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Evaluation of Xe Ions Transition Probabilities

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Spontaneous emission is often the basis for optical emission diagnostics. Whenever a plasma is far from coronal equilibrium spontaneous emission is an important decay process, leading to significant plasma cooling as well as an optical diagnostic. Xe plasmas are becoming more common in the laboratory and in industry applications (plasma thrusters, plasma reactors, lightning) because of the low ionization energy of the Xe atom and of its ions. At the same time the high atomic number (Z=54) produces very rich spectra of plasmas containing Xe I to VI species with excitation of the outmost six noble gas 5p electrons possible.

Unlike the more common cases of He or Ar plasmas, which have been extensively studied some time ago, the Xe spectra, even for the neutral atom, are poorly known. The existing compilations of the corresponding transition probabilities and collision cross sections have many gaps. Relativistic effects are important for Xe, complicating the development of satisfactory Collisional Radiative (C-R) type models for low temperature plasmas. Because of the importance of Xe plasmas for contemporary industrial applications, especially for electric propulsion and in the divertor region of Tokamak plasmas, we are systematically addressing the C-R modeling [1], seeking the most extensive comparison of our theoretical results with values measured in various experimental devices in our l aboratory and/or observations available in the literature.

We have applied the same theoretical methods applied to the Ar case [2] to build the atomic database needed for our C-R model for Xe. A compilation of energy levels for the Coulomb approximation has been recently made available [3]. In the present work we restrict ourselves to the case where the local electron temperature (Te) of the plasma is sufficiently low for the Xeq+ ions with q¿4 to have a negligible effect on the line intensities calculated by the C-R model for the Xe I and Xe II spectra. Note that the appearance of the four times ionized species for Xe occurs at lower temperatures than for Ar due to the lower ionization limits of the Xe ions and the increased importance of the inner shells. A simple coronal model [4] calculation shows that including the ion stages Xe I to IV in the C-R model is expected to be sufficient for the study of the plasma properties up to about 10 eV.

For our theoretical Xe I to IV spectra, comparisons with experimental spectra mainly for the 6s 6p, 7p and 6p 5d, 6d multiplets show satisfactory agreement. In building the atomic database for our C-R model care was taken to include a complete set of data for all transitions between multiplets. Special care was devoted to transition probabilities belonging to the experimentally observed leading transitions. Samples of the data compilation will be shown in the Conference.