Publ. Astron. Obs. Belgrade No. 65 (1999), 67 – 70

MEASURED STARK WIDTHS OF SEVERAL Ar IV SPECTRAL LINES

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1. INTRODUCTION

Only four papers deal with experimental investigation of the Stark widths of triply ionized (Ar IV) argon spectral lines (Platiša *et al.* 1975a,b; Purić *et al.* 1988; Hey *et al.* 1990; Kobilarov and Konjević 1990). These experiments were realized at electron temperatures between 20 800 K and 110 000 K. In this temperature domain the experimental Stark FWHM (full width at half intensity maximum, w) values in Platiša *et al.* (1975a,b) and those in Hey *et al.* (1990) show discrepancies in respect to the existing theoretical predictions, especially in the case of the 280.944 nm Ar IV spectral line. The w values at 20 800 K in Platiša et al (1975 a,b) lies belowe, while those in Hey *et al.* (1990), at T = 81 000 K, lies above theoretical values based on the modified semiempirical formulae (Dimitrijević and Konjević 1980). The aim of this paper is to provide some new data on the Stark width of triply ionized argon spectral lines at 22500 K electron temperature (T) and $1.9 \cdot 10^{23}$ m^{-3} electron density (N). We have measured Stark FWHM of four Ar IV spectral lines which play an important role in diagnostics of the various astrophysical plasmas including calculations of stellar envelope opacities (Seaton 1988 and references therein). Measured values have been compared to the available theoretical data.

2. EXPERIMENT

The modified version of the linear low pressure pulsed arc (Djeniže et al 1989, Djeniže et al 1998) has been used as a plasma source. A pulsed discharge was driven in a quartz discharge tube of 5 mm i.d. and has an effective plasma length of 5.8 cm. The tube has end-on quartz windows. On the opposite sides of the electrodes the glass tube was expanded in order to reduce sputtering of the electrode material onto the quartz window. The working gas was argon and helium mixture (72% Ar +28% He) at 130 Pa filling pressure in flowing regime. Spectroscopic observation of isolated spectral lines were made end-on along the axis of the discharge tube. A capacitor of 14μF was charged up to 2.5 kV. The line profiles were recorded by a shot-by-shot technique using a photomultiplier (EMI 9789 QB) and a grating spectrograph (Zeiss PGS-2, reciprocal linear dispersion 0.73 nm/mm in the first order) system. The exit slit (10μm) of the spectrograph with the calibrated photomultiplier was micrometrically traversed along the spectral plane in small wavelength steps (0.0073 nm). The photomultiplier signal was digitized using oscilloscope, interfaced to as computer. A sample output is shown in Fig.1.

The measured profiles were of the Voigt type due to the convolution of the Lorentzian Stark and Gaussian profiles caused by Doppler and instrumental broadening. For electron density and temperature obtained in our experiment the Lorentzian

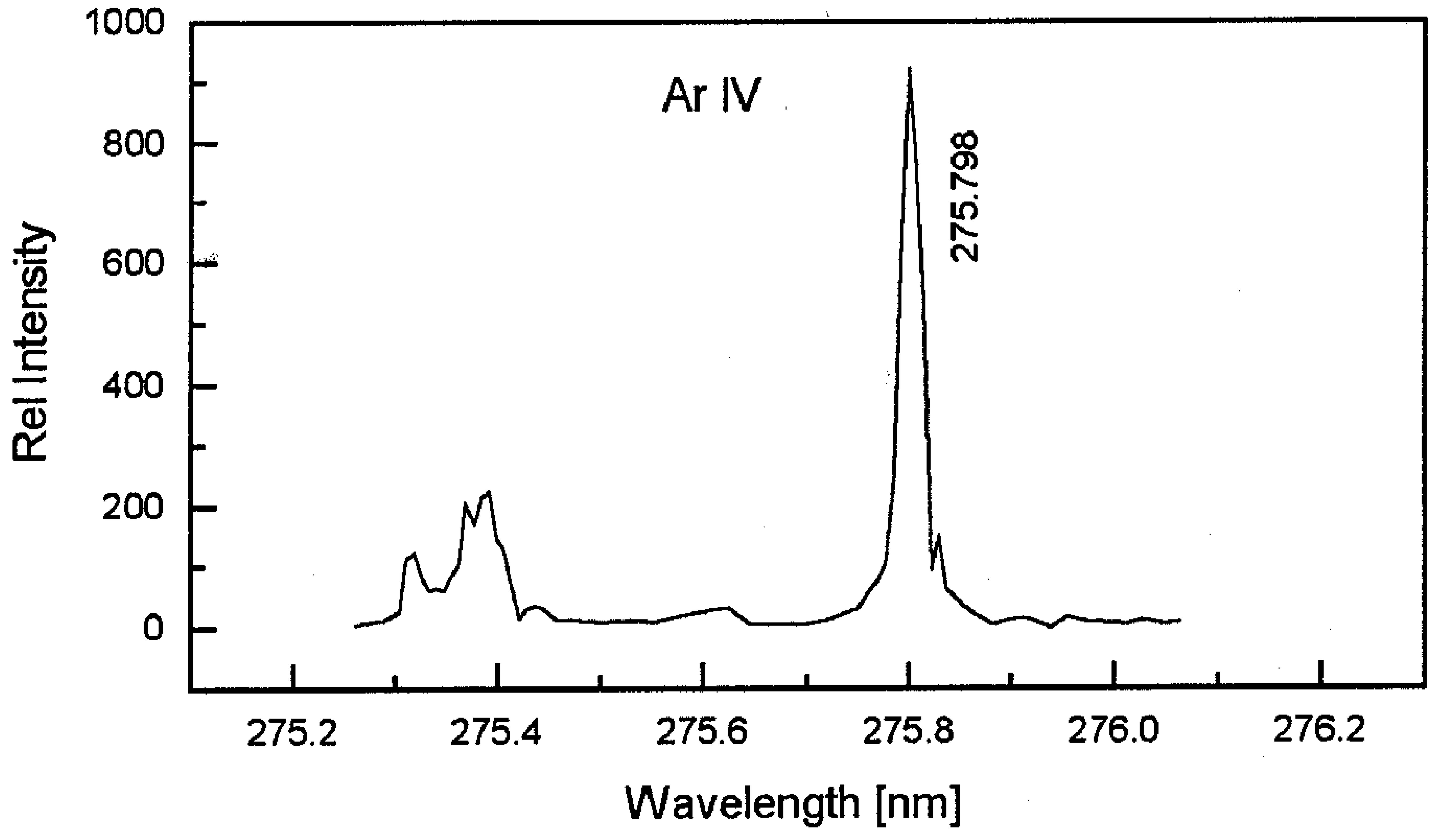

Fig. 1. Recorded spectrum at $15^{th}\mu$s after the beginning of the discharge.

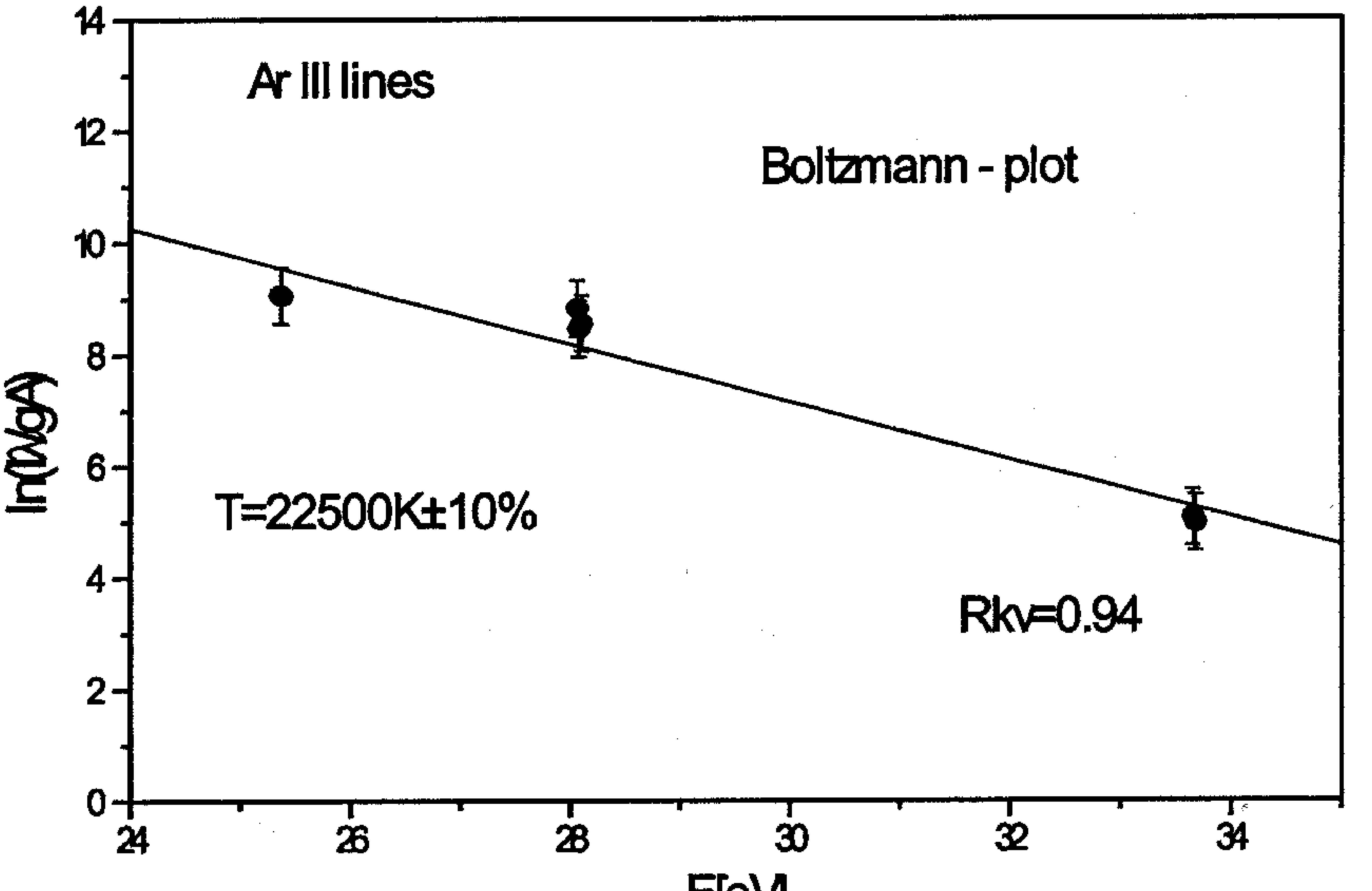

Fig. 2. Boltzmann-plot of seven Ar III lines.

fraction in the Voigt profile was dominant. Van der Waals and resonance broadening were estimated to be smaller by more than an order of magnitude in comparison to the Stark, Doppler and instrumental broadening. A standard deconvolution procedure (Davies and Vaughan 1963) was used. The Stark widths were measured with ±8% error. Great care was taken to minimize the influence of self absorption on Stark width determinations. The opacity was checked by measuring line-intensity ratios within multiplets (4UV) in the case of the Ar IV spectrum. The values obtained were compared with calculated ratios of the products of the spontaneous emission probabilities and the corresponding statistical weights of the upper levels of the lines. It turns out that these ratios differed by less than ±4% in the 15th μs of the discharge.

The plasma parameters were determined using standard diagnostics methods. The electron temperature was determined from the Boltzmann-slope of seven Ar III lines (330.2, 331.1, 335.8, 334.5, 333.6,
248.9, and 250.4 nm) with a corresponding upper-level energy interval of 8.32 eV. The necessary atomic parameters were taken from Wiese et al (1969) and Striganov and Sventickii (1966). At 15μs after the beginning of the discharge (the moment when the spectral line profiles were analyzed) the found electron temperature was 22 500 K ±10% (see Fig. 2).

For electron density measurement we used the convenient Stark width of the He II Paschen$-\alpha$ 468.57 nm spectral line. The obtained value was $N = 1.90 \cdot 10^{23}\,\mathrm{m}^{-3}$ ±9%.

3. RESULTS

Our experimental results of the measured Stark FWHM values at 22 500 K electron temperature and an $N = 1.90 \cdot 10^{23}$ m^{-3} electron density are given in Table 1. The comparison of our new experimental Stark widths values and existing theoretical data will be presented in Djeniže *et al.* (2000).

Table 1

Transition	λ (nm)	FWHM (0.1nm)
$4s\ ^4P - 4p\ ^4D$	280.94	0.210
	278.89	0.190
$4s\ ^4P - 4p\ ^4P^0$	264.03	0.160
$4s'\ ^2D - 4p'\ ^2F$	275.79	0.202

4. DISCUSSION

In order to allow easy comparison among measured and calculated Stark width values, we report in Fig.3. variations of 2w (FWHM) with the electron temperatures for a given electron density equal to 10^{23} m^{-3}. Theoretical predictions, calculated on the basis of the modified semiempirical formulae (SEM) (Kobilarov and Konjević 1990) and on the basis of the impact and classical path approximation (Hey et al 1990; Hey and Berger 1982) (+), represent only electron contribution to the Stark width.

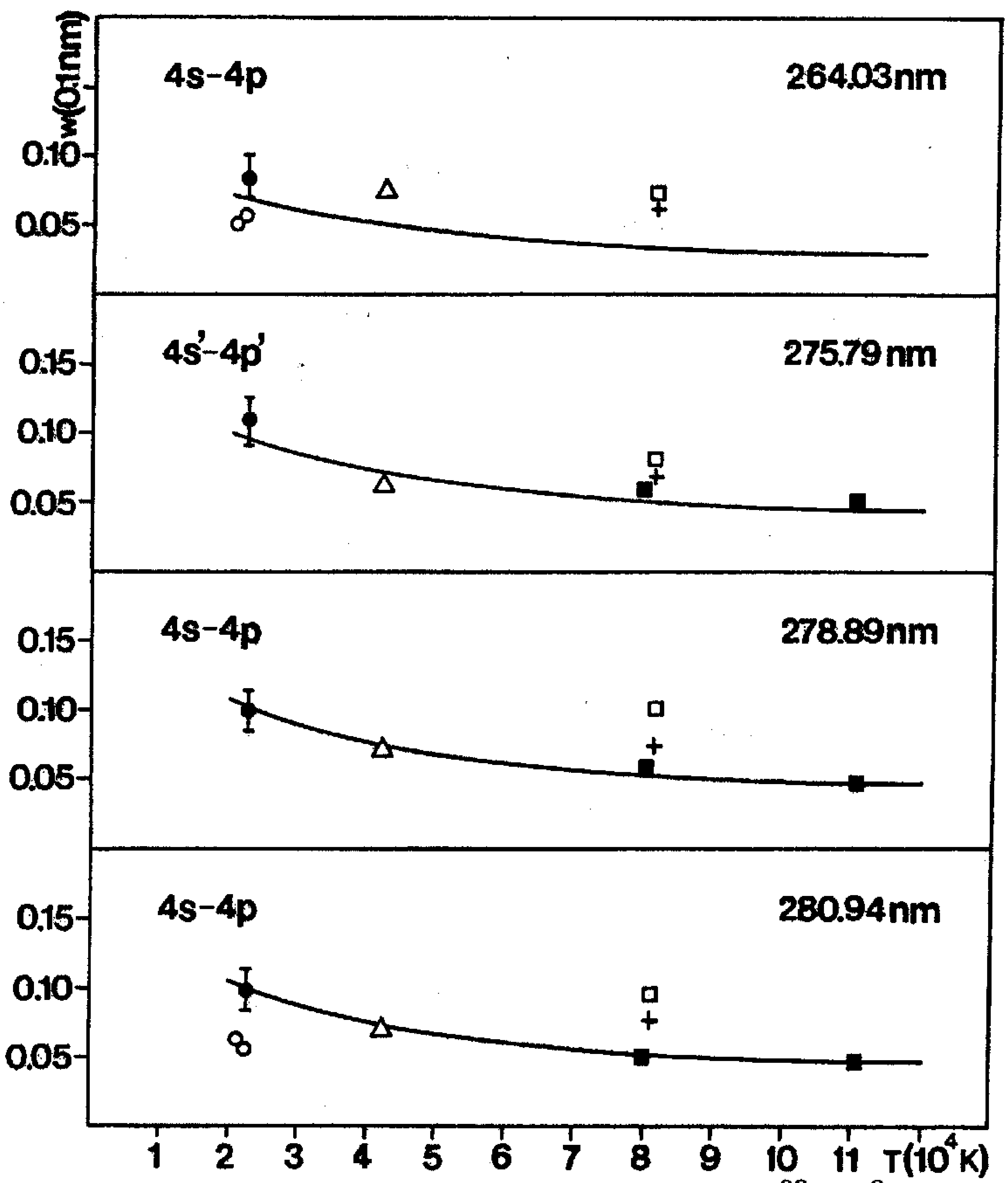

Fig. 3. Stark FWHM values vs. electron temperature at an 10^{23} m^{-3} electron density. •, this work; ∘, Platiša *et al.* (1975); ■, Kobilarov and Konjević (1990); , Hey *et al.* (1990); △, Purić *et al.* (1990); –, SEM formula (Kobilarov and Konjević 1990); +, Hey's calculation (Hey *et al.* 1990).

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