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MEASURED STARK WIDTH AND SHIFT OF 393.367 nm CaII RESONANCE SPECTRAL LINE

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SUMMARY: Stark width and shift of CaII 393.367 nm resonance spectral line at 43 000 K electron temperature have been measured and compared with existing theoretical values.

INTRODUCTION

Spectral lines of ionized light elements in hot star spectra are present in large number. Informations about Stark broadening parameters of ionized calcium spectral lines are of great astrophysical interest (for the evaluation of a physical modelling of stellar atmosphere abundance.)

A large number of experimental papers deal with the broadening of singly – ionized calcium spectral lines. Many of them are devoted to the investigation of the principal resonance spectral lines. About only three experiments (Robert and Eckerle, 1967; Roberts and Barnard, 1972 and Hadžiomerspahić et al, 1973) concern investigation of CaII resonance lines Stark broadening parameters at electron temperature (T) larger than 20 000 K. However, there are no published experimental data on Stark parameters at T larger than 30 000 K. Existing experimental CaII Stark broadening data of the resonance lines were selected and presented graphically in Fig. 1 in Konjević and Wiese (1990). It is seen that large discrepancies still exist, where the experimental data points fall into two groups separated by more than factor of two.

The aim of our investigation is to provide experimental Stark FWHM (fullwidth at half maximum intensity) (w) and shift (d) values for resonance 393.367 nm CaII spectral line in a linear low-pressure pulsed arc operating in N_2 at 43 000 K electron temperature. Our experimental data are compared with relevant experimental (Robert and Eckerle, 1967; Roberts and Barnard, 1970; Hadžiomerspahić et al, 1973 and Jones et al, 1972) and theoretical (Sahal-Bréchot 1969; Barnes and Peach, 1970; Jones et al, 1971; Griem, 1974; Dimitrijević and Konjević, 1981; Dimitrijević and Konjević, 1987; Dimitrijević and Sahal-Bréchot, 1993) values.

2. EXPERIMENT

The linear pulsed arc, that has been used as a plasma source, has been described elsewhere (Djeniže et al, 1990; Djeniže et al, 1991). Calcium atoms have been obtained as impurities by sputtering from the

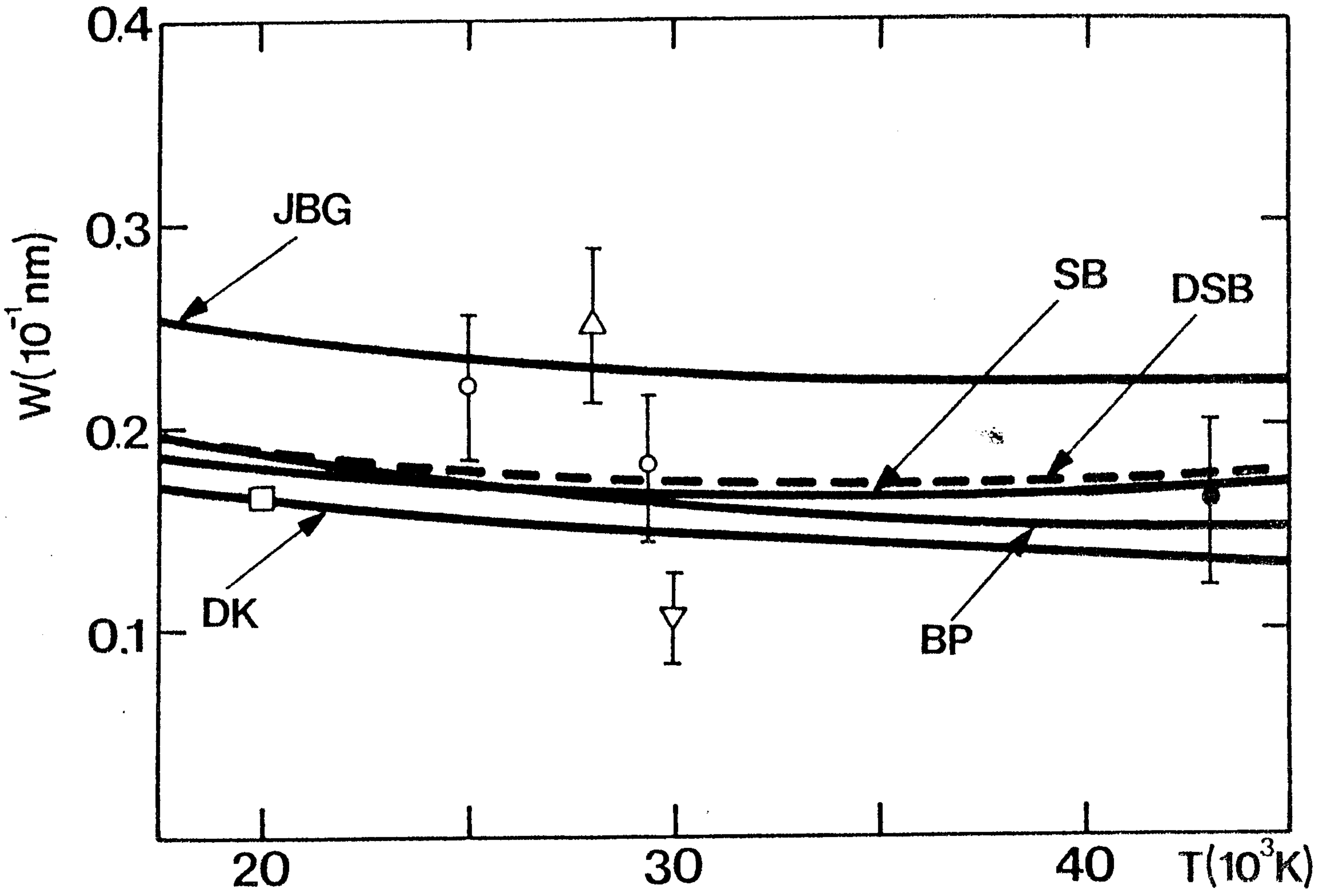

Fig. 1 Stark FWHM (w) versus the electron temperature for the CaII $4s^2S - 4p^2P^0$ resonance lines at $N = 10^{23}\ m^{-3}$ electron density. Experimental results: •, our data, o, Hadžiomerspahić et al 1973; △, Roberts and Barnard 1972; ▽, Robert and Eckerle 1967; □, Jones et al 1972. Calculated values: JBG, Jones et al 1971 and Griem 1974; SB, Sahal-Bréchot 1969; DK, Dimitrijević and Konjević 1981; BP, Barnes and Peach 1970 and DSB, Dimitrijević and Sahal-Bréchot 1993.

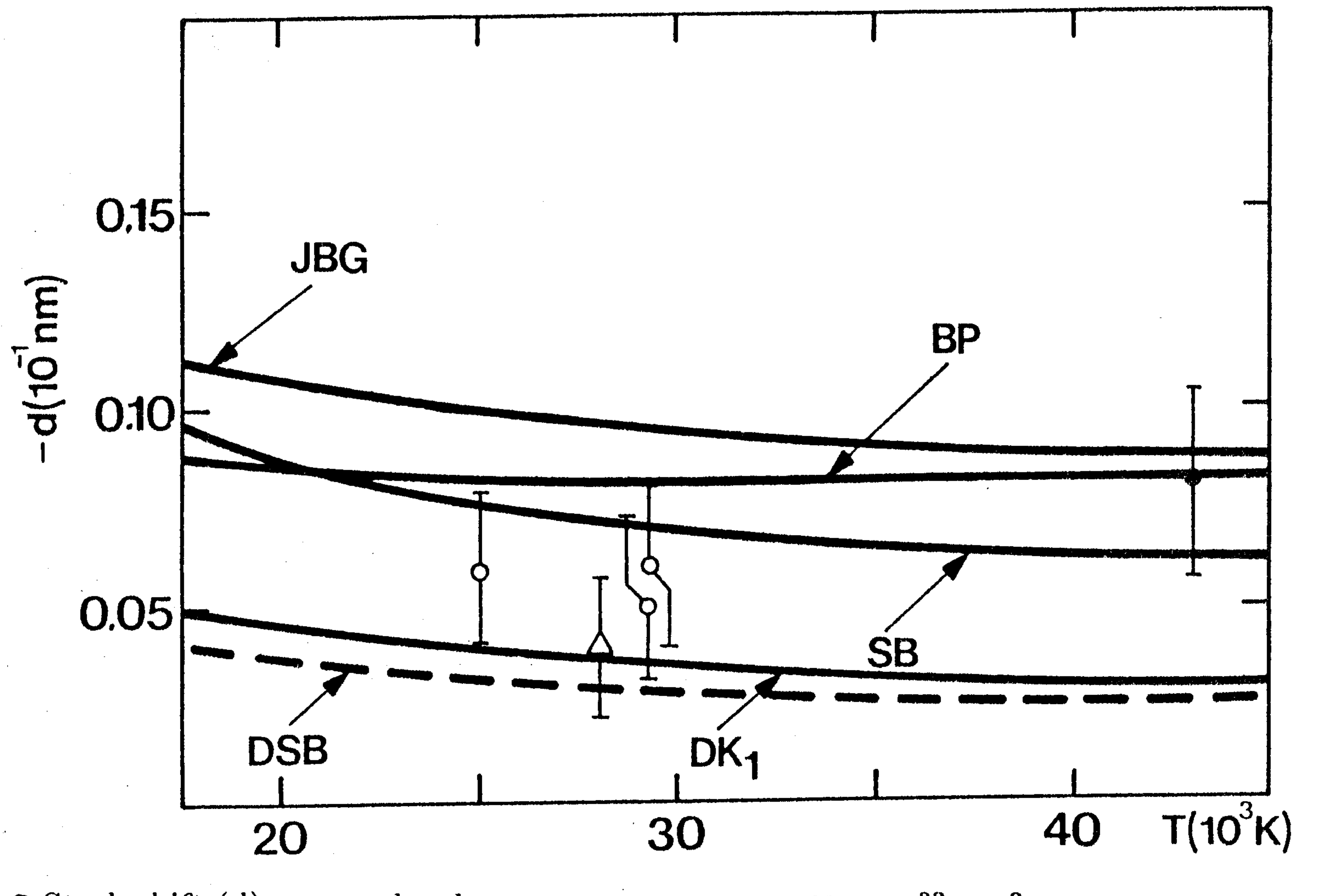

Fig. 2 Stark shift (d) versus the electron temperature at $N = 10^{23}\ m^{-3}$ electron density. DK_1, Dimitrijević and Konjević 1987. Other notation is the same as in Fig. 1.

glass walls of the discharge tube painted preliminary with calcium salts. In order to release impurity atoms from glass walls more successfully we have used special kind of the energy source described elsewhere (Djeniže et al, 1992) in details. It consists of two separate condensers of 8 and 0.3 μF that were discharged in succession after controlled time intervals. Condensers were charged to energies 58 J and 28 J, respectively. We have obtained homogenous distribution of the impurities and simultaneously, resonably high electron concentration (order 10^{23} m^{-3}). In this way it was ensured that Stark effect has a dominant role on both broadening and shift of spectral lines. We have used N_2 as a driving gas at the pressure of 430 Pa.

The line profiles were recorded by a shot-by-shot technique described elsewhere (Djeniže et al, 1990, 1991; Purić et al, 1987). The measured profiles were of Voigt type due to the convolution of the Lorentzian Stark and Gaussian profiles caused by Doppler and instrumental broadening. Van der Waals and resonance broadening were found to be negligible. The self-absorption of the measured spectral lines can be neglected owing to the very low concentration of the investigated emitting atomic species in the plasma. Reproducibility of the investigated spectral line radiation intensities was 85% what can be taken as acceptable considering the method used to introduction the impurity atoms. A standard deconvolution procedure (Davies and Vaughan, 1963) was used. The Stark width values were measured 30 μs after the beginning of a discharge. Estimated errors in our experimentally measured Stark FWHM (w_m) data were within ±15% at given electron temperature and density. The Stark shifts were measured relative to the unshifted spectral lines emitted by the same plasma. The unshifted spectral lines were observed at later times during plasma decay and at considerably lower electron densities (Purić and Konjević, 1972). Stark-shift data (d_m) were determined with absolute error of ±0.002 nm at given electron temperature and density. The electron temperature (T) was found from the ratios of the relative intensities of 347.9 nm NIV, 393.8 and 393.4 nm NIII and 399.5 nm NII spectral lines, assuming existence of the LTE, with the estimated error of ±12%. The necessary atomic data were taken from (Wiese et al, 1966). The electron density (N) was measured using the Stark broadening of convenient 399.5 nm NII spectral line with an estimated error of ±10%.

3. RESULTS

We have measured w and d of 393.367 nm CaII resonance spectral lines belonging to $^2S-^2P^0$ (No. 1) multiplet of 4s-4p transition array at 43 000 K electron temperature and 1.76×10^{23} m^{-3} electron density. Measured values are the following:

$$w_m = 0.0286 \text{ nm} \quad \text{and} \quad d_m = -0.0140 \text{ nm}$$

within estimated accuracy of ±15%.

4. DISCUSSION

Our results for w and d are presented graphically in Fig. 1 and 2, respectively, together with the other authors experimental data (for the $T \geq 20\,000$ K) and various theoretical calculations as a function of the electron temperature at $N = 1 \times 10^{23}$ m^{-3} electron density.

From Figs. one can conclude:

1. The agreement between the w_m and d_m values with the calculated values on the base of the quantum mechaniccal theory (BP) (Barnes and Peach, 1970) is very good, within 9%.

2. Within the accuraccy of the measurements, the agreement between the w_m value with the results of the semiclassical (SB) (Sahal-Bréchot, 1969) and (DSB) (Dimitrijević and Sahal-Bréchot, 1993) and semiempirical (DK) (Dimitrijević and Konjević, 1981) calculations is satisfactory (within 25%).

3. Acceptable discrepancy exists, within 40%, between w_m and Griem's 1974 theoretical results.

4. Distinct disagreement exists, up to the factor of 2.7, between d_m and calculated (DK_1) values according to Eq. (4) from Dimitrijević and Konjević (1987) (based on the modified semiempirical approaches) and up to the factor of 3.0, between d_m and calculated (DSB) values (Dimitrijević and Sahal-Bréchot, 1993) based on the semiclassical approaches.

Direct comparison of our results with experimental data of other authors is not posible due to the different electron temperature (plasma composition) at wich the data were recorded.

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МЕРЕНА ШТАРКОВА ШИРИНА И ПОМЕРАЈ РЕЗОНАНТНЕ ЛИНИЈЕ 393.367 nm ИЗ СПЕКТРА CaII

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Оригинални научни рад

Штаркову ширину и померај резонантне линије 393.367 nm из спектра CaII смо мерили на електронској температури од 43 000 K и упоредили са постојећим теоријским вредностима.