Seminar

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Institute for Plasma Research

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Title: Relativistic calculation of cross-sections for electron-induced processes and their application in optical plasma diagnostics and machine learning methods

Speaker: Dr. Indhu Suresh
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Date: 07th November 2025 (Friday)

Time: 10.00 AM

Venue: Seminar Hall, IPR

Abstract

Laser-produced plasmas (LPPs) are transient and spatially inhomogeneous, posing significant diagnostic challenges. Accurate estimation of key plasma parameters, such as electron temperature and density, relies on collisional-radiative (CR) models, which account for the interplay of collisional and radiative processes governing atomic and ionic populations. These models, particularly when combined with optical emission spectroscopy (OES), enable parameter extraction but are often limited by the scarcity of reliable electron impact excitation (EIE) cross-section data. The present work addresses these gaps by focusing on LPPs of Tin (Sn) [1], Molybdenum (Mo) [2], and Gallium (Ga) [3, 4], elements relevant to applications in extreme ultraviolet generation, fusion, and semiconductor technology. Using the relativistic distorted wave (RDW) approximation and the multi-configurational Dirac-Fock structure, fine-structure-resolved EIE cross-sections were calculated for Sn I, Sn II, Mo I, Ga I, and Ga II, with many reported for the first time. The results were validated against available data and incorporated into detailed CR models, which, when coupled with time-resolved OES, enabled reliable plasma diagnostics. To meet the need for real-time diagnostics and reduce the computational cost of CR modelling, machine learning (ML) techniques such as random forest and gradient boosting regression were developed and integrated with CR simulations and OES data. Trained on large CR model-generated datasets, the ML models achieved high accuracy (R2> 0.99) and were successfully validated with experimental measurements, offering fast and precise diagnostics [5]. Overall, this work delivers new EIE cross-section data, advances CR models, and demonstrates ML-assisted frameworks for real-time characterization of LPPs, providing versatile tools for both scientific research and industrial plasma applications.

References :

[1] Suresh, I., Srikar, P. S. N. S. R., Priti, Srivastava, R., & Gangwar, R. K. (2023). *Plasma Sources Science and Technology*, 32(7), 075006.
[2] Suresh, I., Srikar, P. S. N. S. R., Priti, Srivastava, R., & Gangwar, R. K. (2022). *Plasma Sources Science and Technology*, 31(9), 095016.
[3] Suresh, I., Priti, Srivastava, R., & Gangwar, R. K. (2024). *Spectrochimica Acta Part B: Atomic Spectroscopy*, 213, 106860.
[4] Suresh, I., Priti, Srivastava, R., & Gangwar, R. K. (2024). *Plasma Sources Science and Technology*, 33(2), 025018.
[5] Suresh, I., Srikar, P. S. N. S. R., & Gangwar, R. K. (2024). *Physics of Plasmas*, 31(11), 113501.