Seminar

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Institute for Plasma Research

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Title: Sheath Effects on the Resonance Hairpin Probe in Negative Ion Diagnostics

Speaker: Mr. Pawandeep Singh
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Date: 10th July 2024 (Wednesday)

Time: 11:00 AM

Venue: Seminar Hall, IPR

Joint the talk online: https://meet.google.com/sve-bvmj-tso

Abstract

Sheaths are non-neutral zones that develop around surfaces exposed to a plasma as a result of a large difference in ion and electron mobility. Its effects can be seen in many situations when plasma and a surface come into contact. Typical instances include plasma processing of substrates, plasma-wall interaction in tokamaks, laboratory dust particle charging, and orbiting satellites in space. The sheath problem also arises in electric probe diagnostics. In essence, the sheaths control the collection of ions and electrons on the probe surfaces. The properties of sheaths are inextricably linked to the plasma through the charge particle flux at the boundary separating the sheath from the quasi-neutral plasma.

This thesis aims to investigate the impact of the sheath that forms around the cylindrical limbs of a hairpin probe on the detection of negative ions. In particular, when using analytical models combined with the experimentally obtained resonance frequency characteristic of a hairpin probe, certain pertinent characteristics emerge. These characteristics include the sheath correction factor for an ion-collecting probe and the precise value of the electric field at the sheath boundary. This enables an accurate determination of the saturation current ratio, sheath width, and sheath potential profile. This is especially important for estimating the negative ion density and the thermal electron effect on the sheath dielectric constant. This thesis also briefly presents an experimental investigation of a pulsed-bias hairpin probe to determine negative ion density. It is found that the signature of negative ions becomes clouded during the recovery of depleted plasma density. To mitigate this overshadowing of negative ion density and recovery, an optimal bias voltages are thus introduced.

1. Pawandeep Singh, Swati and S. Karkari, “Equilibrium properties of inhomogeneous partially-magnetized plasma containing negative ions” Journal of Physics D: Applied Physics, 2022, 55, 235201.
2. Pawandeep Singh, S. Dahiya, A. Pandey and S. Karkari, “Hairpin probe assisted saturation current ratio method to determine plasma electronegativity” Plasma Sources Science and Technology, 2023, 32, 045013.
3. Pawandeep Singh, A. Pandey, S. Dahiya, Y. Patil, N. Sirse, S. Karkari, "Effect of thermal electrons on electron and ion sheath around DC biased hairpin probe in an electronegative plasma" (arXiv:2406.13497, Under Communication).

4. Pawandeep Singh, A. Pandey, S. Dahiya, S. Karkari, “Determining sheath edge electric field around cylindrical pins of a DC-biased hairpin resonator probe”. Plasma Sources Science and Technology, 2024, 33(5), 055012.
5. Pawandeep Singh, S. Dahiya, A. Pandey, Y. Patil, S. Karkari, "Development of Volume Produced Negative Ion Source using a CCRF Discharge" (arXiv:2406.13506, Under Communication).
6. Pawandeep Singh and S. Karkari, "Optimization of pulsed bias hairpin probe for negative ion diagnostics" (Under Communication).