Seminar

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Institute for Plasma Research

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Title: Effect of impurity gas seeding on the boundary region of a tokamak

Speaker: Mr. Shrish Raj
Institute for Plasma Research, Gandhinagar

Date: 27th March, 2024 (Wednesday)
Time: 10:30 AM
Venue: Seminar Hall, IPR

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Abstract

The present thesis work is devoted to an investigation of the impact of neutrals on the interchange plasma turbulence present in the boundary regions (edge/SOL) of a tokamak. An extended theoretical model based on the drift-reduced Braginskii equations [1] has been developed. This model self-consistently incorporates the coupling of interchange plasma turbulence in the edge and SOL regions with medium-Z impurity gases such as N_2, Ne, and Ar. The model equations have been solved using the BOUT++ [2] framework under uniform ion temperature conditions. The two-dimensional (2D) fluid simulations, carried out in a slab geometry, examine in detail the dynamical interaction between the charged ions and the plasma turbulence. The principal findings are presented in terms of observed modifications in the radial profiles of plasma density, electron temperature, and neutral density [3].

Additionally, the transport of impurity ions under different curvature conditions has been studied. The numerical findings suggest that the low ionization states produced in the outer SOL region can migrate inward due to the poloidal electric field E_y, and in the inner region, they can further ionize, generating higher-charged ions. Consequently, the density of higher-charged ions may vary if the effective gravity (curvature) is altered. These findings have been

utilized to explain the fluctuations in radiation power during impurity seeding experiments in ADITYA-U [4]. The simulations also reveal that the transport of singly stripped impurity ions is directly associated with mono-polar density holes.

To validate the numerical findings, an analytical relationship between impurity ion density and plasma vorticity in the presence of various density sources and sinks has been derived. The analytical expression has been compared with simulation results and the amount of impurity ion transport by these holes has been quantified [5].

Furthermore, this model has been adapted for ITER-like conditions with the inclusion of ion temperature and generating low-frequency ITG turbulence. When applied to study plasma-impurity interaction, this model shows a self-consistent reduction in the transport coefficients. This behavior is reminiscent of results obtained from past SOLPS-ITER simulations within the pedestal region. The present results however fall somewhat short of achieving the targeted Q=10 performance of ITER – a shortcoming that is planned to be addressed within the future scope of the thesis.

References:

[1] *S. I. Braginskii. Review of Plasma Physics, volume 1. New York: Consultant Bureau, 1965.*

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[3] *Raj, S., Bisai, N., Shankar, V., & Sen, A. (2020). "Effects of nitrogen seeding in a tokamak plasma". Physics of Plasmas, 27(12), 122302.*

[4] *Raj, S., Bisai, N., Shankar, V., Sen, A., Ghosh, J., Tanna, R. L. et.al.(2022). "Studies on impurity seeding and transport in edge and SOL of tokamak plasma". Nuclear Fusion, 62(3), 036001.*

[5] *Raj, Shrish, Nirmal Bisai, Vijay Shankar, and Abhijit Sen. "Argon, neon, and nitrogen impurity transport in the edge and SOL regions of a tokamak." Physics of Plasmas 30, no. 6 (2023).*