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Using C-R models to determine electron density and temperature in discharges containing rare gases[1]

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Electron density n_e and electron temperature T_e are important parameters for describing the plasma discharges. In many cases, the rare gases are used as a feed gas or added as a trace gas in low-temperature discharges. The intensity ratio of their optical emissions can be used to determine these parameters nonintrusively by using simple collisional–radiative models (C-R model) describing the kinetics of the excited levels. In this presentation, some simple C-R models for optical diagnostics are reviewed. Kinetic regimes, with different dominant processes, are identified for the Paschen 2p, 3p, 4p and 5p levels. One can then select proper excited levels to determine the plasma parameters according to the operation conditions. For example, for a low-pressure Ar/Xe inductive discharge, the $2p_1$ and $2p_5$ levels of Ar and Xe are in the corona regime, with the electron impact excitation from the ground state being dominant. Rate of this process is sensitive to the electron energy. As a result, line-ratios of Ar and Xe are used to give T_e. To obtain n_e, line-ratios of argon 3p, 4p and 5p levels are used, due to the significant electron impact transfer processes on these levels. This technique has been applied for a capacitive discharge containing Ar/Xe/CF_4.Similar method can be used for atmospheric-pressure nonequilibrium discharges to obtain the electron density. For example, for an argon microwave microplasma, the $2p_1$, $2p_3$ and $2p_6$ levels are found to be in the high-pressure nonequilibrium regime, with both the electron-impact and atom-collision processes being important. This provides a strong dependence of the line-ration on of n_e . T_e and n_e obtained from this technique are compared with that from other methods, such as the Langmuir probe and the Stark broadening method. Satisfactory agreement is obtained. The uncertainties and limitations of the line-ratio technique are also discussed.

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