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Diffuse interstellar bands towards o Per and ξ Per

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Spectroscopic characteristics of interstellar matter vary strongly with the direction to the target star. Spectra of o Per and ξ Per contain many prominent and weak diffuse interstellar bands as well as absorption lines of some identified interstellar atoms and molecules. Using echelle optical spectra of these bright and moderately reddened stars we selected well detectable diffuse interstellar bands (DIBs). We measured intensities of all well noticeable absorption features to compare them with their counterparts observed in spectra of the other target stars.

Key words: ISM: lines and bands

INTRODUCTION

Diffuse interstellar bands (DIBs), the mysterious absorption features observed in the spectra of reddened stars, have very long history which is well described e. g. in [2, 3]. DIB survey with precise wavelengths in the spectrum of o Per was published in [1]. Using echelle spectra with resolution $R = 45000$, the authors found 271 DIBs in the range from 4460 Å to 8800 Å and determined their central wavelengths with accuracy of about 0.1 Å. Using spectra of better resolution for o Per, the authors of [5] found that numerous DIBs in atlas of [1] are artefacts caused probably by telluric lines. Therefore, we undertook the careful search for true DIBs in o Per spectra. Furthermore, we carried out the spectral analysis for ξ Per, the reddened and hot star which is located on the sky relatively close to oPer.

THE TARGET AND COMPARISON STARS AND THEIR OBSERVATIONS

Spectroscopic binary o Per (HD 23180) is our first target star. It is a bright ($V = 3.8^m$) and hot (B1 III/B3 V) star with short period of revolution. Additionally, it is obscured by single interstellar cloud, introducing moderate reddening $E(B-V) = 0.3^m$. Therefore, DIBs' profiles and their tiny substructures do not suffer from extra Doppler broadening due to different radial velocities of obscuring clouds, that is the case for many other target stars.

The ξ Per (HD 24912) was our second target star. It is a hot star of O7.5 III spectral type and apparent magnitude of 4.0^m. It has moderate interstellar reddening $E(B-V) = 0.29^m$.

As a comparison (not reddened) star we took β Tau (HD 35497). It is a very bright ($V = 1.68^m$) B7 III star and lies relatively close on the sky to our target stars. Therefore the target and comparison stars could be observed one after another with similar air masses.

Echelle spectra of our stars were observed at Pic du Midi Observatory (France) with 2-m Bernard Lyot Telescope equipped with spectropolarimeter NARVAL having spectral resolution of 67000. S/N of the original single spectrum is over 1000. All orders together (there are 40 of them) cover the wavelength range from 3700 Å to 10480 Å. Target stars were observed in two subsequent nights to get their spectral pictures in two different phases of revolution (stellar lines change their positions from one night to another, in contrary to interstellar lines).

After routine processing in Pic du Midi Observatory the original spectra were transformed into convenient `ASCII` data tables using `FORTRAN` code written by Bogdan Wszołek. Then, visual search and measurements were carried out with using `ReWiA` program (version 1.4), authorized by Jerzy

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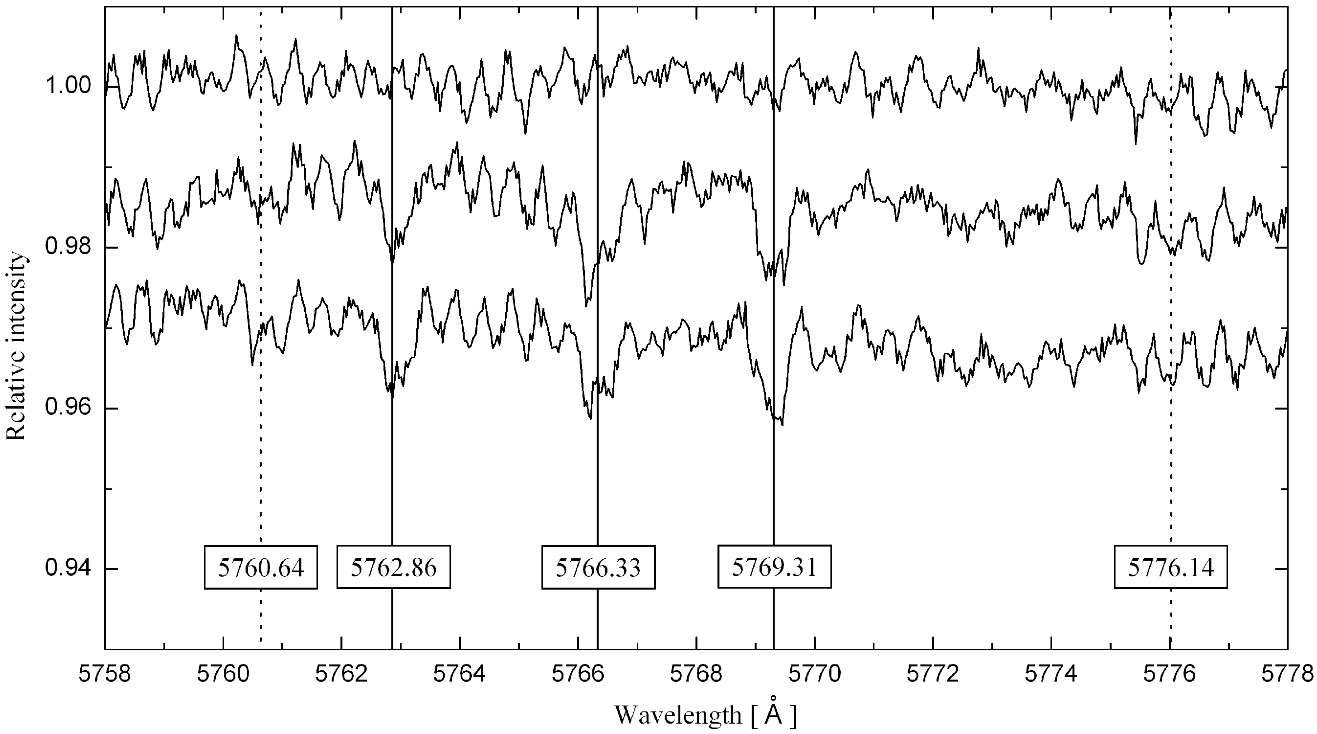

Fig. 1: Normalized spectra of (from top to bottom) β Tau (not reddened comparison star, March 13, 2010, air mass (AM) = 1.1), o Per (March 13, 2010, AM = 1.65) and o Per (March 12, 2010, AM = 1.25). No division by comparison spectra was done. Solid vertical lines denote DIBs which are selected to be measured. Dashed lines indicate places where we expected to see DIBs (after [1]) but we could not confirm them.

Borkowski from Nicolaus Copernicus University in Toruń, written especially for astronomical spectra analysis.

RESULTS

Results of our measurements of DIBs in o Per spectra are collected in Table 1. Measurements of prominent DIBs and identified atomic and molecular lines in ξ Per spectra are given in Table 2. Figure 1 shows how measured DIBs may look like.

FINAL REMARKS

Analysing spectra of o Per and ξ Per we found and measured many interstellar absorption features, collected in Tables 1, 2. Comparison star spectrum allowed us to find all dangerous cases when telluric lines is overlapping with DIBs. We found that telluric lines may response for many substructures seen in DIB profiles. We included here only relatively easily detectable features, omitting numerable, but hardly noticeable, structures. Results of our analysis will help to find differentiations in spectral characteristics of interstellar matter in the direction of ξ Per and o Per, especially for testing methods of finding spectroscopic families among DIBs [4].

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Table 1: DIBs in the spectrum of Per: approximate position (λ) of the profile centre, equivalent width (EW) and its uncertainty (uEW), profile depth (D) (in percentage of continuum level).

λ [Å]	EW [mÅ]	uEW[mÅ]	D [%]
4683.20	5.0	0.5	1.2
4726.65	75.0	7.0	2.8
4735.02	3.5	0.3	1.2
4762.75	6.1	1.2	0.9
4964.07	12.2	0.7	2.2
4979.89	3.1	0.6	0.4
4984.96	6.7	1.2	1.7
5170.68	3.4	0.8	1.0
5176.14	4.7	0.7	1.0
5419.04	11.5	1.0	1.3
5494.26	8.0	0.6	1.8
5512.86	11.0	0.7	1.6
5541.94	6.3	1.0	1.1
5545.19	10.4	1.2	1.1
5546.67	5.2	0.8	1.2
5594.80	3.4	0.3	0.9
5762.86	5.2	0.8	1.2
5766.33	4.5	0.8	1.1
5769.31	5.0	1.0	0.9
5780.77	85.0	6.0	3.9
5828.82	5.5	1.2	0.8
5840.85	4.1	1.0	0.8
5850.03	34.4	2.1	3.9
6090.03	10.9	1.8	2.0
6140.21	6.9	1.2	1.3
6203.38	30.0	5.0	2.0
6234.22	3.3	0.3	1.3
6269.94	10.3	0.8	1.3
6284.37	90.0	10.0	2.8
6287.60	4.6	0.3	1.3
6367.49	4.4	0.8	1.1
6376.24	7.5	0.3	1.7
6379.47	39.3	2.0	6.4
6439.77	7.0	0.5	1.1
6445.42	5.8	0.7	1.4
6613.83	53.7	2.0	6.4
6665.48	3.7	0.5	0.8
6672.47	2.4	0.3	0.6
6729.52	5.7	0.3	1.0
7224.33	22.2	2.0	3.0
7367.42	9.5	1.2	1.5

Table 2: Interstellar absorption features in the spectrum of ξ Per: approximate position (λ) of the profile centre, name of the feature, profile depth (D) (in percentage of continuum level), equivalent width (EW) and its uncertainty (uEW).

λ [Å]	feature name	D [%]	EW [mÅ]	uEW [mÅ]
3860.02	Fe I (3859.913)	1.7	1.55	0.15
3874.69	CN (3874.608)	1.7	1.15	0.35
3886.52	CH (3886.410)	4.9	3.15	0.35
3890.32	CH (3890.213)	2.6	1.10	0.30
3933.81	Ca I (K) (3933.663)	89.5	120	1.00
3957.80	CH^+ (3957.700)	14.8	12.00	0.45
3968.60	Ca I(H) (3968.468)	43.7	70.25	1.55
4226.83	Ca I (4226.728)	1.5	2.40	0.05
4232.67	CH^+ (4232.280)	17.1	22.13	0.60
4300.42	CH (4300.321)	7.5	9.90	0.30
4726.44	DIB	1.6	45.00	1.10
4734.93	DIB	0.5	1.75	0.10
4762.94	DIB	2.6	42.25	0.95
4964.05	DIB	1.1	9.80	0.60
4979.85	DIB	0.7	2.50	0.20
4984.94	DIB	0.8	4.60	0.20
5170.53	DIB	0.5	2.50	0.05
5494.26	DIB	1.3	11.20	0.90
5512.76	DIB	0.7	4.60	0.20
5541.96	DIB	0.8	11.80	0.65
5545.17	DIB	0.7	10.45	0.45
5780.65	DIB	9.3	212.90	5.80
5797.16	DIB	4.8	41.4	0.20
5828.53	DIB	0.4	4.50	0.20
5850.00	DIB	2.3	31.8	5.50
5890.13	Na I (D2)	90	299	7.00
5896.12	Na I (D1)	88	258	2.00
6089.98	DIB	1.5	13.15	0.45
6140.26	DIB	0.7	6.27	0.30
6194.83	DIB	0.7	4.55	0.05
6196.18	DIB	4.3	21.37	0.50
6234.20	DIB	0.9	9.05	0.15
6269.93	DIB	3.3	70.25	7.95
6284.37	DIB	9.5	853	21.0
6367.54	DIB	0.5	7.47	0.85
6376.18	DIB	1.9	17.93	2.35
6379.44	DIB	4.4	32.7	0.30
6439.57	DIB	0.8	8.85	1.45
6445.42	DIB	1.2	13.2	0.20
6449.43	DIB	0.4	7.35	0.25
6613.75	DIB	8.8	91.6	1.20
6600.86	DIB	1.8	18.6	2.10
6672.43	DIB	1.2	10.40	2.70