Stark width of 4p'\left[\frac{1}{2}\right]–4s\left[\frac{3}{2}\right]_{o} Ar \, \text{I transition} (696.543 \, \text{nm})

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Abstract. The full width at half maximum (FWHM) of the 696.5 nm Ar I spectral line profiles was measured in the plasma temperature range from 13 500 K to 24 000 K and free electron density from 1.2 to \(1.0 \times 10^{23} \, \text{m}^{-3}\). Results were obtained for this line emitted from the near-cathode region of an atmospheric pressure, 200 A arc burning in pure argon. Our results are compared with data existing up to now. In the electron density range of our experiment, the 696.543 nm Ar I line Stark FWHM is linearly proportional to the electron density. The observed dependence of the FWHM on the plasma temperature and electron density is in qualitative agreement with Griem’s theory; however, the ratio of calculated and measured FWHM was equal to 1.55, for the dependence on electron density and temperature. The dependence of FWHM on electron density, obtained by weighted least squares fitting of all our data with the constraint that the curve passes through the origin, is well represented by the following equation:

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\Delta \lambda_{\text{FWHM}}^{\text{our data}} = (1 \pm 0.067) \times 0.08297 \, \text{nm} \times \left(\frac{N_{e}}{10^{23} \, \text{m}^{-3}}\right),
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with \(\lambda_{\text{FWHM}}^{\text{our data}}\) in nm and \(N_{e}\) in \(\text{m}^{-3}\), for the temperature \(T = 13\,000 \, \text{K}\).

1. Introduction

The measured spectral line shape is the result of the interaction of different mechanisms causing broadening of spectral lines. In thermal plasmas, having temperatures around 20 000 K, the dominant mechanism of the spectral line broadening is the Stark effect. This component of the observed line profile may be well approximated by a symmetric Lorentzian function. In many experimental conditions other broadening effects have to be taken into account. In particular, the Doppler effect and apparatus function contributes to the line profile and must be taken into account as the Gaussian component of the measured line profile. The effective line shape is a convolution of the Gaussian and Lorentzian components, and can be represented by the Voigt function. Very small asymmetry of the line profile, due to collisions of atoms and ions, was also detected in the Ar I line shape [2]. In this work, this asymmetry is neglected.

The 696.543 nm Ar I line (Mult. 13, transition 4p'\left[\frac{1}{2}\right]–4s\left[\frac{3}{2}\right]_{o}) is of great interest because it is a strong and well isolated line of the neutral argon spectrum. For this reason, it is often used in the diagnostic of argon plasmas. This line corresponds to the transition from the upper energy level \(E_{u} = 13.324 \, \text{eV}\) (statistical weight: \(g_{u} = 3\)) to the lower energy level \(E_{l} = 11.545 \, \text{eV}\) \((g_{l} = 5)\), and has the transition probability \(A_{696.543 \, \text{nm}} = (6.39 \pm 5\%) \times 10^{9} \, \text{s}^{-1}\), as proposed by Wiese et al [3].

In earlier publications [4–6], we described results of our studies of the near-cathode region of the electric arc burning in pure argon. In this paper, we use the same arc and