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Collisional-Radiative Models of Low Ionized Rare Gas Plasmas

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We have recently developed a time-independent Collisional Radiative (C-R) model which is necessary to perform spectroscopic diagnostics of relatively cool Ar and Xe plasmas [1]. The higher electronic temperature (Te) limit of the present model corresponds to situations where the available energy is sufficient to remove all six of the outer (3p or 6p) electrons of the atom.
Comparisons of the theoretical spectra generated from this model with those obtained experimentally from various Ar and Xe plasmas have been used for validation of the theoretical approach [2]. Our results are also compared to those derived from the well known set of codes developed at LANL [3].
Non-intrusive emission spectroscopy p lasma diagnostics allows for the evaluation of the local temperature and density; it also provides information on the constituents and on the most important processes encountered in the plasma. For a satisfactory application of such diagnostics a full C-R model is needed, taking into account all of the species present, both neutral and ionized, together with their excited state level structure and transition probabilities between the levels; all contributing processes are taken into account through their respective reaction rates.
Our C-R model has been used to analyze various Ar and Xe spectra. A version specific to lower temperatures was previously used to diagnose and model two prototype Stationary Plasma Thrusters (SPT-50) made available to us at the Ecole Polytechnique and the ONERA Laboratories, both located in Palaiseau, fed with Ar and Xe, a coaxial microwave Ar plasma reactor (RCM) functioning in our Laboratory and a direct current Ar discharge device with carbon cathode operating at the LPIIM laboratory of Universit de Provence [4]. It is now used to study the spectrum of a low temperature Xe plasma contained in a hollow cathode with dielectric barrier available at the LPGP Laboratory and the radiation emission of the WEGA Stellarator operated at IPP Greifswald, when fed with Ar [5]. According to measurements made at IPP, a Te of about 10 eV is typical in WEGA for Ar discharges, with an electron density, ne of about 1012 cm3. Our calculations based on a coronal model show the full Ar I to Ar V spectra, plus some radiation from Ar5+ [6]. Of course, all of these spectra are not expected to be simultaneously present in an homogeneous plasma with a single Te , but in the case of the separatrix- and/or limiter-plasma of WEGA a mixture of temperatures may explain the simultaneous detection of signatures of all of the ionized Ar species on top of the neutral, possibly altering the total radiated energy. Therefore a superposition of Maxwellian distributions may be necessary for some or all of the present species. Typical Ar I-III spectral lines have been identified in the present work in various WEGA discharges. The main features of the relevant spectra will be shown and discussed during the Conference. They will also be compared to our theoretical spectra, in order to investigate the relative populations of each ionized species and judge about the form of Te in connection with departure from a unique Maxwellian distribution.

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