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THE HYDROGEN AND HELIUM LINES BROADENING IN THE GLOW DISCHARGE AT ATMOSPHERIC PRESSURE

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The Stark broadening of the hydrogen H_β and helium HeI 492.2 nm lines was used in experiments (Arkhipenko et al. 1998, 1999, 2000) for sizing of the spatial distribution of a constant and variable components of an electrical field intensity in the cathode fall region of glow discharge in helium at atmospheric pressure. The external electric field is small in other discharge regions. Therefore it is necessary to take into consideration other broadening mechanisms of a spectral lines in these regions. The analysis of the hydrogen and helium lines profiles in a positive column, Faraday dark space, glow and in the cathode fall region is carried out in the present work.

The glow discharge in helium at atmospheric pressure has the stable characteristics and can be used as a light source in spectroscopy and a test object for improvement of the different diagnostics. The working gas is helium. The hydrogen was not specially introduced, and acted in the discharge chamber as small (~ 0.01 %) impurity with a helium flow. The discharge current was 1 A, and the electrode voltage 250–270 V. The plasma parameters of the discharge are: the electron density $n_e \sim 10^{13} \div 5\ 10^{14}$ cm^{-3}, the electron temperature $T_e \sim 1$ eV, the gas temperature $T_g \sim 1000$ K. The radiation of the discharge was focused 1:2 onto the entrance slit of the scanning double grating monochromator with inverse linear dispersion 0.5 nm/mm. The photoelectric step-by-step registration of the line profiles with application of the CAMAC equipment and personal computer was used. The height of entrance slit was 1 mm while width of entrance and exit slits was 20 μm resulting in 0.012 nm instrumental width. The aperture slit of width 1.5 mm located before lighting system of monochromator was used for achievement of the spatial resolution along discharge axis ~ 10 μm. As the discharge luminescence is non-uniform in cross section, the procedure of the Abel inversion was applied to the experimental line profiles.

The hydrogen and helium lines profiles measured in a positive column, Faraday dark space and in glow, have the form close to dispersion one. In the cathode fall region these profiles are Gaussian. At first the separation of different broadening mechanisms was made for reception of the fitted line profile. The instrumental and Doppler broadening were taken into account in all cases. This broadening mechanisms bring to the Gaussian summary profile. The resonant and Stark helium line broadening and the Van der Waals and Stark hydrogen line broadening result in the dispersion profiles. The summary line profile was described by the convolution corresponding Gaussian and dispersion profiles. As the gas temperature is practically invariable along an discharge axis, the calculated according to (Konjevic 1999) parameters of the Van der Waals, resonant and Doppler broadenings were considered constant along an discharge axis too The Stark broadening half-width was determined by comparison of experimental and fitted profiles. The obtained widths of hydrogen H_β and HeI 492.2 nm lines were used for the estimation of electron density according to (Griem 1974). Both these estimations have given the close results. In a positive column the electron density is 3-5 10^{13} cm^{-3}, in a glow ~ 5 10^{14} cm^{-3}.

The large Stark broadening half-width are required for approximation of experimental profiles in cathode fall region. Such half-widths can be at concentration of the charged particles ~ 10^{16} cm^{-3}. Such concentration value is not given by its any estimation. In addition the line profile is similar to Gaussian one, that specifies other broadening mechanism, which is differed from considered above. The broadening owing to the large electric field gradient in cathode fall region (~ 500 kV/mm at the achieved optical resolution ~10 μm) can not explain of the observed line profiles.

The assumption was stated, that the observed line broadening in this region result in the effect of the oscillating component of an electric field. Its nature is not established specifically now, but among the probable causes inducing such oscillations, it is possible to call of the edge microinhomogeneities on a cathode surface, which are formed during the discharge operating. Another probable cause can be connect with the formation of an domains in near cathode plasma (Oreshko 1991), which occurs at inequality of flows of the directed drifts of electrons and ions in time, exceeding the Maxwellian time of the space charge relaxation. The Stark broadening and shift of lines in an external electrical field of intensity ~ 10-50 kV/cm with oscillating component ~ 10-15 kV/cm bring in the dominant contribution to formation of the spectral line profiles.

Thus, the carried out analysis of the helium and hydrogen spectral lines profiles in different regions of the glow discharge at atmospheric pressure has allowed to receive the distribution of electron density, distribution of the electrical field intensity in the cathode fall region and also has shown an opportunity of the discharge use for study of parameters of the different kinds of the line broadening.

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