Experimental study of Ne II spectral lines shapes in the cathode sheath of an abnormal glow discharge

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We report on the experimental study results of the Ne II 369.421 nm, Ne II 371.308 nm, and Ne II 372.711 nm spectal line shapes in the cathode sheath (CS) region of an abnormal glow discharge in pure neon. The experimental profiles were studied by means of the optical emission spectroscopy (OES), see Fig. 1. Several strong ionic neon lines from the near UV region exhibit extensively broadened wings in their spectral profiles. Throughout the CS region, Ne II line profiles are comprised of the central peak and an excessively broadened pedestal. The change in the Ne II line shapes at four positions along the CS is illustrated in Fig. 2.

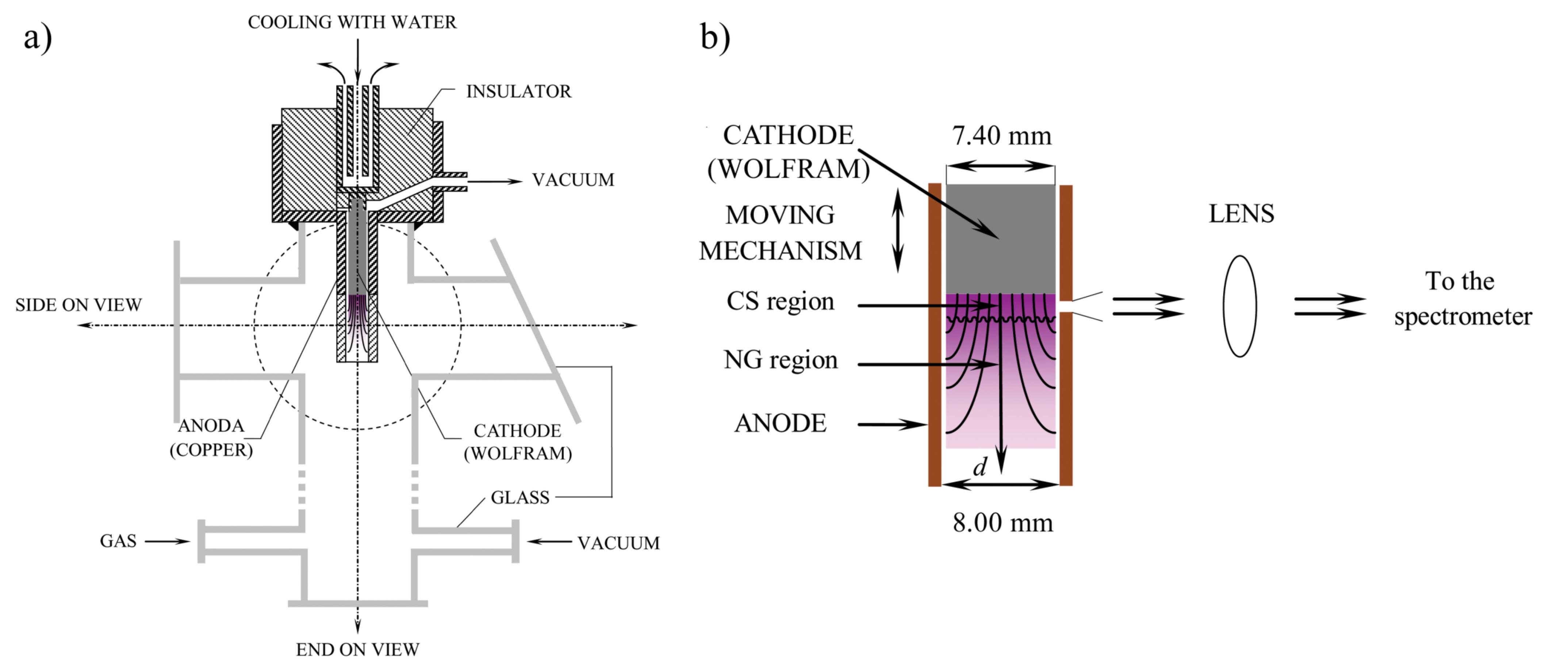

Fig. 1. Schematic drawing of modified Grimm glow discharge source [1, 2]. b) A magnified view of the encircled part from a).

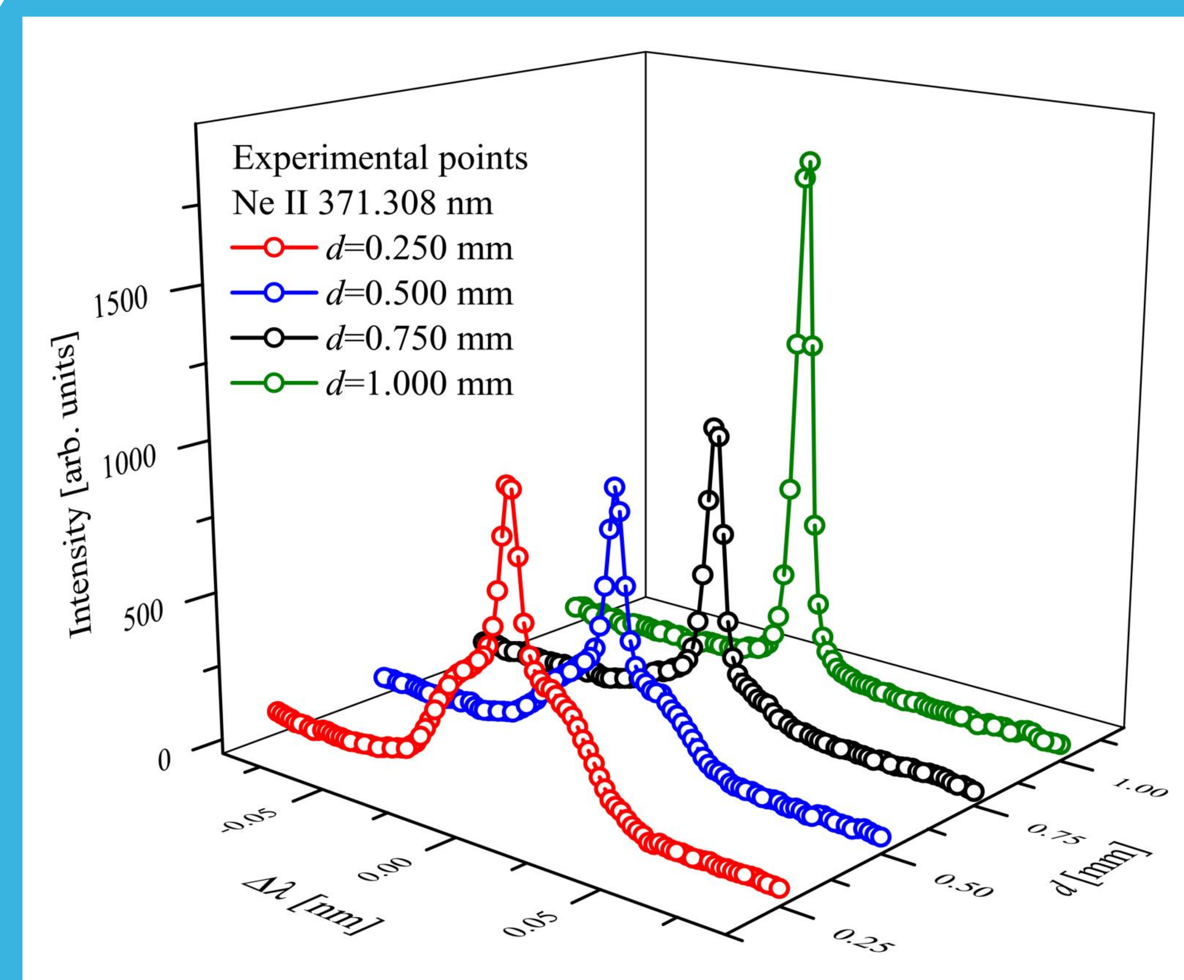

Fig. 2. 3D plot of the spectral profiles of Ne II 371.308 nm line recorded side-on at four distances d from the cathode. Line intensity is shown against the wavelength shift $\Delta\lambda=\lambda-\lambda_0$ from the central wavelength λ_0 = 371.308 nm.

The shapes of the Ne II lines along the CS region are fitted with the model function:

$$I_{mod}(\Delta\lambda) = G_c(\Delta\lambda; A_c, w_c) + G_w(\Delta\lambda; A_w, w_w) + b \tag{1}$$

that is, the sum of two zero-centered Gaussians vertically shifted by the base-line level b. The first one, $G_c(\Delta\lambda; A_c, w_c)$, describes the central part of the line profile , while the second, i.e. $G_w(\Delta\lambda; A_w, w_w)$, describes the wings. In figure 3, we compare the prediction of the iterative kinetic model (see [3]) with the best fit of a Ne II 371.308 nm line profile obtained by (1). The phenomenological model function (1) describes reasonably well the profiles being studied, hence it could be used to estimate the overall Doppler profile $D(\Delta\lambda)$ of the radiation. This means that $D(\Delta\lambda)$ can be taken as the sum of the two Gaussians, $G_{Dc}(\Delta\lambda; A_{Dc}, w_{Dc})$ and $G_{Dw}(\Delta\lambda; A_{Dw}, w_{Dw})$, approximating the Doppler profiles of the line central part and of the line wings, respectively, such that their convolutions with the instrumental profile give the two Gaussians $G_c(\Delta\lambda; A_c, w_c)$ and $G_w(\Delta\lambda; A_w, w_w)$.

The variation of the pedestal profile FWHMs w_{Dw} (in nm) with the distance to cathode d (in mm) is depicted in Fig. 4a. These two quantities are correlated as:

$$w_{Dw} = a - b \cdot d^2 \tag{2}$$

where a and b are some constants whose values depend on the cathode material [4]. The variation of electric field strength E (in kV/cm) with the distance to the cathode d is shown in Fig. 4b and is correlated with d as (see [4]):

$$w_{Dw} = e + f \cdot E - g \cdot E^2 \tag{3}$$

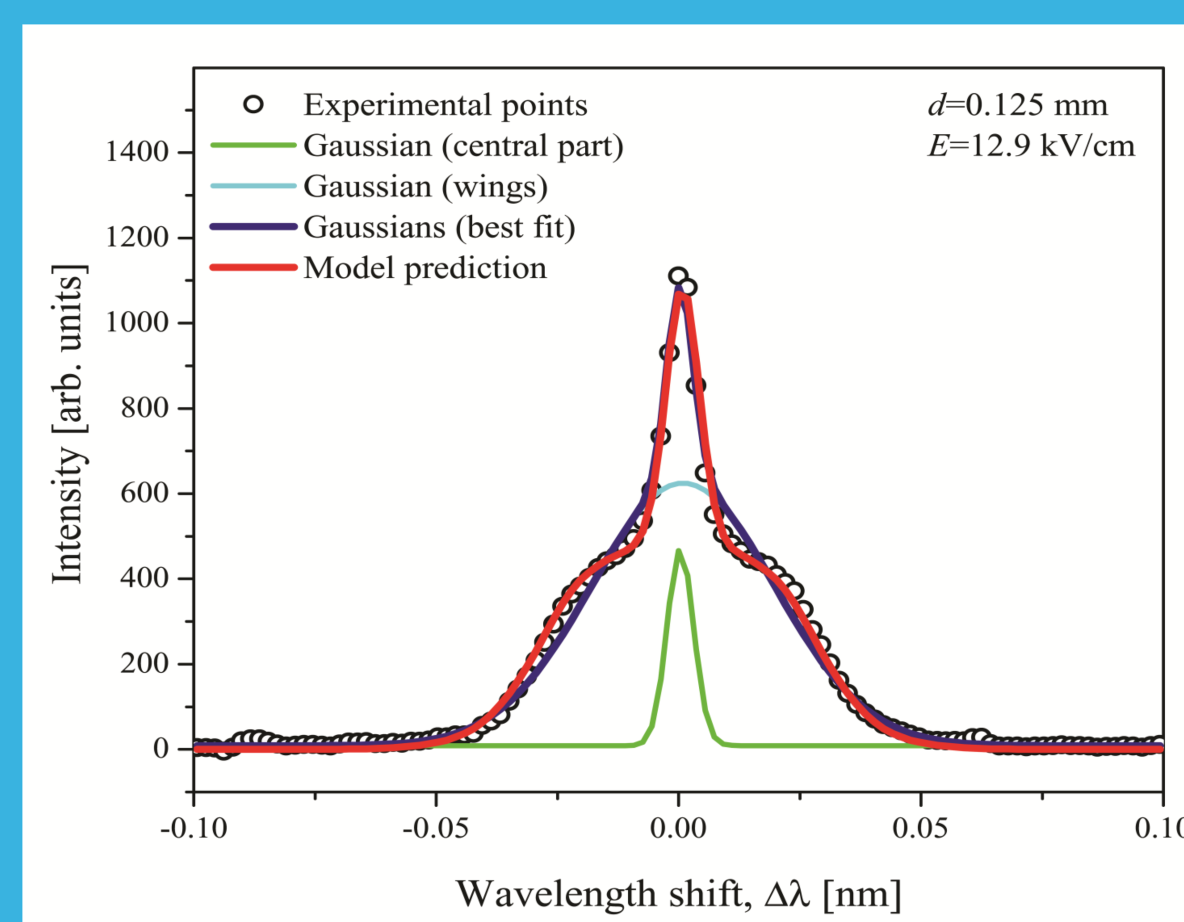

Fig. 3. The comparison between the prediction of the iterative kinetic model [3] with the best fit obtained by the model function (1) of the Ne II 371.308 nm line profile.

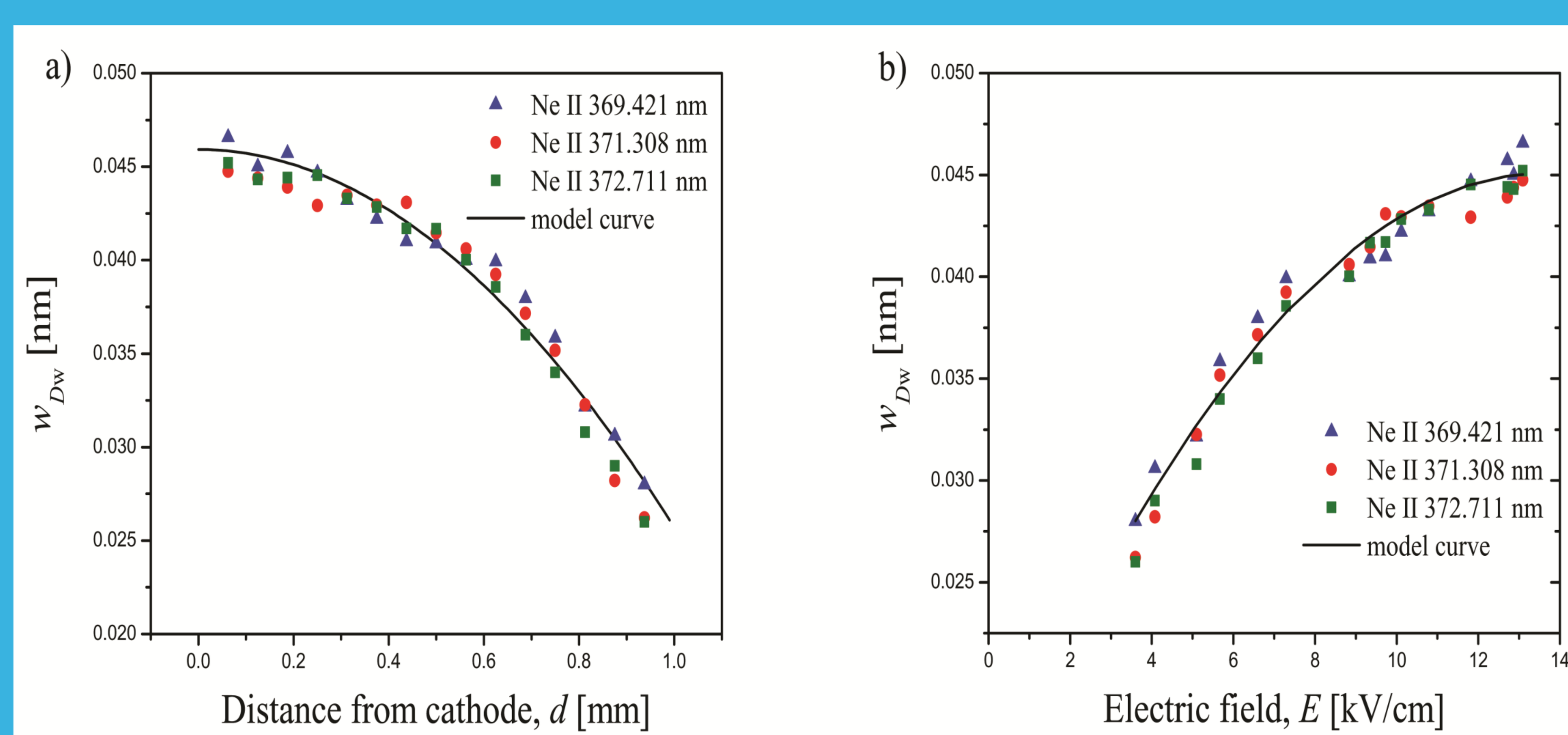

Fig. 4. (a) Symbols show the FWHM of the Doppler profile w_{Dw} of line wings against distance from the cathode, d, and the full line shows the phenomenological model curve (2) which predicts the average variation of w_{Dw} with d for the three Ne II lines recorded side-on. (b) The same as in (a), but for the correlation (3) between w_{Dw} and the strength of electric field E.

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ACKNOWLEDGEMENT

This work is supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia.