

Seminar

Institute for Plasma Research

Title: Study of high frequency electrostatic drift waves in presence of ion-neutral collisions and investigation of self-organized critical and multifractal behaviour with implications in nonlocal transport of Aditya-U tokamak

Speaker: Dr. Siba Prasad Acharya
Institute for Plasma Research, Gandhinagar

Date: 24th March 2026 (Tuesday)

Time: 10:00 AM

Venue: Seminar Hall, IPR

Join the talk online: URL: <https://bharatvc.nic.in/viewer/5992138016>

(Conference ID: 5992138016; Password: 232142)

Abstract

In this talk, I will focus on two different topics. Firstly, high frequency electrostatic drift wave modes are shown as hybrid modes generated by mixing with cyclotron dynamics and grow at the expense of cyclotron modes due to mode coupling effects. The role of density gradient is to break the symmetry between the two cyclotron branches with strong values of the gradient causing the branch modified by drift to overlap with the cyclotron branch leading to a mode coupling instability. The analysis is carried out in the framework of a fluid model without invoking collisional or finite Larmor radius effects. A second order nonlinear equation with variable coefficients has been derived to govern the dynamics of high frequency electrostatic drift waves in a moving frame of $(2 + 1)$ spatio-temporal dimensions to show the wave characteristics in various parameter ranges. Subsequently, effects of ion-neutral collisions are included in the model to derive a cubic dispersion relation with complex coefficients for high frequency drift waves. Different solutions of the nonlinear equation indicate the stabilizing effects of ion-neutral collisions on the drift waves due to which they propagate by forming solitary wave-like structures. The possibilities of excitation of the high frequency electrostatic drift waves have been explored in the context of certain laboratory and astrophysical plasma systems including tokamaks and solar corona where the existence of steeper density gradients is more probable. In particular, theoretical calculations indicate that the high frequency drift waves can be excited in the maximum gradient regions of the scrape-off layer (SOL) in Aditya-U tokamak. This further warrants experimental investigations of this interesting fact.

Secondly, we have focused to study the multiscale nature of fluctuations in fusion plasmas where largest scales are of the order of the dimensions of the device and smallest scales are of the order of Larmor radius of charged particles. In this regard, self-organized criticality (SOC) plays a crucial role due to its scale invariance nature. Initially, magnetic fluctuations of different plasma discharges in Aditya-U tokamak are analyzed to study typical signatures of SOC systems. This has been investigated using presence of $1/f$ power laws, long-range correlations and non-Gaussian probability distribution functions. The presence of long-range correlations in magnetic fluctuations has been studied with help of the Hurst exponent estimated using rescaled range (R/S) statistics. This is also accompanied with estimating the generalized Hurst exponent with help of multifractal detrended fluctuation analysis (MFDFA) to study the multifractal nature. Fluctuations in floating potential and ion saturation current show SOC dynamics in certain frequency ranges. Implications of these results on nonlocal transport in Aditya-U tokamak have been discussed. In particular, our results indicate

that nonlocal effects like observed sharp increase in density and temperature at core of Aditya-U tokamak associated with simultaneous decrease at edge may occur due to avalanching phenomena of SOC systems. Similarly, the multifractal nature of fluctuations indicate the presence of multifractality in edge turbulence.

Two different topics are covered in this talk due to the fact that the high frequency drift waves as well as self-organized critical behaviour of fluctuations can have significant implications in cross-field transport of different magnetically confined plasma systems.

References:

- [1] T. Klinger, A. Latten, A. Piel, G. Bonhomme, T. Pierre and T. Dudok de Wit *Physical Review Letters* 79, 3913 (1997).
 - [2] A. Ghosh, S. K. Saha, S. Chowdhury and M. S. Janaki *Physics of Plasmas* 22, 122111 (2015).
 - [3] S. P. Acharya and M.S. Janaki *Chaos, Solitons and Fractals* 160, 112210 (2022).
 - [4] S. P. Acharya and M. S. Janaki *Under Review in Physics of Plasmas* (2026).
 - [5] T. L. Rhodes, R. A. Moyer et al. *Physics Letters A* 253, 181-186 (1999).
 - [6] O. Pan, Y. Xu, C. Hidalgo et al. *Nuclear Fusion* 55, 113010 (2015).
 - [7] R. Sanchez and D. E. Newman *Plasma Physics and Controlled Fusion* 57, 123002 (2015).
-