Continuum Emission Spectroscopy on a Plasmaline Microwave Discharge Source

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The visible range of radiation is the most often studied one. Essential plasma properties could be obtained by passive diagnostics of optical emission in this spectral region of a discharge. Because of the large errors in the usual determination of plasma properties it is convenient to apply multiple diagnostic methods. This so-called poly diagnostic approach can decrease the uncertainties a lot.

In this study absolute bremsstrahlung continuum measurements were carried out. This straightforward technique was already used in the past[1]. From which we learned that accurate calibration is an important issue. In order to do so, one needs an absolute calibrated radiation source. Here a deuterium lamp and a tungsten ribbon lamp were used. As a validation the results of electron density were compared to Thomson Scattering measurements. The latter, active laser diagnostic method, is more reliable than continuum emission, but also more demanding. The complete setup for this diagnostic, including a triple grating spectrograph (TGS) for blocking the intense Rayleigh scattered light, is described elsewhere in detail[2,3].

The experiment was conducted on a plasmaline discharge setup. That means a discharge sustained by an inner conductor which is surrounded by a quartz tube. On the outside of this containment a vacuum vessel is situated with a low variable pressure of 1 to 20 mbar of argon gas. The input power at a fixed frequency of 2.45 GHz is about 100 to 300 W. A monochromator equipped with an CCD-camera for long-term light exposure was used. It should be mentioned here that line radiation of the plasma close to the wavelength of interest for continuum measurements has, depending on the resolution of the monochromator, a very strong influence on the measured continuum radiation. For that reason an additional set of interference filters was used to narrow the spectral range of the incoming light. Due to the low power densities only a low ionization degree is reached. Therefore here is only the electron-atom bremsstrahlung of importance and the contributions of electron-ion scattering and recombination were calculated to be negligible.

From the theoretical point of view it is also important to evaluate an accurate emission coefficient in the case of the continuum radiation. This is needed to determine an absolute electron density. In other experiments and simulations it was proved that the continuum emission is described quite good in the infrared by the classical calculations, which basically integrates the convolution of the momentum transfer cross section with the electron energy distribution function over the incoming energy of the electrons[4]. A different approach is the scattering of a electron on an atom in the quantum mechanical description. But in fact here assumptions regarding the potential of the atom have to be made.

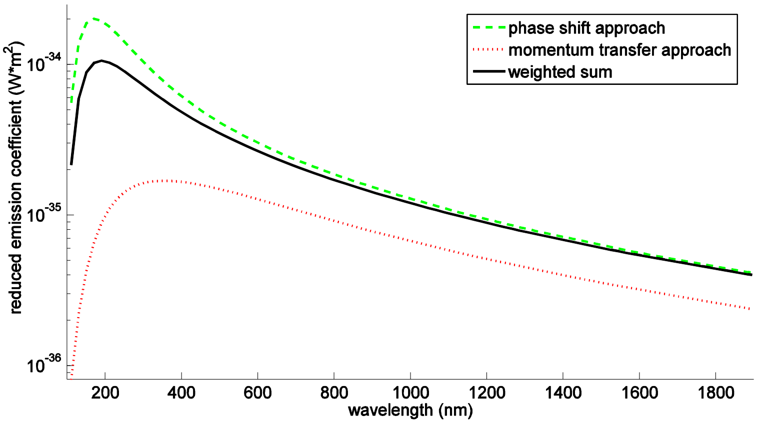

Figure 1: Comparison of reduced emission coefficient $\varepsilon = j/(n_e\, n_a)$ for T_e = 1.3 eV, in argon gas at T_h = 600 °K.

Therefore a combination of the phase shift approximation and the classical momentum transfer approach was used. The weighting of the sum of this two contributions is a function of the temperature. In this way this two different approaches lead to a good estimation for the emission coefficient(5). Generally the phase shift approximation gives somewhat higher emission coefficients but this is even more true for small wavelength of $\lambda < 400$nm. Whereas the classical momentum transfer approach gives an underestimation of the emission coefficient. Under our plasma conditions of low gas pressure and small ionization degree the weighting is shifted in favor of the phase shift approximation.

The empirical validation of the weighting factor was done by the experiment and the above mentioned laser scattering method.

Reference

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