ON TECHNETIUM ABUNDANCE IN LATE-TYPE STARS

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ABSTRACT. Technetium abundances in the atmospheres of S- and C-stars are estimated by comparing the synthetic spectra and high dispersion observed spectra for the TcI λ 5924.47 region. It was found that reliable estimates are possible only for the pure S-stars and SC-stars. For the late carbon stars only the upper limit of the Tc abundance can be found. For TX Psc (C6.5) it was found to be $\lg\varepsilon_{Tc} = 0.5$.

1. INTRODUCTION

Three of the most intense resonance lines of TcI occur in the λλ 4000 - 4300 spectral interval. It is quite difficult to obtain high-dispersion spectrograms for that region, particularly for carbon-rich stars. Even with a very efficient spectrograph coupled to the DAO 1.2-meter telescope 6 hours were needed to Dominy and Wallerstein (1986) to obtain 2.4 Å/mm spectra for the bright mira χ Cyg ($m_B \sim 5.0$). Therefore most observers use a comparatively modest dispersion, 9 - 18 Å/mm (Kipper and Kipper, 1984).

Some years ago Smith and Wallerstein (1984) analysed the spectra of some stars with a dispersion of 5 - 6.7 Å/mm near the TcI intercombination line λ 5924.47. Their observing list contained a barium star, S- and SC-stars. In the spectra of the observed stars the CN red-system bands are relatively weak and it was possible to identify and measure the TcI line. The use of the yellow spectral region has some serious advantages: first, late-type stars are brighter in this region, and, secondly, this region can be observed by most solid-state detectors.

I decided to study the possibilities of using the yellow spectral region for Tc abundance determination for even later-type S- and C-stars.

2. OBSERVATIONS

The observing list contained two late-type carbon stars V460 Cyg (C6,2), TX Psc (C6,5) and a S-star χ Cyg (S7,1). Observations were made in 1986 with a CCD-detector attached to the coude spectrograph of the 2.6-meter telescope of the Crimean Astrophysical Observatory. The spectra have a dispersion of 3 Å/mm and cover a spectral region of 30 Å.

G. Cayrel de Strobel and M. Spite (eds.), The Impact of Very High S/N Spectroscopy on Stellar Physics, 459–462.

3. ANALYSIS OF SPECTROGRAMS

The spectra were reduced using the subroutines from the semiautomatic spectrophotometric reduction system developed at the Tartu Astrophysical Observatory (Kipper, 1986). Due to a very high signal to noise ratio the relative intensities found from various exposures do not differ more than 0.5%, when the traces left by cosmic particles have been removed.

The dispersion curve was constructed and the instrumental broadening was found using the narrow telluric lines in the spectrum of the Moon. Using 21 such lines this curve was obtained with the accuracy of 0.008 Å. The line positions were determined as the points, which halve the equivalent widths of the lines.

In the spectrum of χ Cyg it was not possible to identify the TcI λ 5924.47 line though Dominy and Wallerstein (1986) were able to measure the TcI blue line λ 4088.7. They estimated the Tc abundance $\lg\varepsilon_{Tc} = 1.7$. Using the photographic spectra obtained with the 1.5-meter telescope of the Tartu Astrophysical Observatory with the dispersion of 9.6 Å/mm and the synthetic spectra for the model (3000/0.0/1.0) (Johnson, 1982) I estimated the Tc abundance for χ Cyg $\lg\varepsilon_{Tc} = 2.0$ from the TcI λ 4262.26 line. In the spectrum of χ Cyg in the region containing the TcI λ 5924.47 line the very strong TiO bands are observed, which is consistent with the low ZrO abundance index for this star. It is impossible to calculate a yellow region synthetic spectrum for χ Cyg for the lack of molecular data for all the TiO γ'-system bands having lines in the relevant region (L. Hänni, private communication). Therefore for S-stars one can hope to identify and measure the TcI yellow line only if the star has a high ZrO index (pure S-stars) or for SC-stars as this was done by Smith and Wallerstein (1983).

In the spectrum of TX Psc there is a feature, which can be identified with the TcI line. Technetium lines in the blue spectra of this star are very strong (Little-Marenin and Little, 1979).

In order to estimate Tc abundances the synthetic spectrum approach was used. Johnson et al. (1982) when modelling the spectra of TX Psc and V460 Cyg using carbon-rich models (Johnson, 1982) found for both stars $T_{eff} = 3000$ K, the ratio of carbon and oxygen abundances C/O $\sim$ 1.02, the carbon isotopic abundance ratio $^{12}C/^{13}C \sim 25$ and the microturbulent velocity $\xi_t \sim 4 - 6$ km/sec.

These data together with the line list compiled and kindly supplied to us by R. Bell were used to calculate the synthetic spectra. The wavelenghts of the CN red-system lines observed in the solar spectrum (Sotirovski, 1972) were corrected. The oscillator strength for the TcI λ 5924.47 line calculated by Garstang (1981) was used.

As Bell's line list was compiled for oxygen-rich stars and did not contain all the lines observed in late carbon stars it was impossible to reach a good fit for the whole 30 Å region. Nevertheless it was possible to estimate Tc abundance. For comparing the synthetic spectra with the observations the computed spectra were smeared with a Gaussian profile with the half-width of 0.3 Å. This profile contains the apparatus profile 0.25 Å and macroturbulence (8 km/sec). The width of the instrumental profile was determined from the observed width of narrow telluric lines in the spectrum of the Moon.

4. RESULTS

The best fit of the synthetic spectrum with the observed ones for both stars was obtained using the microturbulent velocity of ξ_t = 2 - 3 km/sec and macroturbulence in addition to the instrumental broadening. As the pertinent wavelength region contains the isotopic lines of ^{13}CN the carbon isotopic abundance ratio was also estimated as $^{12}C/^{13}C \sim 50$. This estimate depends mainly on the visibility of the $Q_2(9)$ λ5923.44 line of the (7 - 2) ^{13}CN band. As an illustration, the figure compares the observed spectra with the synthetic spectrum computed for the model (T_{eff} = 3000 K, lg$g$ = 0.0, C/O = 1.02). The positions of the TcI line and some of the ^{12}CN (7 - 2) band Q_1 branch lines are marked with vertical strokes. One of those strong lines closely coincides with the TcI line and therefore there is no hope to find accurate Tc abundances for these carbon stars. One can only estimate the upper limit for technetium abundance, which in case of TX Psc turns out to be lgε_{Tc} = 0.5.

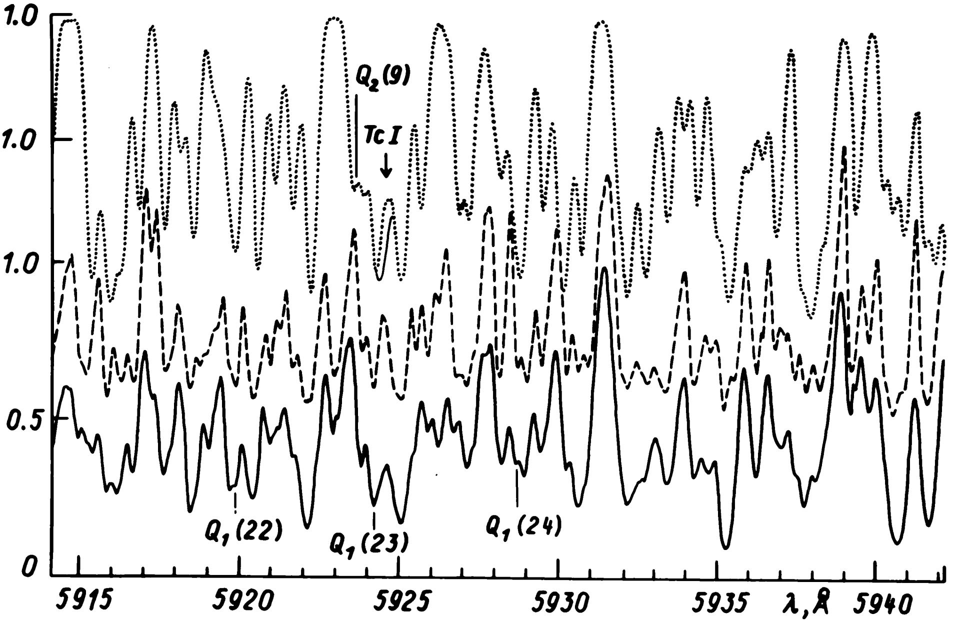

Fig. 1. The observed spectra of TX Psc (full line) and V460 Cyg (dashed line) around 5925 Å as compared with a corresponding synthetic spectrum (dotted line). The TcI line at λ 5924.48, some of the ^{12}CN (7 - 2) Q_1-branch lines and a ^{13}CN line Q_2 (9) are indicated.

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