Electron-Impact Excitation of Inert Gas Atoms (Ions) and Plasma Modeling

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The study of electron impact excitation (EIE) of atoms / ions and their related application to plasma diagnostics is an active area of research. The characterization of plasma i.e. for its diagnostic purposes a collisional-radiative (CR) model is required. The plasma modeling requires large amount of accurate atomic data for electron impact excitation process so that the proper plasma modeling can be done. Therefore, there is a need to carry out reliable calculation using relativistic distorted wave (RDW) theory to obtain the cross sections for several fine structure transitions involved in the plasma. Thereafter, the development of suitable CR model is then done by incorporating the calculated fine-structure excitation cross-sections for the plasma. In this light, we have taken up two separate studies and carried out the calculations. This work, I plan to present in the ICTP-IAEA workshop and briefly described below.

Diagnostics of Ar/N_2 mixture plasma with detailed electron-impact argon fine-structure excitation cross sections: CR model is developed for the Ar/N_2 mixture plasma using reliable EIE cross sections of argon. We consider several fine structure transitions of argon and their corresponding cross sections used in the model have been obtained using fully relativistic distorted wave theory. Processes, which account for the coupling of argon with nitrogen molecules, have been added in the model. For diagnostic purposes we couple CR model with the optical emission spectra (OES) measurements of Lock *et al* [1]. The plasma parameters *viz*. electron density (n_e) and electron temperature (T_e) are evaluated by optimizing the model simulated intensities with the eight emission lines (out of $3p^5 4p\ (2p_i) \rightarrow 3p^5 4s\ (1s_i)$ transitions) observed through the measurements. We find from our study that as the concentration of N_2 increases in the Ar/N_2 mixture from 0 to 10%, our extracted electron density varies from 2.3×10^{11} to 2.8×10^{11} cm^{-3} and the electron temperature decreases from 1.0 to 0.43 eV which are in good agreement with the available probe measurement. The details of the CR model along with the results recently published [2].

Electron Impact Excitation of Xe+ Ion and Polarization of Its Subsequent Emissions: I studied the electron impact excitation of Xe^+ ion. The study of neutral and ionic state of xenon has important fundamental interest and applications viz. in ion thrusters for space propulsion. Fully relativistic distorted wave calculations have been performed to study the electron impact excitation of singly ionized xenon from its ground $5p^5$ (J = 3/2) state to different fine structure excited states of the $5p^4 6s$, $5p^4 6p$, $5p^4 7s$, $5p^4 7p$, $5p^4 5d$ and $5p^4 6d$ configurations. The ground and excited bound states of Xe^+ ion have been represented through the relativistic multi-configuration Dirac-Fock wave functions while projectile electron distorted continuum wave functions are obtained by solving the Dirac equations. Calculations are performed for the excitation cross sections and the corresponding rate-coefficients of the considered different transitions. For each transition, analytic fitting to the calculated cross sections are also studied for plasma modeling purposes. In addition, using the density matrix theory and the calculated different magnetic sub-level excitation cross sections the linear polarization of the radiation emitted by the different optically allowed transitions are obtained. All the details of calculations along with the results recently published [3]. Now using these calculated cross sections, we are developing a CR model to study the 460.3 nm, 484.4 nm, 529.2 nm and 541.9 nm most intense lines of Xe^+ ion recorded by Czerwiec *et al* in their OES [4].

References:

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