Seminar

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Institute for Plasma Research

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Title: Studies of Sheath Effect on Resonance Hairpin Probe for Electronegative Plasma Diagnostics

Speaker: Mr. Pawandeep Singh,

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Date: 7th February 2024 (Wednesday)

Time: 03:30 PM

Venue: Seminar Hall, IPR

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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.

The thesis deals with the impact of the sheath created around the cylindrical wire surfaces of a resonator hairpin probe that is applied in low-temperature plasma for the diagnosis of negative ions. In particular, using analytical models combined with the experimentally obtained resonance frequency characteristic, a number of useful parameters, namely the sheath correction factor for an ion-collecting probe, and the exact value of the electric field at the sheath boundary, have been established. This allows to determine the saturation current ratio accurately to estimate negative ion density and also facilitates calculation of density and potential profile inside the sheath. The work also revisits how the thermal electrons affect the sheath's dielectric properties when the hairpin probe is externally biased from the ion saturation to the electron saturation regime. This underlying property has a strong influence on the estimation of electron density and the sheath width found using a DC-biased hairpin probe.

Additionally, positive ion recovery inside collapsing ion sheath around the cylindrical wire surfaces of a resonator hairpin probe has been investigated by introducing a train of negative voltages to the hairpin. It is seen that in the absence of negative ions, electron density recovery happens at the positive ion time-scale, whereas a transient overshoot in electron density is seen when significant number of negative ions are present, provided the negative probe-bias is quickly brought back to plasma potential. These renewed findings are found to have important consequence on the estimation of negative ion density based on a pulsed bias hairpin probe.

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1. ***Pawandeep Singh***, *Swati and Shantanu Kumar Karkari, Journal of Physics D: Applied Physics, 2022, 55, 235201.*
2. ***Pawandeep Singh***, *Swati Dahiya, Avnish K Pandey and Shantanu Kumar Karkari, Plasma Sources Science and Technology, 2023, 32, 045013*
3. ***Pawandeep Singh***, *Swati Swati, Avnish Pandey, Shantanu Karkari, "Effect of thermal electrons on electron and ion sheath around DC biased hairpin probe in an electronegative plasma" (Under Communication with PSST)*
4. ***Pawandeep Singh***, *Avnish Pandey, Swati Dahiya, Shantanu Karkari, "Determining Sheath edge electric field around cylindrical pins of a DC biased hairpin resonator probe" (Under Communication with PSST).*