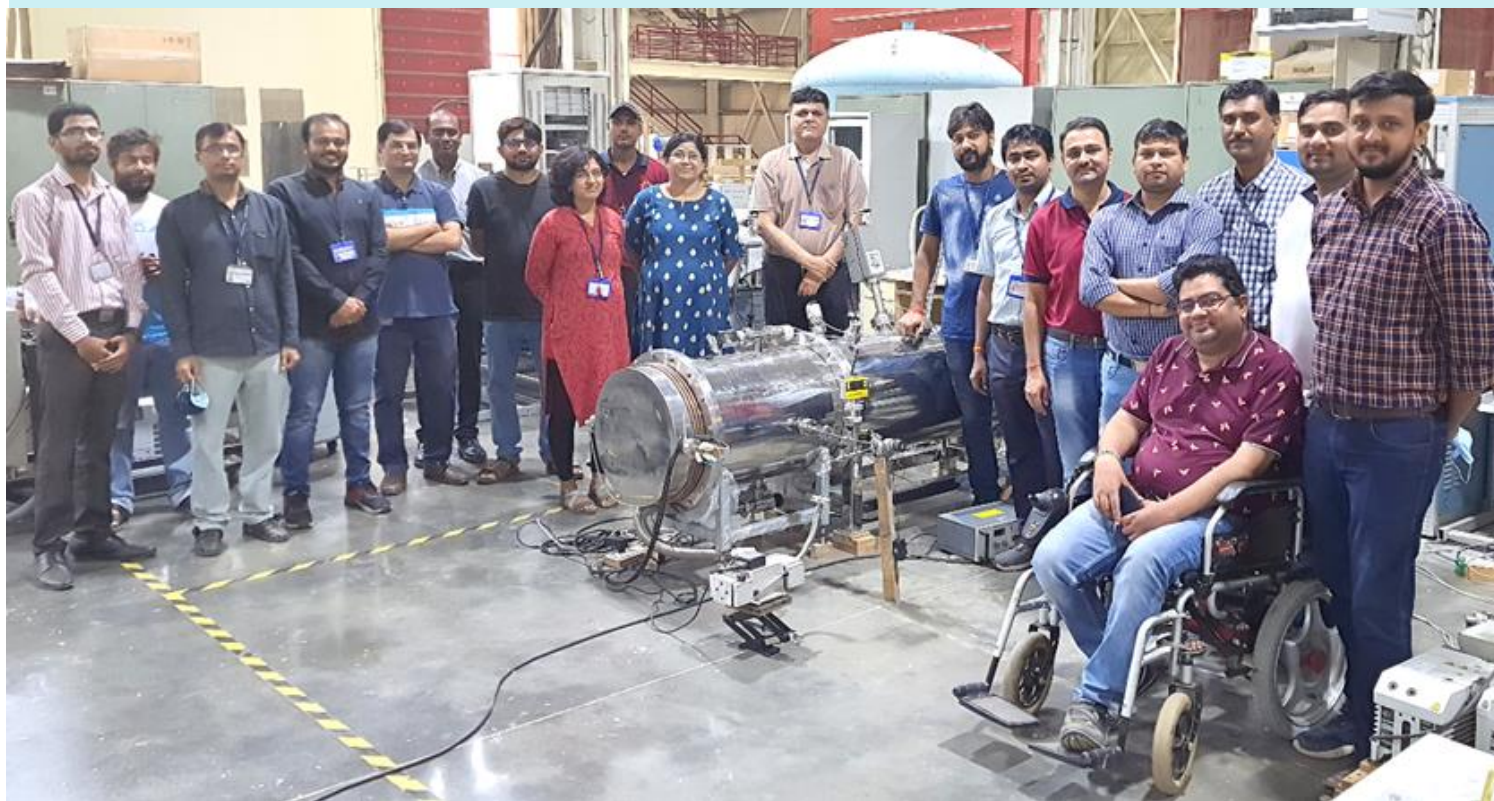
# The Fourth State

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

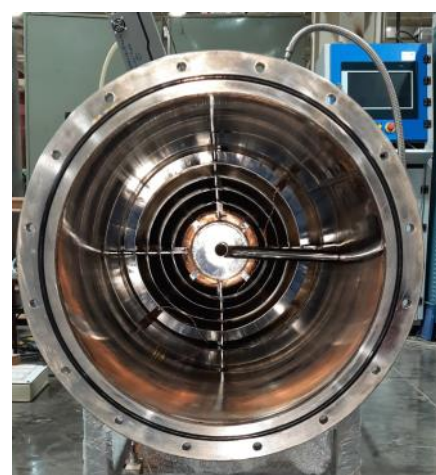
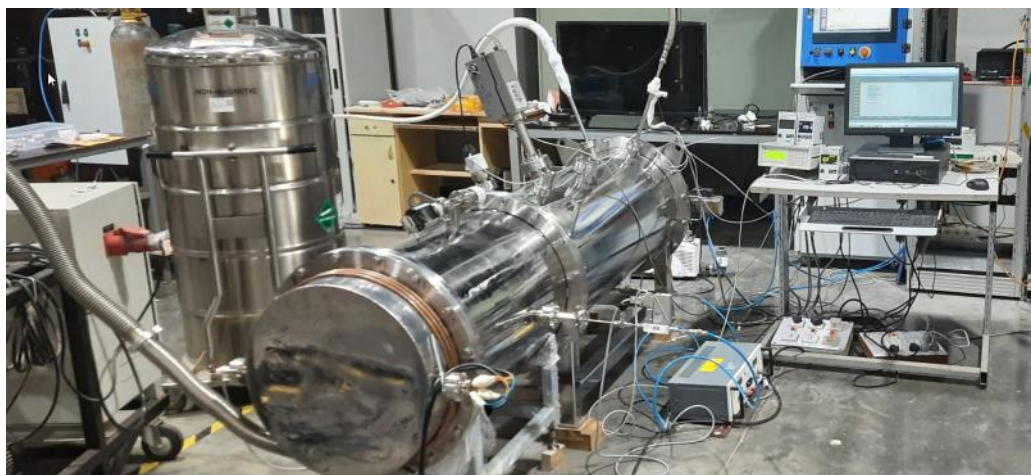


## In-house Development of LN<sub>2</sub> Cooled Sorption Cryopump for SST-1 Tokamak

A Liquid nitrogen-cooled sorption cryopump has been developed for the pumping of the vacuum vessel of the SST-1 Tokamak. This pump was tested for its performance and then installed on the radial port of SST-1. The pump has been designed for operation during the baking of the SST-1 vacuum vessel at 150°C. The pumping speed for water vapour was observed to be approximately 26,000 liter/sec while maintaining a pressure of  $10^{-6}$  millibar, for evacuating gas load of  $\sim 2.6 \times 10^{-2}$  mbar-liter/sec. The pumping speed was maintained during external heating, during which 258 Watts of external radiation heat load was handled by the pump. This is a contribution to *Atmanirbhar Bharat*.



The developed cryopump with team members of Cryopump, SST-1 Vacuum and Cryogenics Divisions



(L) The developed cryopump being tested (R) the inside view of the pump



The National Science Day 2022 was conducted as part of the *Azadi Ka Amrut Mahotsav* celebrations during 1-4 Feb, 2022 as an online event. Competitions were held in both offline (Poster and Essay) as well as online (Quiz, Skit, Eloquence and Science models) modes. Around 324 students and 15 teachers from 67 schools across Gujarat state participated in the various competitions that were conducted online over a week. Students and teachers from 23 schools won a total of 42 prizes. Details of prizes are listed on the [NSD2022 website](#).

Position	School	Prizes won	Points
1st Place	New Era Senior Secondary	Quiz, Essay (E), Poster (H,G), Model (T), Eloquence (H)	49 points
2nd Place	Podar International School, Ahmedabad	Poster (H), Model (S), Eloquence (G), Skit	27 points
3rd Place	Delhi Public School, Gandhinagar	Quiz, Poster (G), Eloquence (E)	25 points

As part of AKAM, a comic book for children on plasma was created by Outreach Division in English and this was also translated into 13 Indian languages by IPR staff members. This comic book was released by Director, IPR during the concluding session of NSD-2022. The comic book in all the translated languages are available on the IPR Outreach [website](#).



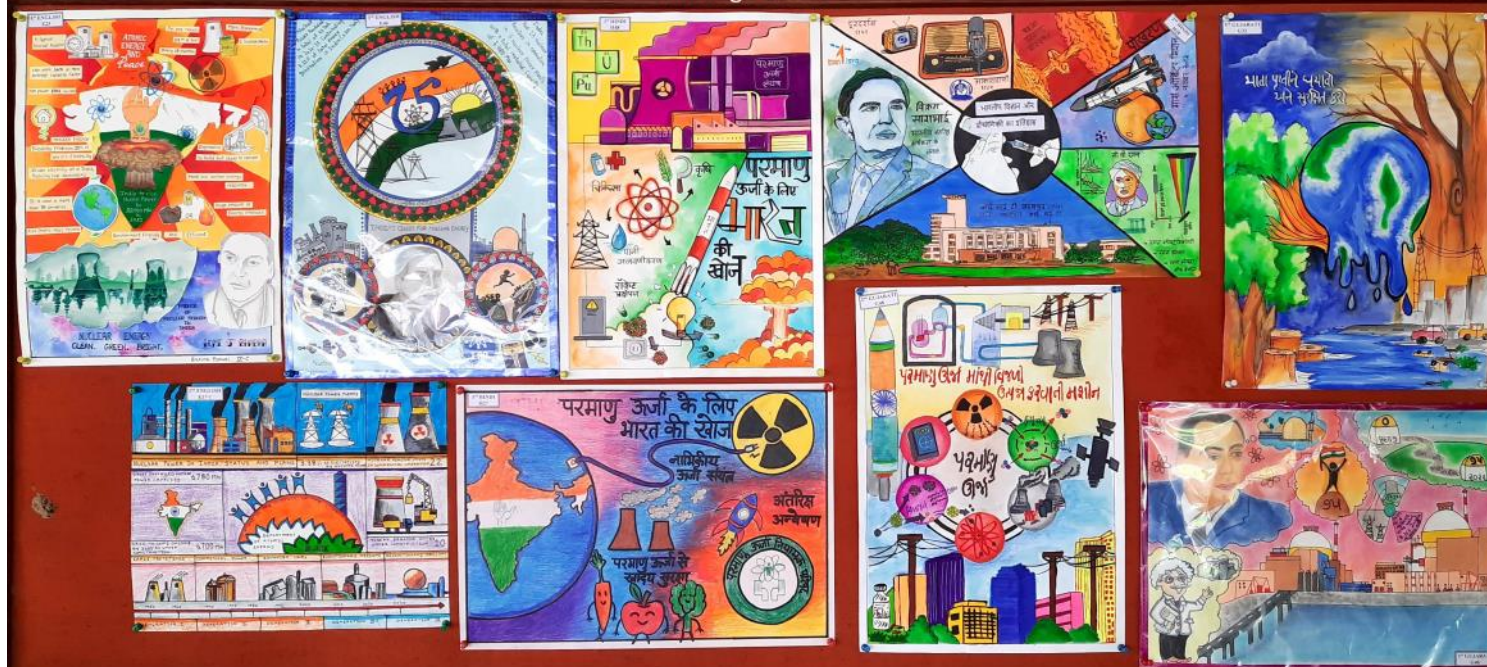
Images from the concluding session of NSD-2022 and the release of the comic book on plasma



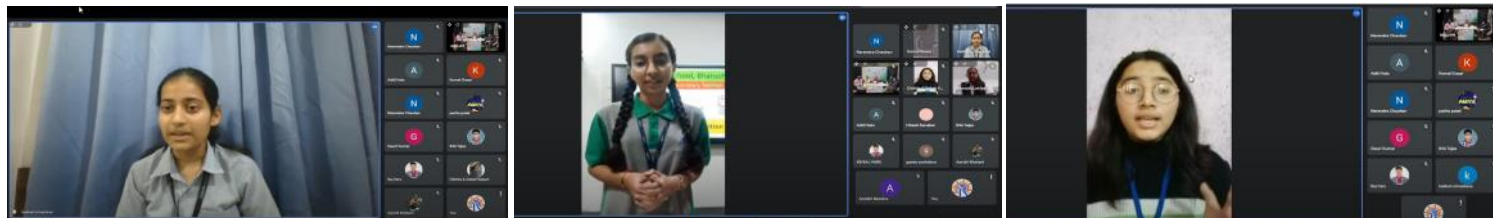


Prize winners of Quiz Competition (L) 1st - Tarishi Parmar (M) 2nd - Nitanshu Solanki (R) 3rd - Amogh Bhamerkar

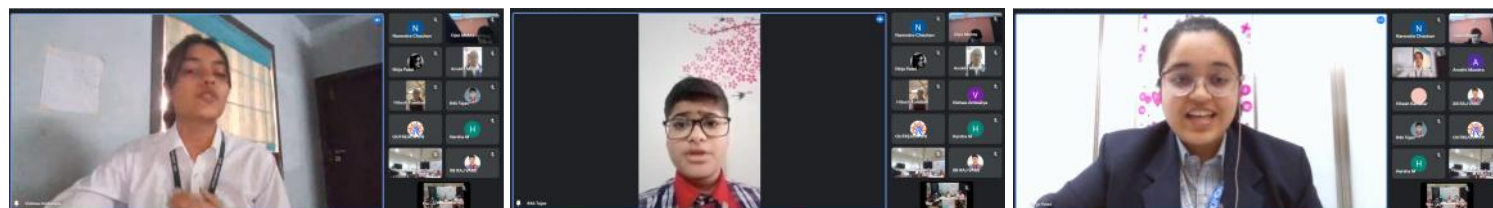
NSD-2022 Poster Competition  
Winning Posters



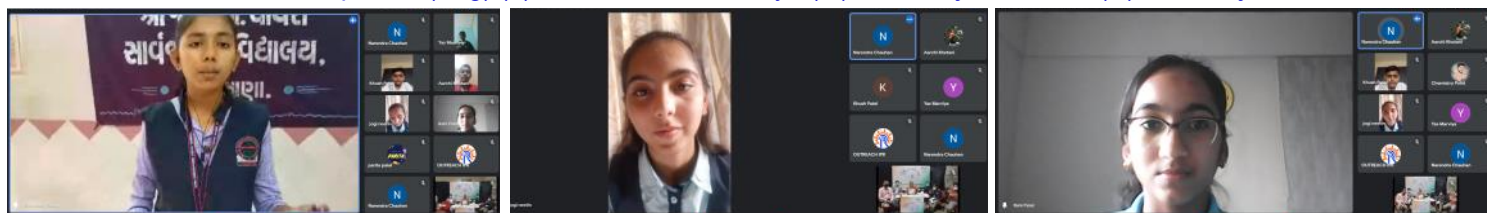
Prize winning posters of English, Hindi and Gujarati categories



Prize winners of Eloquence (Hin) (L) 1st - Kashvi Srivastava (M) 2nd - Komal Buch (R) 3rd - Dishita V Nikhilkumar



Prize winners of Eloquence (Eng) (L) 1st - Vishwa Ambaliya (M) 2nd - Tejas Dwivedi (R) 3rd - Nirja Vishal Patel



Prize winners of Eloquence (Guj) (L) 1st - Mansvi Kant Parmar (M) 2nd - Krisha Nitinbhai Jogi (R) 3rd - Rahi Patel

Competition	1st Prize	2nd Prize	3rd Prize
Essay Hindi	Bharvani Hirva	Shruti Lalitbhai Chosaliya	Neev Dalal
Essay English	Monalisa Das	Jiya Amitbhai Patel	Kashvi De
Essay Gujarati	Solanki Darshan Vinodbhai	Prinsh N. Gadhiya	Rajput Kavy Jaysinh





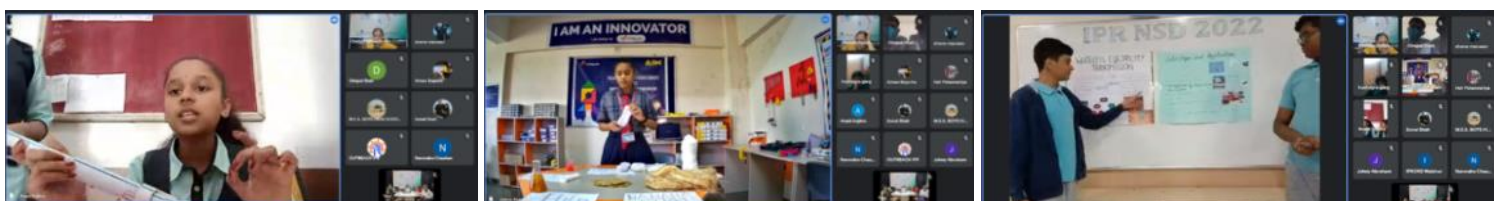
Release of the comic book "Wonderful World of Plasma"



Prize winners of Skit (L) 1st - Podar International School, Ahmedabad (M) Shree. G.K. Dholakiya School, Rajkot (R) 3rd - Shree Saraswati Vidya Mandir, Amreli



Winners of Students' Science Model (Rural Schools) (L) 1st - Khushi Pedhadiya (M) 2nd Dhruv Parmar, Ayush Parmar (R) 3rd - Ayushi Patel, Janshi Goswami



Winners of Students' Science Model (Urban Schools) (L) 1st - Avani Sojitra, Trisha Shelarka (M) 2nd - Dhvani Sharma (R) 3rd - Arnav Bopche, Akshat Singh



Winners of Teachers' Science Model (L) 1st - Avinash Jayswal (M) 2nd - Aditya Kavalanekar (R) 3rd - Bhavna Ahuja





The finals of the eloquence and science models being conducted online.



Interaction with teachers

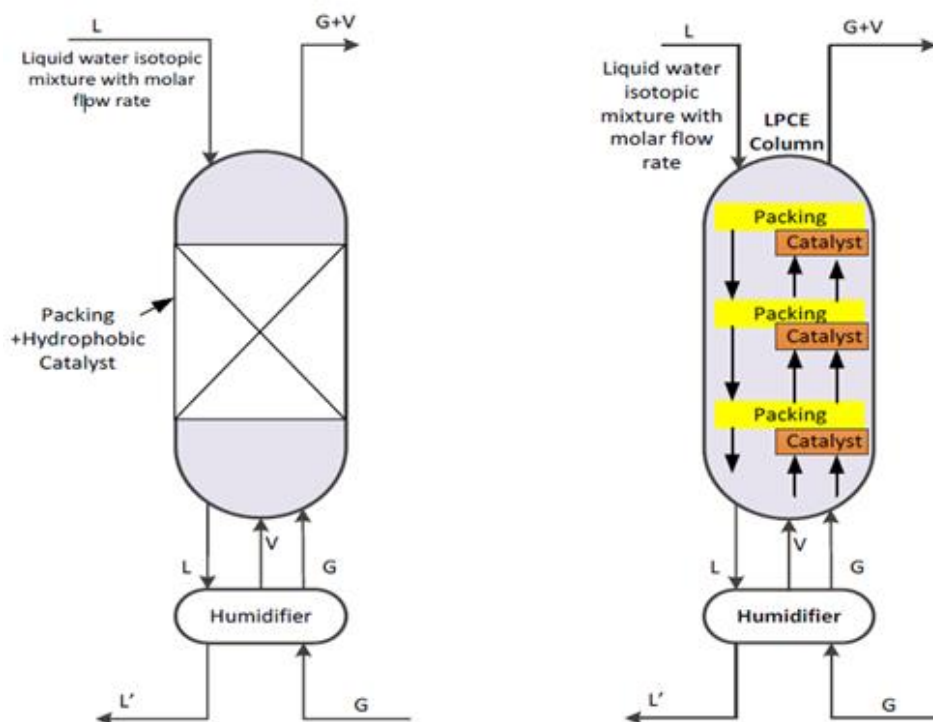


The NSD- 2022 team



## Successful Completion Of Model Development For Dynamic Simulation Of Liquid Phase Catalytic Exchange Unit (LPCE) Along With An Electrolysis Unit

For water detritiation at ITER, a very specific unit operation is planned in which the tritium is recovered from tritiated water using liquid-phase catalytic exchange (LPCE) process combined with an electrolysis unit. LPCE column, along with the electrolysis unit, is called combined electrolysis and catalytic exchange (CECE) process in general. IN-DA and ITER-IO, signed a task agreement (TA-C32TD35F1), on 28th February, 2019, with the objective that, IN-DA shall provide the custom built model of the LPCE unit of water detritiation system in ASPEN CUSTOM MODELER for simulation and optimization of process design parameters. ITER-IO is using ASPEN for the process development of various unit operations for tritium separation/processing unit operations in tritium plant. LPCE being a very specific separation process and unavailability of its build-in ready-made module in the ASPEN simulation software, raised the requirement of the Custom built module. This will also be helpful in developing a global process simulation model for ITER Tritium plant. The framed task was completed in February 2021, with the successful submission of the reports and the codes developed.

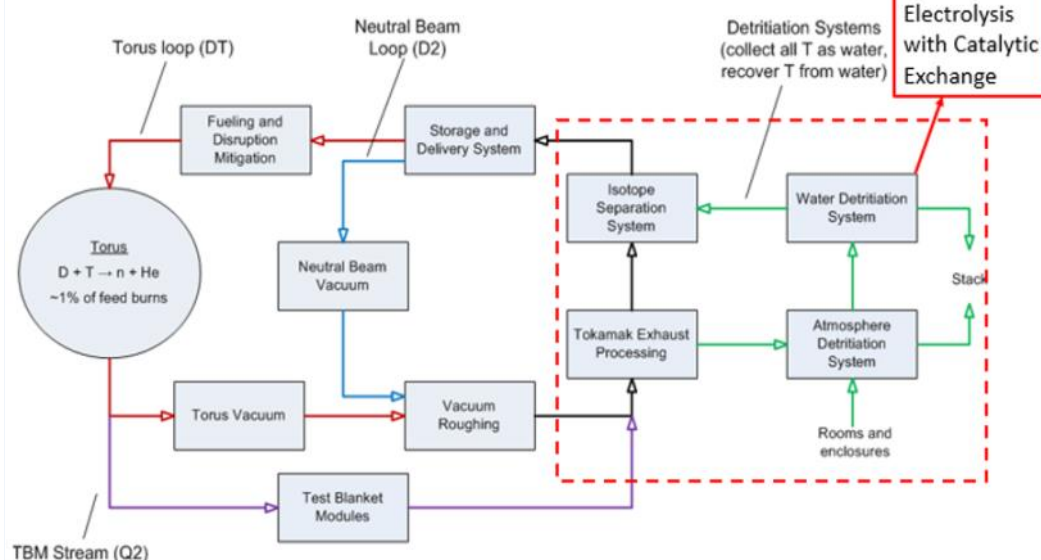


Configurations in LPCE column, (L) Trickle bed type (R) Segregated bed type

in the electrolyser or for parametric optimization of the column before replicating it in the ACM environment. The numerical model is developed for two type of column configurations of catalyst and packing in the LPCE column (as shown in figure-1), both in MATLAB as well as in ACM. For the verification of both the numerical models, ITER-IO provided the real time test

cases and also some steady state results of the already existing codes. Also a validation study of the mathematical model is performed using the experimental data of a facility currently using LPCE process for water detritiation, provided by ITER-IO.

Due to nearly similar coding environment of ACM and MATLAB, and an experience in the MATLAB programming, IN-DA decided to develop the MATLAB numerical model to analyze the sensitivity of the system to accumulation of heavier isotopic composition



Schematic showing the placement of the LPCE in the Tritium Plant of ITER.

Apart from the code development it is also concluded the requirement of minimum three reaction rate constants for the chemical isotopic exchange for the modeling of system processing a feed with trace tritium and potentially high deuterium concentrations. On the other hand just one mass transfer coefficient is sufficient to describe the phase isotopic exchange rate in the model.

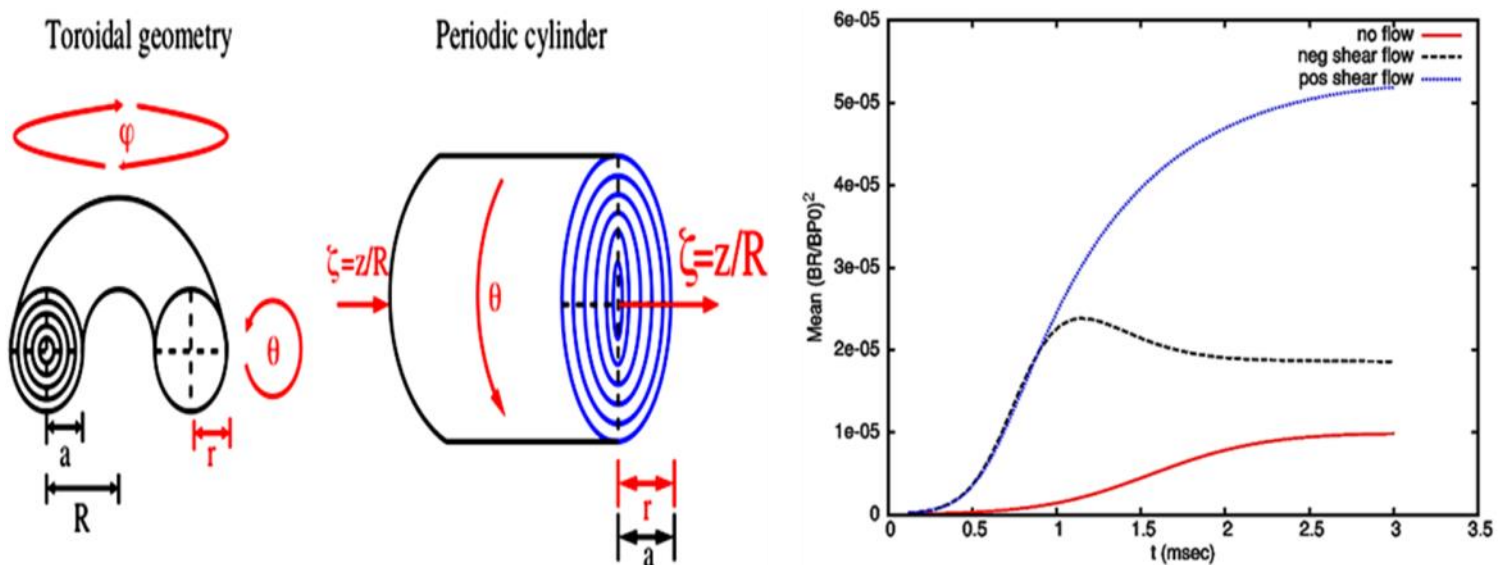
The strongest magnetic field in a tokamak is in the toroidal direction around the full length of the torus. This alone is however insufficient to contain the plasma, whose positively and negatively charged particles, although following magnetic field lines, would drift vertically in opposite directions due to the non-uniform toroidal magnetic field.

Hence, a poloidal magnetic field is required to prevent particle motion resulting in this effect. The combination of these two magnetic fields produces helical nested (pseudo) magnetic flux surfaces around the full domain of the torus. Tokamak is affected by various instabilities, particularly Macro-instabilities (like classical tearing mode, kink, etc.) which affect plasma stability, and Micro-instabilities (like micro-tearing mode) that affect plasma transport.

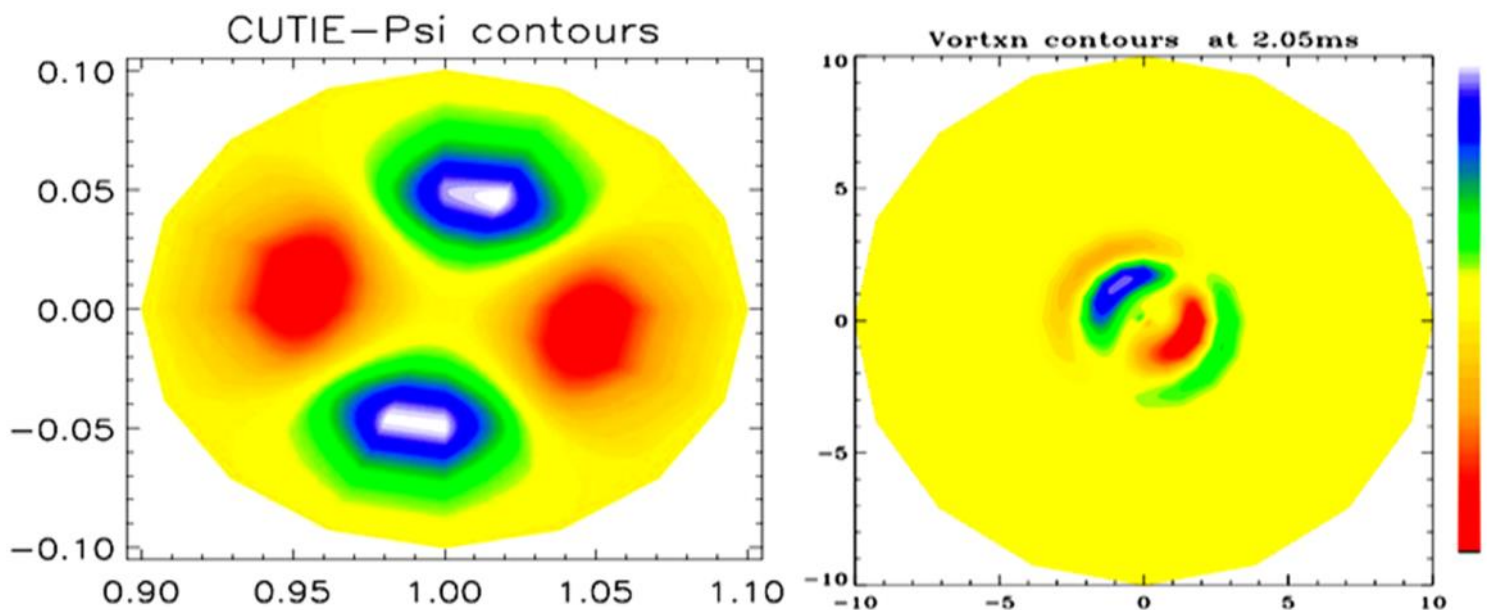
In this work, a particular class of Macro-instabilities has been numerically studied which are current driven resistive instabilities, such as the tearing and kink instabilities that play a key role in tokamak plasma stability and disruptions. The investigations of the effect of equilibrium flows have been carried out, which are known to have a beneficial effect on these instabilities, hence are of great importance experimentally.

A simple fluid description of the plasma in a cylindrical geometry has been considered and the CUTIE (Culham Transporter of Ions and Electrons) code has been used in the simulation runs performed on IPR HPC Cluster ANTYA. The cylindrical geometry investigations, using CUTIE show that in the linear regime pure axial sheared flows have a destabilizing influence while pure sheared poloidal flows tend to stabilize mode. These effects are independent of the sign of the flows.

In tokamak operations, flow is an unavoidable aspect of operations. By understanding the nature of flows, we can use it to our advantage and improve performance, confinement, and control impurities.



(L) A schematic representation of the geometry of a tokamak.  $R$  = Major Radius,  $a$  = Minor Radius and  $r$  = radial position ( $R$ ) Comparison of nonlinear evolution in absence of flow and different directions of flow.



(L) Contour plot of the (2,1) tearing mode as obtained from the CUTIE code (R) Vorticity contours of the (1,1) kink mode as obtained from the CUTIE code.

- ◆ **Dr. Rakesh Moulick**, gave an invited talk on "*Fundamentals of Plasma Physics*" at a Workshop on Thin Film Deposition and Device Fabrication, Vellore Institute of Technology, Vellore on 8th January 2022
- ◆ **Mr. Rajiv Sharma**, gave a talk on "अतिसुचालक फ्यूजन चुम्बकों के लिए न्यूट्रान प्रतिरोधी इन्सुलेशन पदार्थ का स्वदेशी विकास" at राष्ट्रीय हिंदी वैज्ञानिक वेब-संगोष्ठी- समाज-कल्याण में विकिरण एवं नाभिकीय प्रौद्योगिकी के अनुप्रयोग, IGCAR, Kalpakkam, on 10-11 January 2022
- ◆ **Dr. Braj Kishore Shukla**, gave a talk on "*EC-wave experiments on SST-1*" at 31st ITPA meeting of TG SOL and Divertor Physics on 18 January 2022
- ◆ **Mr. Sagar Agrawal**, gave a talk on "*Role of elemental composition of co-sputtered metallic thin film precursor in growth of CZTS layer*" at 2nd International Conference on Nanomaterials for Energy Conversion and Storage Applications (NECSA-2022), Pandit Deendayal Energy University (PDEU), Gandhinagar, on 22nd January 2022
- ◆ **Dr. Akash**, Indian Institute of Technology (BHU), Varanasi, gave a talk on "*High-Power Microwave / Millimeter wave Vacuum Electron Tubes and Passive Components*" on 28th January 2022
- ◆ **Dr. Basanta Parida**, gave a talk on "*Sputtering yield and nanopattern formation study of BNSiO<sub>2</sub> (Borosil) at elevated temperature relevance to Hall Effect Thruster*" on 4th February 2022
- ◆ **Dr. Gaurav Shukla**, Pandit Deendayal Energy University, Gandhinagar, gave a talk on "*Measurement of intrinsic plasma rotation in Aditya-U tokamak*" on 07th February 2022
- ◆ **Mr. Tanmay Macwan**, gave a talk on "*Effect of Short Gas-puff Pulses and Biased-electrode on Transport, MHD Instabilities, Plasma-Wall Interaction and Runaway Electrons in ADITYA-U Tokamak*" on 08th February 2022
- ◆ **Prof. B. S. Murty**, Indian Institute of Technology, Hyderabad, gave a talk on "*The exciting world of Materials*" on 10th February 2022 (Colloquium #310)
- ◆ **Dr. Jervis Ritesh Mendonca**, gave a talk on "*Equilibrium studies using IPREQ code and MHD simulations using the CUTIE code in ADITYA-U tokamak*" on 14th February 2022
- ◆ **Dr. Nageswara Rao Epuru**, gave a talk on "*Laser Photodetachment for the electron density and negative ion density measurements using Hairpin probe in the SPIN-eX Plasma device*" on 15th February 2022
- ◆ **Dr. Sandra KR**, Indian Institute of Technology Madras, Chennai, gave a talk on "*A Method for Non-intrusive Position Sensing using Multiple Mutually Coupled Planar Coils*" on 18th February 2021
- ◆ **Dr. Sadaf Jethva**, Saurashtra University, Rajkot, gave a talk on "*Studies on Properties of Mixed Valent Oxides*" on 25th February 2022

## Upcoming Events

- ◆ 3rd International Conference on Mathematical Modeling, Computational Intelligence Techniques and Renewable Energy (MMCITRE-2022), 4-6 March 2022. <http://mmcitare.com/>
- ◆ Workshop on Pulsed Power Technology and Applications, Saint-Paul-lez-Durance, France, 10-11 March 2022. <https://www.pulsed-power.org/events/pptworkshop>
- ◆ 7th International Conference on Machine Learning Technologies (ICMLT 2022), Italy, 11-13 March 2022 <http://www.icmlt.org/>
- ◆ Southern Regional Algebra Conference (SRAC-2022), United States, 18-20 March 2022. <https://www.gcsu.edu/southern-regional-algebra-conference-2022-department-of-mathematics>

## Know Your Colleague



**Mr. Sudhirsinh Vala** joined the Burning Plasma Diagnostic group at IPR in 2008. He is an M.E. in Electrical engineering from L.D College of Engineering and started his career as an Engineer at GEB. His areas of expertise in IPR are; ECR ion sources, charge particle accelerator, charged particle beam optics, neutron sources, radiation detection and neutron diagnostics.

He has contributed to the development of accelerator-based 14-MeV neutron source and ion beam irradiation facility for fusion research and also was involved in the development of the 2.45 GHz ECR ion source. He is the designated Radiological Safety Officer (RSO) of IPR and coordinates the Radiation Emergency Response Centre at IPR (RERC-IPR) with similar centers outside.

He presently heads the Neutron and Ion Irradiation Section at IPR.

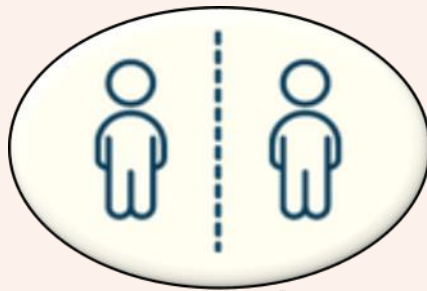


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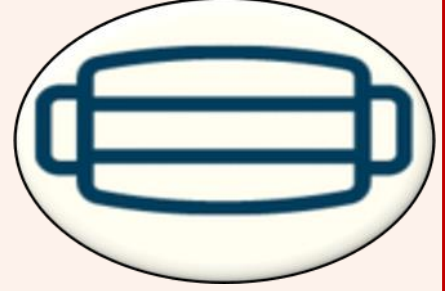
### Help Fight The Covid-19 Pandemic



**Wash Your Hands frequently  
With Soap**



**Ensure Social Distancing  
At ALL times**



**Always WEAR a Mask  
When you go outside**

- ◆ 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 - **S**ocial Distancing : **M**ask : **S**oap/ Sanitizer
- ◆ Strictly follow social distancing while outdoors, especially at work.

**Please get yourselves vaccinated  
against Covid-19**

**कृपया अपने आप को कोविड -19 के  
खिलाफ टीकाकरण करवाएं**

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

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