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Optical Diagnostics using Spectroscopic Measurements of Argon[1]

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Passive, non-invasive optical emission measurements provide a means of probing important plasma parameters without introducing any foreign contaminants into a plasma system. We investigate such parameters as the excited/metastable species concentration and electron energy distribution function (EEDF) in an argon inductively-coupled plasma by measuring the readily observed $3p^5 4p \rightarrow 3p^5 4s$ emissions in the 650-1150 nm wavelength range. We have also developed an optical emission model which uses our experimentally measured electron-impact excitation cross sections into the $3p^5 4p$ levels from both the ground state and metastable levels to calculate the $3p^5 4p \rightarrow 3p^5 4s$ emissions. Moreover, the model includes a number of often neglected but critical processes such as: (i) radiation trapping of $3p^5 4p \rightarrow 3p^5 4s$ emissions resulting from the high number densities of atoms in $\mathrm{Ar}(3p^5 4s)$ levels, (ii) electron-impact excitation from atoms in $\mathrm{Ar}(3p^5 4s)$ resonance levels, and (iii) the effect of non-Maxwellian EEDFs. The agreement between values of the plasma parameters obtained by fitting the model spectra to measured spectra are compared with direct experimental measurements of the corresponding parameters by Langmuir probes and white light absorption spectroscopy under a variety of plasma conditions (pressure, RF power, $\mathrm{Ar/Ne/N_2}$ gas mixtures).

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