MEASUREMENT OF ELECTRIC FIELD DISTRIBUTION ALONG THE CATHODE SHEATH OF AN ABNORMAL GLOW DISCHARGE USING Ne I 556.277 nm LINE

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We present the results of an experimental study of the DC Stark shift of the Ne I 556.277 nm line in the cathode sheath region of an abnormal glow discharge in neon with traces of hydrogen. The electric field (of up to 13.4 kV cm^{-1}) is measured in the cathode sheath region from the π-polarized profile of the hydrogen Balmer H_α line using the Stark polarization optical spectroscopy technique, see Figure 1. The Ne I 556.277 nm line exhibits a quadratic Stark effect and the values of the coefficients, correlating its Stark shift and electric field strength, were determined, see Figure 2. The Stark shifts of the Ne I 556.277 nm line were measured relative to the unshifted peak of the W I 370.792 nm line whose profile from the third diffraction order appears in the recorded spectra near the profiles of the studied Ne lines from the second diffraction order, see Figure 3. In the fitting procedure of the experimental Ne I 556.277 nm spectral line profiles, we employed the model function:

$$I_{\mathrm{mod}}(\Delta\lambda;\Gamma) = \Im * \left[G(\Delta\lambda; H_{Ne}, c_{Ne}, w_{Ne}) + G(\Delta\lambda; H_W, c_W, w_W) \right] + b \quad (1)$$

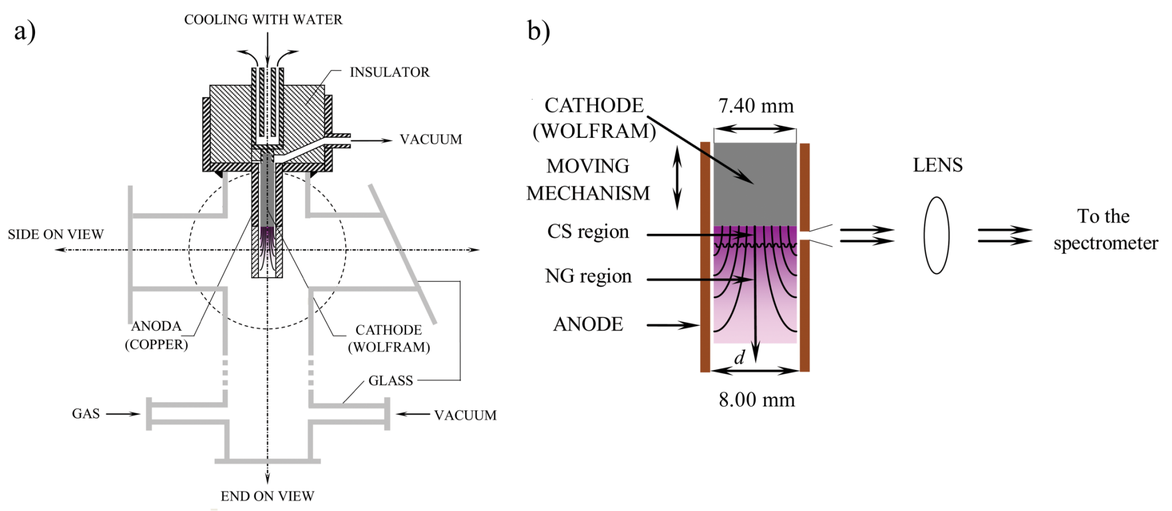

Figure 1. Schematic drawing of our Grimm glow discharge source [1]. b) A magnified view of the encircled part from a).

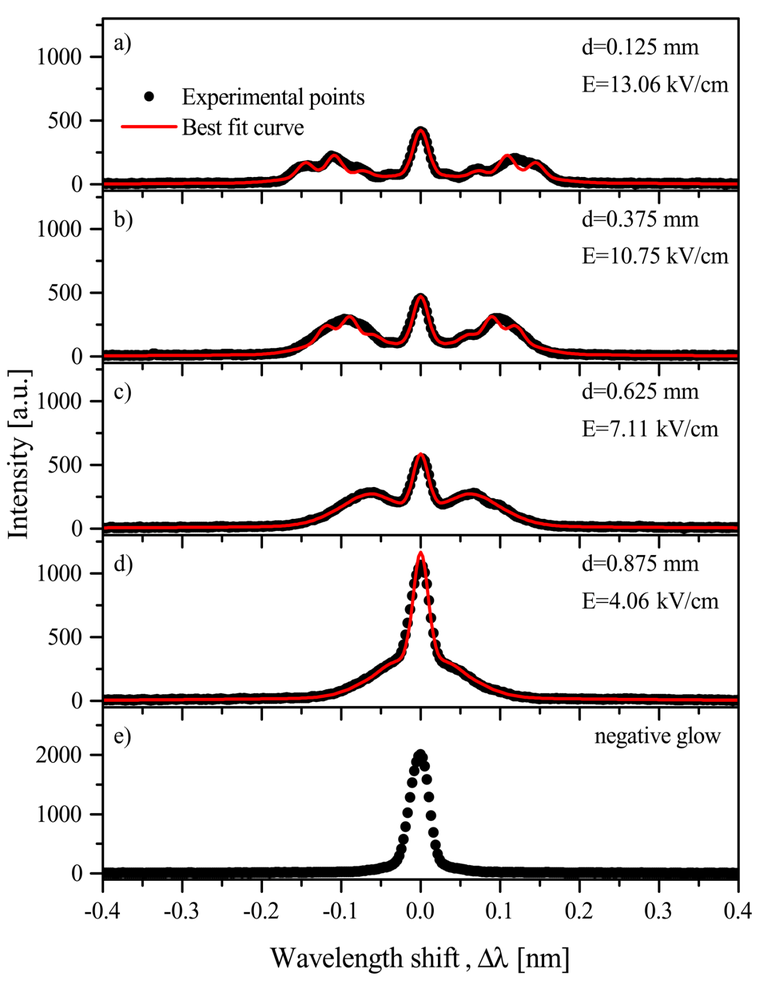

Figure 2. The π-polarized side-on experimental profiles (points) of the H_α line recorded in a neon with 0.8% H_2 GD at four different positions within the CS region. Solid (red) line represents the model function that best fits the experimental data [2].

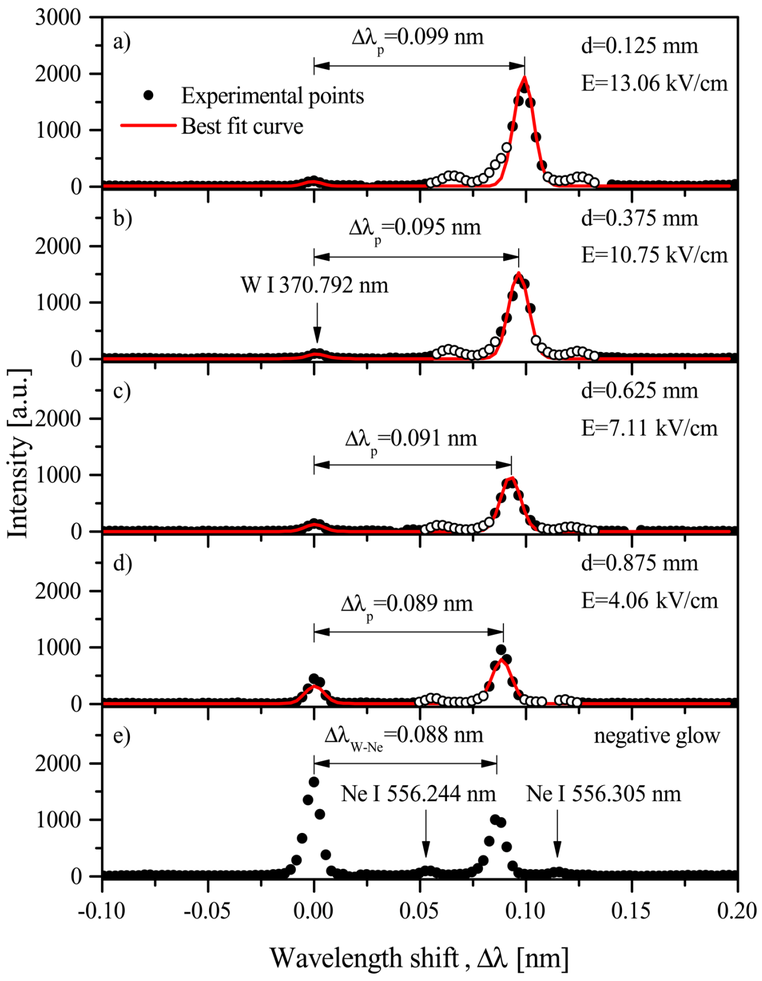

Figure 3. Experimental profiles of the Ne I 556.277 nm spectral line (dots) recorded in a neon with 0.8% H_2 GD and their best-fit (red) curves obtained by the model function (1). Hollow experimental points were discarded in the fitting process [3].

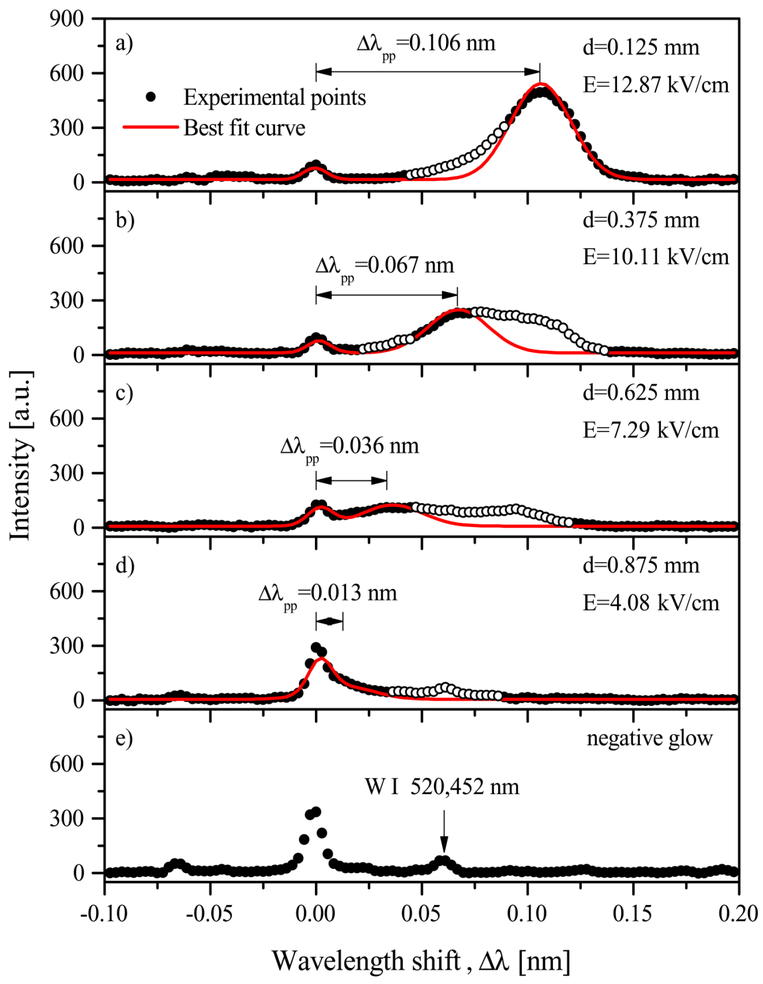

Figure 5. Experimental profiles of the Ne I 520.390 nm spectral line (dots) recorded in a pure neon GD and their best-fit (red) curves obtained by the model function (1). Hollow experimental points were discarded in the fitting process.

In model function (1), $\Delta\lambda$ is the wavelength shift from the line center, Γ stands for the list $\{H_{Ne}, c_{Ne}, w_{Ne,} H_W, c_W, w_{W,}\}$ of the model function fitting parameters, and b is the baseline level. The model function (1) is a sum of two Gaussians, each specified by height H, center c, and FWHM w, and * denotes the convolution with the instrumental profile $\Im$, which is in our case the unit-area Gaussian of w_{inst}= 8.2 pm FWHM. The Stark shifts determined with the foregoing numerical procedure are presented in Figure 5. The red solid line was obtained by the equation (4) given in [4], which in the case of small electric fields reduces to [2]:

$$\Delta\lambda = -\lambda_0^2 C E^2 \ ,$$

where is λ_0 = 556.277 nm and C = - 0.0021 kV^{-2}cm. The results are in good agreement with the best-fit formula proposed by Jäger and Windholz. The Ne I 556.277 nm spectral line of neon was also observed in an abnormal glow discharge with pure neon. Figure 6. shows the distributions of the CS electric field strength in the pure neon discharge obtained from the observed profiles of the Ne I 556.277 nm and Ne I 520.390 nm spectral lines.

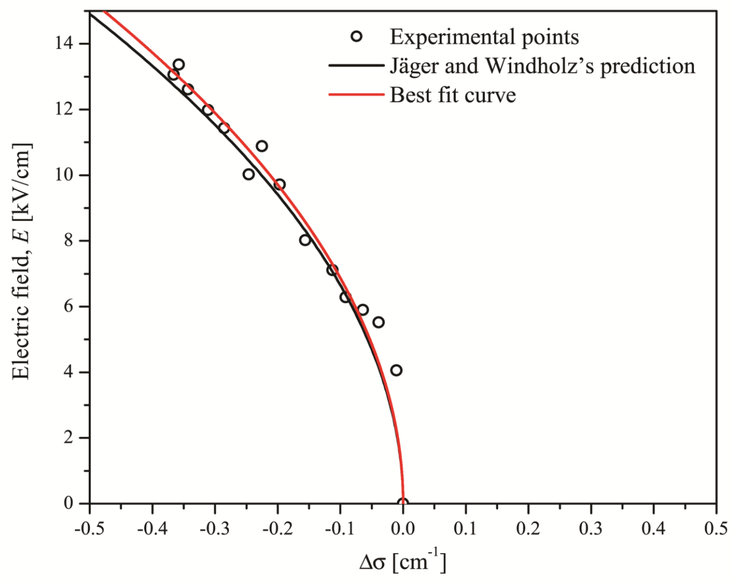

Figure 4. Dependence of the electric field strength E on the Stark shift of the wave number $\Delta\sigma$ for the Ne I 556.277 nm spectral line [4].

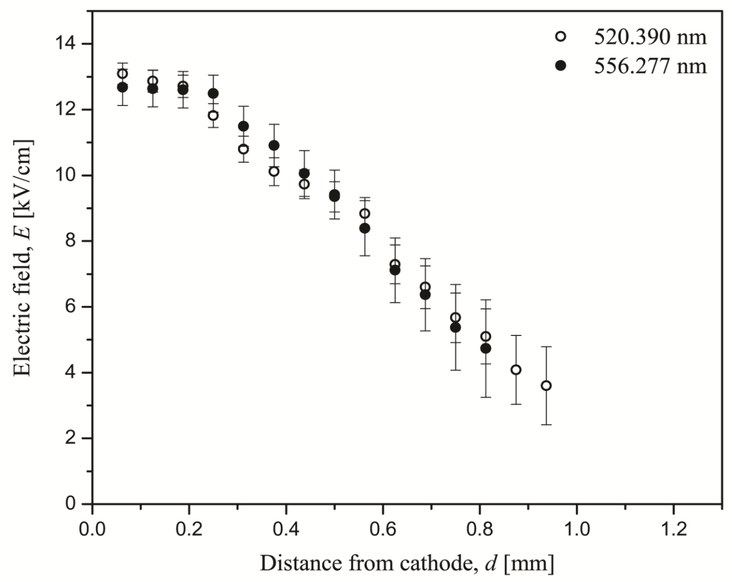

Figure 6. Comparison of the distribution of electric field strength E obtained from observations of Ne I 520.390 nm and Ne I 556.277 nm spectral lines.

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[4] Jäger H and Windholz L 1984 Phys. Scr. 29 344

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