Seminar

Institute for Plasma Research

Title : Spectroscopy modeling of laboratory plasma through a detailed plasma model using the reliable electron impact excitation cross-sections

Speaker: Dr. Shivam Gupta
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Date : 08th January 2021 (Friday)

Time : 03.30 PM

Venue : Online - Join the talk:
https://meet.ipr.res.in/Dr.ShivamGupta_PDFTalk

Abstract :

It is important to study various plasmas generated by different experimental techniques as well as their characterization by developing a suitable plasma model to obtain the plasma parameters viz. electron temperature (Te) and density (ne) [1,2]. In the recent years, efforts are being made to carry out the diagnostics of the different laboratory plasmas by using extensive plasma models. The development of a plasma model for any laboratory plasma requires essentially the atomic data of fine structure energy levels, transition probabilities and electron impact excitation (EIE) cross-sections of involved various transitions for the incorporation of different collisional and radiative processes occurring in the plasma. Recently, with the help of various optical emission spectroscopy (OES) measurements, many detailed collisional radiative (CR) models have been developed where the theoretically calculated EIE cross-sections and other atomic data have been utilized for the characterization of different inert gas viz. Ne, Ar, Kr and Xe plasma. In addition, different spectroscopic studies of Ar/N2 [3], Ar/O2 and Ar/CO2 mixture plasma have been reported only in the recent years. In a similar way, many laser produced plasmas are being created using the different metal targets viz. Zn, Cu, Mg, Al, etc., but due to the lack of complete set of EIE cross-section data of these metal target atoms, the suitable plasma models have not been developed. Moreover, there have been current interest in carrying out the diagnostics of the low temperature inert gas plasma through their ionic emission lines observed in the spectral measurements, but so far there are not extensive studies with the measured ionic emission lines from different inert gas ions. This can also be attributed due the lack of detailed EIE cross-sections for inert gas ions and consequently there is urgent need of the calculations of the same.

However, the reports of detailed or complete set of atomic and electron-collision data are still lacking for many neutral atoms and ions. Unfortunately, the measurements of the electron impact excitation crosssections have been done only at few selected electron impact energies and also mostly for the transitions from the ground state to few selected excited upper states, which are thus not sufficient at all to develop an adequate CR model. Therefore, the requirement of detailed cross-sections for large number of fine structure transitions can only be fulfilled through the theoretical approximation method. In view of this, in my Ph.D. program, an attempt has been made to fulfill such requirements by carrying out the relativistic calculations for the neutral atoms and ions. Specifically for their excitation energies, radiative transition probabilities, EIE cross-sections, and the rate coefficients and thereafter implementing these in a suitable CR model to characterize the laboratory plasmas.

In the light of above discussions, I will present the development of two different collisional-radiative models for the characterization of low temperature laser produced Zn plasma and Ar/N2 inert gas mixture plasma through their reported spectral line measurements. In addition, the calculation of EIE cross-sections for singly ionized inert gas ions viz. Kr+ [4] and Xe+ [5] ions will be presented. The details of the excitation cross sections results along with the CR model results will be presented in the talk.

References:

[1] S. Gupta, R.K. Gangwar, and R.Srivastava, Plasma Sources Sci. Technol., 28, 095009 (2019).

[2] S. S. Baghel, S. Gupta, R. K. Gangwar, and R. Srivastava, Plasma Sources Sci. Technol., 28, 115010 (2019). [3] S. Gupta, R. K. Gangwar, and R. Srivastava, Spectrochim. Acta - Part B, 149, 203 (2018).

[4] S. Gupta and R. Srivastava, J. Quant. Spectrosc. Radiat. Transf., 253, 106992 (2020).

[5] S. Gupta, L. Sharma, and R. Srivastava, J. Quant. Spectrosc. Radiat. Transf., 219, 7 (2018).