Publ. Astron. Obs. Belgrade No. 103 (2024), 144 *Poster*
https://doi.org/10.69646/aob103p144

CATHODE SHEATH DIAGNOSTICS BY INTEGRAL END-ON OPTICAL EMISSION SPECTROSCOPY IN AN ANALYTICAL GLOW DISCHARGE SOURCE IN ARGON

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Abstract. Most conventionally used glow discharge sources for surface and bulk analysis of solid samples by optical emission and/or mass spectroscopy (OES/MS) follow the classical Grimm design, with a plane sample (cathode) adjacent to the hollow cylindrical anode. In such a design, OES is enabled from the anode end, with an integral end-on view of the entire discharge, i.e. both cathode sheath and negative glow. It has been noticed, though, that the OES of argon lines show asymmetrically broadened profiles with complex structures on the red wings. In this work, we show that these complex end-on wing broadening structures originate from the cathode sheath radiation, dominated by the quadratic Stark effect-induced splitting and shifting of argon line components in a macroscopic electric field, produced by the externally applied voltage. The cathode sheath electric field decreases from the maximum strength F_{max} near the cathode to nearly zero at the sheath end and the beginning of the negative glow. Using the modified Grimm source that enables OES observations both from the end and from the side of the discharge axis, we compared maximum Stark component shifts $\Delta\lambda_s$ recorded side-on nearby cathode where the maximum field F_{max} is attained, with the shifts of end-on recorded wing structures $\Delta\lambda_e$. For four neutral argon Ar I lines, 517.8 nm, 521.0 nm, 537.3 nm, and 541.0 nm, comparing the shifts $\Delta\lambda_s$ and $\Delta\lambda_e$ for different discharge conditions (pressure, voltage, current) and cathode materials, we found a stable linear correlation $\Delta\lambda_s = k\cdot\Delta\lambda_e$ for each individual spectral line, and for the whole set of four Ar I lines, with latter being $k = 1.129 \pm 0.011$. Provided that the side-on shifts $\Delta\lambda_s$ for each individual Ar I line are calibrated against the independently measured electric field and the F_{max} is known, this correlation can be used for the estimation of F_{max} in standard analytical glow discharge sources with end-on optical observations available only. In turn, assuming linear regression of the electric field from F_{max} to zero towards the sheath end, its thickness d_c can be estimated also, providing important input parameters for discharge modeling and design.