ISSUE 8 JULY 2021

GAṆANAM (गणनम्)

HIGH PERFORMANCE *COMPUTING* NEWSLETTER

INSTITUTE FOR PLASMA RESEARCH, INDIA

INSIDE THIS ISSUE (2 Pages)

Mechanism of Blob Formation in the Scrape-off Layer of a Tokamak Plasma

Vijay Shankar (PhD Student, **Plasma Devices Theory and Simulation Division, IPR)**
Email: vijay.shankar@ipr.res.in

Blobs play an important role in the edge plasma dynamics and are believed to contribute towards the anomalous and intermittent nature of plasma transport in the edge region. Over the past years, a large number of theoretical and experimental studies have been devoted towards investigations of their dynamical origin, their physical characteristics and their role in the edge transport. These studies have shown that blobs form in the edge or near the edge-to-SOL transition region where the shear of the radial electric field is high [1]. More recently, the role of radial shear of the poloidal electric field in the presence of radial shear of the radial electric field has been identified as an important ingredient in the blob formation mechanism [2]. These shears cause a differential stretching of a streamer structure in the radial and poloidal directions and when the rate of the stretching exceeds the growth rate of the interchange modes the streamer breaks and gives rise to a blob. Most of the above theoretical investigations on blob formation have been carried out under the simplifying assumption of a uniform background electron temperature. While such an assumption might be reasonable for most L-mode discharges, however, it is not valid for H mode discharges and may not always hold even for L-mode discharges. It is speculated that electron temperature and its gradient may play an important role in the edge plasma dynamics. A radial gradient of electron temperature can lead to a zonal flow shear near the last closed flux surface (LCFS) in the SOL region that can stabilize the edge turbulence and take the plasma into an H-mode operation. Electron temperature and its radial gradient may also be important in the L-mode through their contributions to the monopolar component of the electrostatic potential in a streamer. Thus, the formation of a blob from the breaking of a streamer structure either in the L-mode or H-mode can be significantly influenced by contributions from electron temperature and its gradient. In this work to see the effect of electron temperature and its gradient, we have derived analytically a general criteria of blob formation as:

$$\frac{\delta_x}{\gamma B \delta_y}\frac{\partial E_x}{\partial x}+\frac{1}{\gamma B}\frac{\partial E_y}{\partial x}+\frac{\delta_y}{\gamma B \delta_x}\frac{\partial E_y}{\partial y}\geq 1$$

Here γ is growth rate of interchange instability, δ_x and δ_y are radial and poloidal extent of blob, while $\partial E_x/\partial x$, $\partial E_y/\partial x$, and $\partial E_y/\partial y$ are electric field shears.

> ***"Presence of electron temperature and its gradient ensures monopolar natures of potential, due to which poloidal shear of poloidal electric field plays important role in blob formation in L-mode as well as H-mode discharges."***

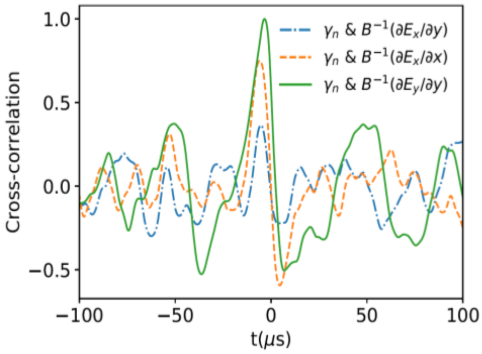


Figure 1: Cross-correlation between γ_n (non-linear growth rate) & $\partial E_x/B\partial x$, γ_n & $\partial E_x/B\partial y$, and γ_n & $\partial E_y/B\partial y$. The cross-correlations becomes the highest for γ_n & $\partial E_y/B\partial y$.

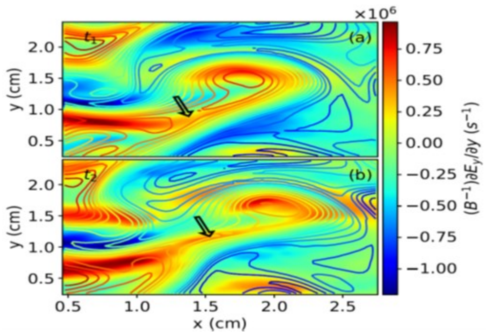


Figure 2: Superposition of plasma density (contour) and $\partial Ey/B\partial y$. The shear $\partial E_y/B\partial y$ becomes maximum at point (1.38 cm, 0.8 cm) during breaking at t_1 as shown in (a), after breaking at t_2 shown in (b).

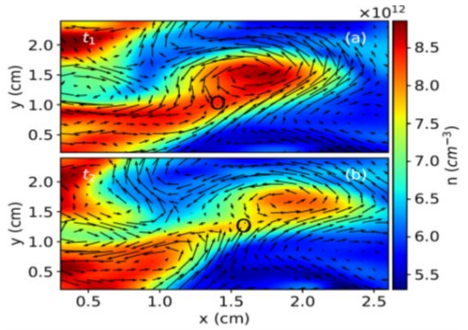


Figure 3. Superposition of plasma density and quiver plots for the radial and poloidal velocities at z=157.08 cm. The breaking positions are shown by "O".

To verify the blob formation criteria in the SOL region, we have performed 3D simulation in ***BOUT++ framework***, which is a MPI parallel code. Grid resolution taken here is $N_x \times N_y \times N_z$ =192×128×16 and code has been run for 50000 time steps using 512 cores of *ANTYA* which takes around 8 hours to complete. Here we have used flux driven model equations for simulation, which are modified form of model equations in [3,4]. From the simulation data we observe that due to monopolar nature of potential, contribution of last term ($\partial E_y/\partial y$) in blob formation, is greater than other terms. From Figure 1 we can see cross-correlation between γ & $\partial E_y/\partial y$ is greater than cross-correlation between γ & $\partial E_y/\partial x$ and γ & $\partial E_x/\partial x$. It is to be noted that the monopolar potential ensures that potential and electron temperature are maximum on the X-axis of the streamer so that E_y and $\partial E_y/\partial y$ will be nearly zero and maximum (In figure 2 shown by arrow), respectively. Therefore, the strong correlation between γ_n & $\partial E_y/\partial y$ can contribute to the formation of plasma blob. The dynamics of plasma during and after a blob formation has been shown in Figure 3(a) and 3(b) by a superposition of the plasma density (colormap) and quiver plots (arrows) related to radial and poloidal velocities. The direction of each arrow indicates the resultant direction of radial and poloidal velocities and magnitude of the resultant velocity is determined by the length of the arrows. The direction of arrows at the center of the blob during its formation stage in Figure 3 (a) indicates the spin/rotation about the local Z-axis in the anti-clockwise direction. A stagnation point appears where the plasma dynamics is minimum as indicated by "O". Here, the minimum plasma motion is confirmed by the minimum length of the arrows near "O" point where a differential plasma velocity is observed mainly due to the existence of different electric field shears. These electric field shears lead to the plasma leaving from this "O" point. Thus, the position is exactly the breaking position of the radially elongated streamer. Figure 3 (b) indicates the plasma dynamics after the streamer breaking. This work has been published (https://doi.org/10.1088/17414326/abeed7).

References:

1. *N. Bisai, A. Das, S. Deshpande, R. Jha, et.al Plasmas , 12(10):102515, October 2005*
2. *N. Bisai, Santanu Banerjee, and Abhijit Sen. Physics of Plasmas , 26(2):020701, February 2019.*
3. *L. Easy, F. Militello, J. Omotani, et.al Physics of Plasmas , 21(12):122515, December 2014.*
4. *N R Walkden, L Easy, F Militello et.al Plasma Physics and Controlled Fusion , 58(11):115010, November 2016.*

Python Package Management Using Conda – Part-1 General Overview

This HPC article series focusses on the need to use Python package management tools like Conda to solve a number of commonly encountered problems on ANTYA HPC related to package dependencies, reproducibility, installing packages, etc. to name a few. This series has been divided into 6 parts, covering 1 part in every issue:

- **Part-1: General Overview**
- **Part-2: Creating Conda Environments and Installing Packages**
- **Part-3: Using Different Conda Channels for Packages Installation**
- **Part-4: Generating and Sharing Your Conda Environments**
- **Part-5: Making Conda Environments Visible in Jupyter Notebook**
- **Part-6: Managing GPU Dependencies in Conda Environment**

What is Conda?

Conda is an open source package and environment management system that runs on Windows, Mac and Linux operating systems. It helps you to find and install Python packages easily and quickly in your user environment without any admin support.

Why use Conda?

Resolving the versions dependencies of your Python application is often challenging and takes lot of time. Requesting for installing Python packages system-wide creates complex dependencies between your project specific application that shouldn't really exist.

> ***"To not reinvent the wheel, Conda ensures your application developed on your local machine is easily reproducible by capturing all package dependencies in a single requirements file"***

ANTYA UPDATES AND NEWS

1. New Packages/Applications Installed

⇒ **Scilab-6.1.0 module**

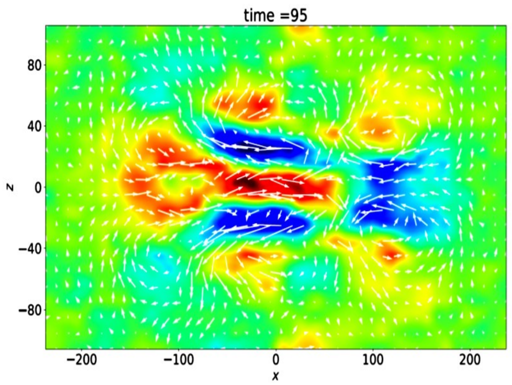
⇒ **IMAS dependencies installation of openjdk, apache_ant, blitzpp, md5plus and libxml2 as individual modules.**

⇒ **ORB5 (Group Account)**

CPU and GPU versions installed successfully in the group account which is accessible to authorized users only.

GPU Application Hackathon (GAH-2021) C-DAC Online Event
July 26, 2021 - August 4, 2021
Registration and Details

Quadrupolar Flow Observed in A 3D Yukawa Liquid
(HPC Picture of the Month)



Pic Credit: **Mr Suruj Kalita**

The above figure is generated using In-house developed multi-node multi-card GPU based MPMD-3D code.

It is produced by Molecular Dynamics simulations of 6.1 X 10^5 particles using 4X P100 GPU cards. The total runtime was 68715 seconds.

Other Recent Work on HPC (Available in IPR Library)

Effect of particle mass inhomogeneity on the two-dimensional Rayleigh-Benard system of Yukawa liquids: A molecular dynamics study	PAWANDEEP KAUR
Numerical Prediction of the Operating Point for Cryogenic Twin-Screw Solid Hydrogen Extruder System	SHASHI KANT VERMA
Experimental Validation of Universal Plasma Blob Formation Mechanism	NIRMAL K BISAI
Numerical Simulation of Diesel Combustion Passing Through High Power Arc Region in a Plasma Fuel System	SUNIL BASSI
CFD Analysis of Plasma Process Chamber of 25 TPD Plasma Gasification System	HARDIK GIRISHBHAI MISTRY
Numerical Simulation of RE Deconfinement Experiment Using Local Magnetic Field Perturbation in Aditya Tokamak	SOMESWAR DUTTA
Unambiguous stability of ultra slow electron holes and their characteristics in the novel stability regime	DEBRAJ MANDAL
(Solitary) Electron and Ion Hole Excitation in Current-Driven Plasmas - A status report with new perspectives Part 2 - Simulations	DEVENDRA SHARMA
Simultaneous Close to Exact Estimation of Many Thermodynamic Parameters of 2D Yukawa Fluids	ANKIT DHAKA

Tip of the month

TO CHECK ALL THE AVAILABLE QUEUES RESOURCE LIMITS

```
$ qstat -Qf
```

Acknowledgement

The HPC Team, Computer Division IPR, would like to thank all Contributors for current issue of *GAṆANAM*.

On Demand Online Tutorial Session on HPC Environment for New Users Available
Please send your request to ***hpcteam@ipr.res.in.***

Join the HPC Users Community
hpcusers@ipr.res.in
If you wish to contribute an article in GAṆANAM, please write to us.

Contact us
HPC Team
Computer Division, IPR
Email: ***hpcteam@ipr.res.in***

Disclaimer: " GAṆANAM " is IPR's informal HPC Newsletter to disseminate technical HPC related work performed at IPR from time to time. Responsibility for the correctness of the Scientific Contents including the statements and cited resources lies solely with the Contributors.