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On the diffuse bands related to the C_2 interstellar molecule*

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ABSTRACT

The recently published idea that intensities of some weak diffuse interstellar bands (DIBs) are related to the C_2 molecule column density have been examined. We use a set of high quality echelle spectra of heavily reddened stars, acquired at the Bohyunsan Optical Astronomical Observatory (South Korea), with a resolution $R = 30\,000$. The high quality (high S/N ratio) of our spectra is proved by the fact that despite using the most widely used Phillips (2, 0) band of the C_2 molecule (near 8760 Å), we can trace the (3, 0) Phillips band (near 7725 Å) as well. Equivalent widths of four (5176, 5542, 5546 and 5769 Å) out of 16 examined DIBs demonstrate relatively good correlation with C_2 column density. However, a majority of the studied DIBs, already reported as "C_2" ones, most likely are not related to this simplest carbon molecule. A removal of peculiar objects like HD 34078 from the analyzed sample does not substantially change the level of correlations.

Key words. ISM: lines and bands – ISM: molecules

1. Introduction

Any observationally established relation between any of the unidentified diffuse interstellar bands (DIBs) and any of the well-known interstellar molecular absorptions may help to identify DIBs, revealing the chemical nature of their still unknown carriers. Thorburn et al. (2003) (hereafter, Th03) proposed a set of DIBs, all of them very weak, to be closely related to the C_2 molecule. Interstellar space contains much carbon or hydrocarbon chains discovered by radioastronomical observations; C_2 molecules are very likely building blocks for such more complex species. Thus such a relation, if confirmed, may give us some hints as to the chemical processes that lead to formation of these DIB carriers. Nevertheless, the absence of diffuse interstellar bands in the circumstellar shell of the heavily reddened object IRC +10216, where C_2 was found abundant (Kendall 2002, 2004), may cast doubts on whether any of DIB carriers are related to C_2, despite the lack of quantitative estimates of C_2 abundance.

In the context of relations between C_2 molecules and at least certain DIBs, Douglas (1977) proposed bare carbon chains as possible DIB carriers. However, the laboratory gas–phase spectra of these species are known only for reasonably short chains i.e. until C_5. For longer ones the projects of determining their spectra were conducted in noble gas matrices which makes the experimental spectra difficult to be directly compared to any observational material, but allows one to apply their common characteristics, e.g. intensity ratios. As one may expect abundances of carbon chains to be mutually correlated, a constant strength ratio of some DIB and the C_2 column density may help to identify this DIB carrier.

The above considerations motivate a search for correlations between C_2 features and strengths of certain DIBs, likely formed in (hydro)carbon chains. However, the existing body of C_2 measurements is very scarce. Moreover these measurements were performed (by Th03) toward stars that are not heavily reddened; this makes the weak DIBs very weak in their spectra and their intensity measurements uncertain. It is thus important to collect a sample of spectra of high quality, heavily reddened stars; one may expect relatively strong C_2 bands as well as reasonably easily detectable weak DIBs. Another

* Based on data collected at 1.8 m telescope operated on BOAO Observatory, Korea.

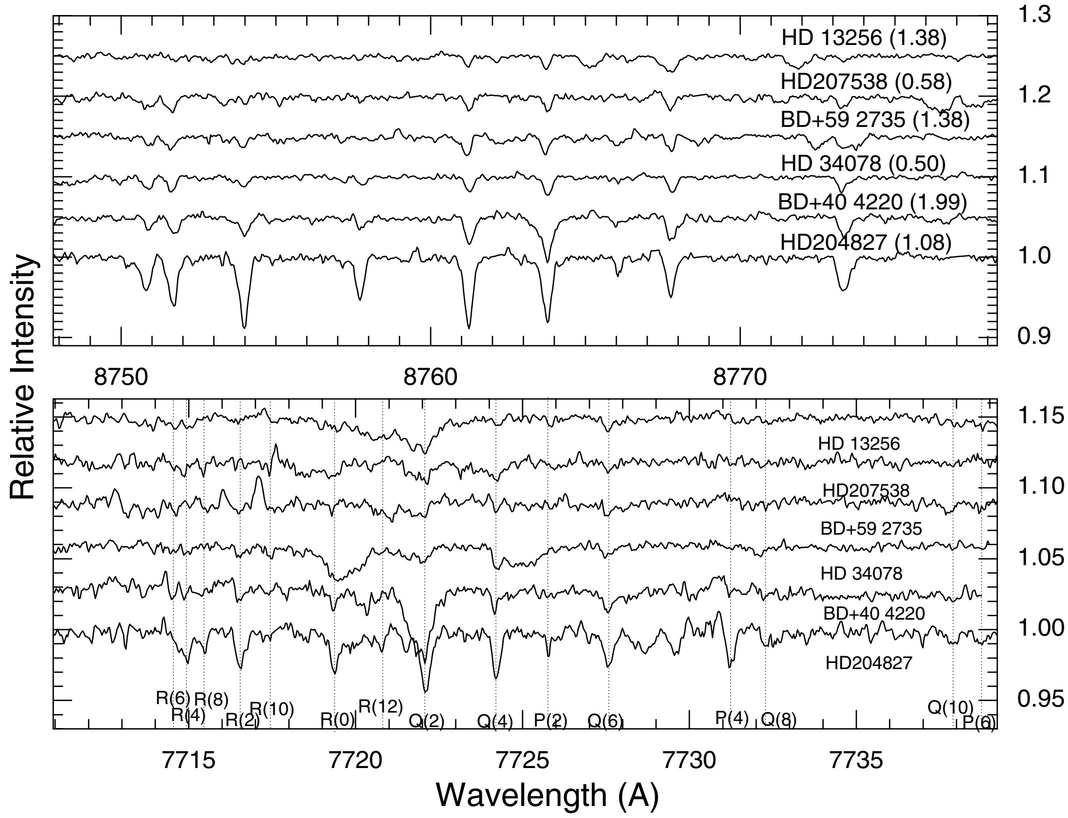

Fig. 1. Phillips (2, 0) and (3, 0) bands of C_2 molecule observed in spectra of some of our target stars (in top and bottom panels respectively). The telluric lines are divided out.

important factor should be a broad range of $E(B-V)$'s which should lead to a broad ranges of intensities of all other interstellar features too. The latter usually correlate more or less tightly to this popular parameter, despite that, as demonstrated in Fig. 3, this correlation is of just rather general sense. A correlation analysis is more reliable if performed on variables spanning relatively broad ranges of values.

The "C_2" DIBs as proposed by Th03 are listed in their Table 2 (18 entries). The weakness of these features makes precise measurements difficult. Apparently this is why Th03 claim that the 4979.58 Å DIB is "new" (see their Table 2). In fact the feature has been described in two earlier papers: Galazutdinov et al. (2001) and Galazutdinov et al. (2002). The data presented in the two latter papers were acquired both at Terskol Observatory and at ESO which makes the detection certain. However, such a hard-to-detect interstellar feature must be weak. Figure 2 of Th03 shows the weakness of all considered DIBs, demonstrating the difficulties in measuring their equivalent widths. The S/N ratio that one can achieve inside weak DIB profiles must be low, allowing relatively large errors of EWs.

Usually the only sufficiently easily available C_2 feature to ground–based observations is the Phillips 2–0 band situated in the near infrared (see Fig. 1). The details of such a band of a homonuclear molecule, full of weak and very narrow features, require high resolution and very high S/N ratio data. Measurements of all spectral features of C_2 band(s) may very likely suffer relatively large errors. The BOES spectra, used in this project, allow us to completely remove the fringing (by flatfielding) which is normally a nuisance while highly sensitive, back-illuminated CCDs.

Heavily reddened stars are necessarily quite faint. This is why it is a very time–consuming task to collect a statistically meaningful sample of high S/N spectra of such objects. The sample collected for this project is an intermediate one (20 objects). However, the broad range of reddenings (see Table 1), which should result in a broad range of intensities of both C_2 features and DIBs, should reveal the relation suggested by Th03 between the known molecule and the unidentified carriers of DIBs.

2. Observations

We have collected echelle spectra of 20 heavily reddened stars (see Table 1) using the fiber fed echelle spectrograph[1] attached to 1.8-m telescope of Bohyunsan Optical Astronomy Observatory (Korea) during 2004 observing runs. As seen from Table 1 all the targets are reddened, some of them very heavily. In total the $E(B-V)$s of the sample stars range from 0.45 to 1.99 which should make weak DIBs and molecular features strong enough to allow detections and reasonably precise measurements but also covering a broad range of values which facilitates a correlation analysis.

[1] A detailed description of the spectrograph is given at `http://www.boao.re.kr/BOES/BOESppt3.files/frame.htm`

Table 1. Observed stars. Columns headings are: Star – object name, V – V magnitude, $E(B-V)$ – reddening, Sp – spectral and luminosity class.

Star	V	$E(B-V)$	Sp
BD+59 2735	9.88	1.38	B0Ib
BD+40 4220	9.05	1.99	O7e
HD 13256	8.68	1.38	B1Ia
HD 34078	5.94	0.50	O9.5Ve
HD 204827	8.0	1.08	B0V
HD 207538	7.3	0.58	B0V
BD+59 451	9.29	0.89	B1II
BD+59 456	9.86	0.79	B0.5V
BD+60 594	9.33	0.62	O9V
HD 15785	8.34	0.76	B1Iab
HD 46149	7.59	0.45	O8.5V
BD+58 2580	10.08	1.04	B0.5V
HD 210839	5.00	0.55	O6e
HD 219287	8.91	1.24	B0Ia
HD 226868	8.91	1.03	B0Ib
HD 228779	8.92	1.53	O9.5Ib
HD 235825	9.29	0.51	O9V
HD 186745	7.04	0.96	B8Ia
HD 206267	5.78	0.49	O6f
HD 228712	8.67	1.33	B0.5Ia

The spectrograph has 3 observational modes with different resolving power: 30 000; 45 000 and 90 000. Our spectra are in the lowest resolution which is caused by the relative faintness of the heavily reddened objects. The spectrograph allows us to cover in a single exposure the wavelength range ~3700 Å–~10 000 Å, divided into 75–76 spectral orders with CCD camera equipped with a 4096×2048 pixels matrix (pixel size 15 μm $\times$ 15 μm). The achieved resolution allows precise measurements of wavelengths and intensities of interstellar features.

Our reduction of the echelle spectra have been performed using both the IRAF (Tody 1986) and the DECH codes (Galazutdinov 1992). The programs allow us to perform all standard procedures of CCD spectra processing and analyzing. The wavelength scale was constructed on the basis of a global polynomial of the form described in detail in Galazutdinov et al. (2000).

Our spectra contain the features of the C_2 Phillips (2–0) band – see the examples given in Fig. 1. It is evident that the sequence of increasing C_2 band intensity is not the same as the sequence of increasing colour excesses. As a demonstration of the quality of our spectra we present also the Phillips (3–0) band observed towards our selected targets (Fig. 1). This band was discovered by van Dishoeck & Black (1986) in the spectrum of ζ Oph. However, to achieve high enough S/N ratio they observed this bright object for 7 h and present the C_2 features between telluric lines. Recently this band was reported in spectra of heavily reddened stars by Gredel et al. (2001) and by Gredel (2004). Our Fig. 1 demonstrates the band in the spectra of stars listed in Table 1 without the telluric lines which have been removed using the proper standard (Spica). Although the (3–0) band is weaker than the (2–0) one it behaves in the same fashion, i.e. the spectra form the same sequence of intensities – see Fig. 1.

The column densities of the C_2 rotational levels were derived from the (2–0) band of the C_2 $A^1\Pi_u$–$X^1\Sigma_g^+$ Phillips System using the profile fitting technique (Fig. 2). The molecular cloud velocity (v) and column densities of rotational levels $J'' = 0$ to $J'' = 18$ were simultaneously fitted to the observed spectra. The Doppler broadening parameter (b) was fitted together with v and column densities only for sightlines with strong C_2 lines. For stars with shallow C_2 lines the Doppler broadening parameter was set manually, and an average C_2 column density for different b values was computed. The (2–0) band oscillator strength $f_{2,0}^{A-X} = 1.36 \times 10^{-3}$ was adopted from Erman & Iwamae (1995). The wavelengths and oscillator strengths for individual lines were adopted from van Dishoeck & de Zeeuw (1984).

The column densities of the higher (unobserved) rotational levels (J'') of the C_2 molecule were estimated from the Bolzmann function:

$$N(J'') = (2J''+1) \cdot \frac{N_\mathrm{T}}{Q_\mathrm{r}} \cdot \exp\left(-\frac{BJ''(J''+1)hc}{kT_\mathrm{rot}}\right) \quad (1)$$

where Q_r is the partition function at rotational temperature T_rot, and N_T is the total abundance of C_2. The C_2 ground state rotational constant $B = 1.82$ cm^{-1} (Douay et al. 1988). The rotational temperature T_rot was calculated from column densities of rotational levels $J'' = 6$ to $J'' = 16$ of the stars: BD +40 4220, HD 13256, HD 34078, HD 204827, HD 207538. The least squares fit to the linearized form of Eq. (1) yields $T_\mathrm{rot} = 267$ K, and this value was used for all stars.

For three stars the rotational levels $J'' = 0$ or $J'' = 2$ were not observed. We have calculated column densities for these levels from Eq. (1), but the rotational temperature was obtained for each star independently. For HD 46149 $T_\mathrm{rot} = 163$ K (from $J'' = 4$–6), for the star BD +58 2580 the rotational temperature $T_\mathrm{rot} = 109$ K (from $J'' = 2$–6), and for HD 235825 $T_\mathrm{rot} = 260$ K (from $J'' = 4$–8). The total C_2 column density ($N_\mathrm{tot}(C_2)$) presented in Table 3 is the sum of rotational levels up to $J'' = 20$.

2.1. C_2 Phillips (2–0) band and diffuse interstellar bands

Th03 placed the spectra in sequence after being normalized to E_{B-V}. In Fig. 3 we compare two fragments of the spectra of our heavily reddened targets. Despite the E_{B-V}s which are different by a factor of 2, several of the DIBs are of almost identical intensity in both spectra (5797, 5828, 5850, 6367, 6379 and 6425 Å). At the same time some rather broad DIBs are evidently stronger towards BD+40 4220 (5780 and 5844) while some narrow features are stronger in the spectrum of HD 204827 (6410 and 6439). This demonstrates the lack of a tight correlation between E_{B-V} and column densities of many DIB carriers. The same concerns known molecular species; e.g., in Fig. 1 it is clearly seen that intensities of C_2 features correlate quite poorly with reddening. We thus consider any normalization to $E_{B-V} = 1$ as risky and we do not apply it in our further considerations.

Table 2. The equivalent width of DIBs (mÅ) measured in spectra of program stars.

Star	4364	4726	4734	4964	4969	4980	4985	5170	5176	5419	5513	5542	5546	5763	5769	5793	6729
BD+59 2735	6 ± 2	256 ± 23	12 ± 4	54 ± 7	15 ± 5	10 ± 3	18 ± 2	15 ± 2	14 ± 2	36 ± 3	22 ± 2	12 ± 2	10 ± 2	16 ± 2	13 ± 2	16 ± 2	13 ± 1
BD+40 4220	0 ± 2	221 ± 39	6 ± 6	56 ± 4	4 ± 1	17 ± 3	32 ± 5	15 ± 2	29 ± 5	52 ± 4	35 ± 3	21 ± 3	13 ± 3	12 ± 3	20 ± 4	11 ± 3	16 ± 2
HD 13256	2 ± 1	187 ± 15	9 ± 4	43 ± 3	6 ± 2	6 ± 2	22 ± 2	5 ± 2	15 ± 3	31 ± 2	31 ± 3	12 ± 2	9 ± 1.5	8 ± 2	7 ± 1	3 ± 1	10 ± 1
HD 34078	0 ± 2	108 ± 12	11 ± 2	25 ± 2	8 ± 2	7 ± 2	12 ± 1	0 ± 1	blend	14 ± 2	8 ± 1	7 ± 2	0 ± 2	2 ± 1	8 ± 2	4 ± 1	3 ± 3
HD 204827	15 ± 3	221 ± 22	17 ± 3	52 ± 2	10 ± 3	13 ± 2	30 ± 3	13 ± 2	37 ± 5	46 ± 3	34 ± 3	23 ± 3	19 ± 3	13 ± 2	21 ± 3	23 ± 3	19 ± 1
HD 207538	2 ± 1	122 ± 10	4 ± 1	27 ± 2	8 ± 1	9 ± 1	13 ± 1	8 ± 1	19 ± 3	23 ± 2	23 ± 1	10 ± 2	9 ± 1	11 ± 1	5 ± 1	17 ± 2	10 ± 1
BD+59 451	0 ± 2	158 ± 19	3 ± 1	31 ± 2	8 ± 1	13 ± 2	17 ± 3	8 ± 2	19 ± 4	22 ± 2	29 ± 4	13 ± 2	10 ± 2	7 ± 2	7 ± 2	7 ± 2	13 ± 2
BD+59 456	0 ± 2	150 ± 23	0 ± 4	33 ± 2	0 ± 2	0 ± 2	16 ± 2	blend	blend	20 ± 2	30 ± 4	17 ± 3	7 ± 1	7 ± 2	7 ± 2	7 ± 2	8 ± 1
BD+60 594	0 ± 2	138 ± 10	3 ± 2	28 ± 2	4 ± 1	0 ± 4	14 ± 2	14 ± 2	10 ± 2	20 ± 3	16 ± 4	10 ± 1	4 ± 1	8 ± 2	8 ± 2	10 ± 3	13 ± 3
HD 15785	4 ± 1	151 ± 10	6 ± 2	28 ± 2	6 ± 1	7 ± 2	14 ± 1	7 ± 2	14 ± 1	23 ± 1	21 ± 1	14 ± 1	8 ± 1	8 ± 2	8 ± 2	8 ± 2	10 ± 1
HD 46149	0 ± 2	67 ± 10	0 ± 2	17 ± 1	4 ± 1	4 ± 1	10 ± 1	5 ± 1	5 ± 2	7 ± 2	9 ± 2	7 ± 1	4 ± 1	4 ± 1	4 ± 1	7 ± 2	bld
BD+58 2580	0 ± 2	214 ± 22	0 ± 4	43 ± 3	0 ± 4	0 ± 4	23 ± 2	bld	bld	23 ± 1	40 ± 5	10 ± 2	6 ± 1	12 ± 2	8 ± 3	10 ± 3	13 ± 1
HD 210839	0 ± 2	71 ± 8	1 ± 1	15 ± 1	4 ± 1	3 ± 1	6 ± 1	2 ± 1	5 ± 2	8 ± 2	6 ± 2	4 ± 1	1 ± 2	5 ± 1	2 ± 1	7 ± 1	5 ± 1
HD 219287	0 ± 2	130 ± 12	0 ± 2	30 ± 2	6 ± 1	0 ± 2	14 ± 1	bld	bld	32 ± 3	8 ± 3	5 ± 2	3 ± 2	4 ± 2	3 ± 2	5 ± 3	5 ± 2
HD 226868	10 ± 2	152 ± 16	12 ± 3	33 ± 2	7 ± 2	8 ± 1	15 ± 2	6 ± 2	13 ± 2	21 ± 3	21 ± 3	10 ± 2	6 ± 1	8 ± 2	9 ± 2	10 ± 3	9 ± 2
HD 228779	0 ± 2	197 ± 20	0 ± 4	39 ± 2	11 ± 2	12 ± 3	30 ± 3	8 ± 2	16 ± 2	26 ± 3	21 ± 3	16 ± 2	7 ± 1	9 ± 1	9 ± 1	13 ± 4	10 ± 1
HD 235825	0 ± 2	100 ± 14	0 ± 4	10 ± 1	0 ± 2	0 ± 2	8 ± 1	bld	bld	4 ± 2	6 ± 2	4 ± 2	3 ± 2	4 ± 2	3 ± 2	4 ± 3	bld
HD 186745	5 ± 2	205 ± 12	10 ± 2	40 ± 2	16 ± 3	5 ± 1	28 ± 2	flaw	flaw	28 ± 2	27 ± 2	19 ± 2	14 ± 2	17 ± 1	13 ± 1	19 ± 2	13 ± 2
HD 206267	9 ± 1	119 ± 15	5 ± 2	21 ± 2	6 ± 2	7 ± 1	16 ± 2	10 ± 2	9 ± 2	18 ± 3	17 ± 3	10 ± 3	6 ± 2	7 ± 2	7 ± 2	7 ± 2	5 ± 2
HD 228712	0 ± 2	132 ± 15	4 ± 1	23 ± 2	8 ± 2	bld	23 ± 2	4 ± 1	11 ± 2	14 ± 2	17 ± 3	10 ± 2	3 ± 2	1 ± 2	1 ± 2	1 ± 2	6 ± 1

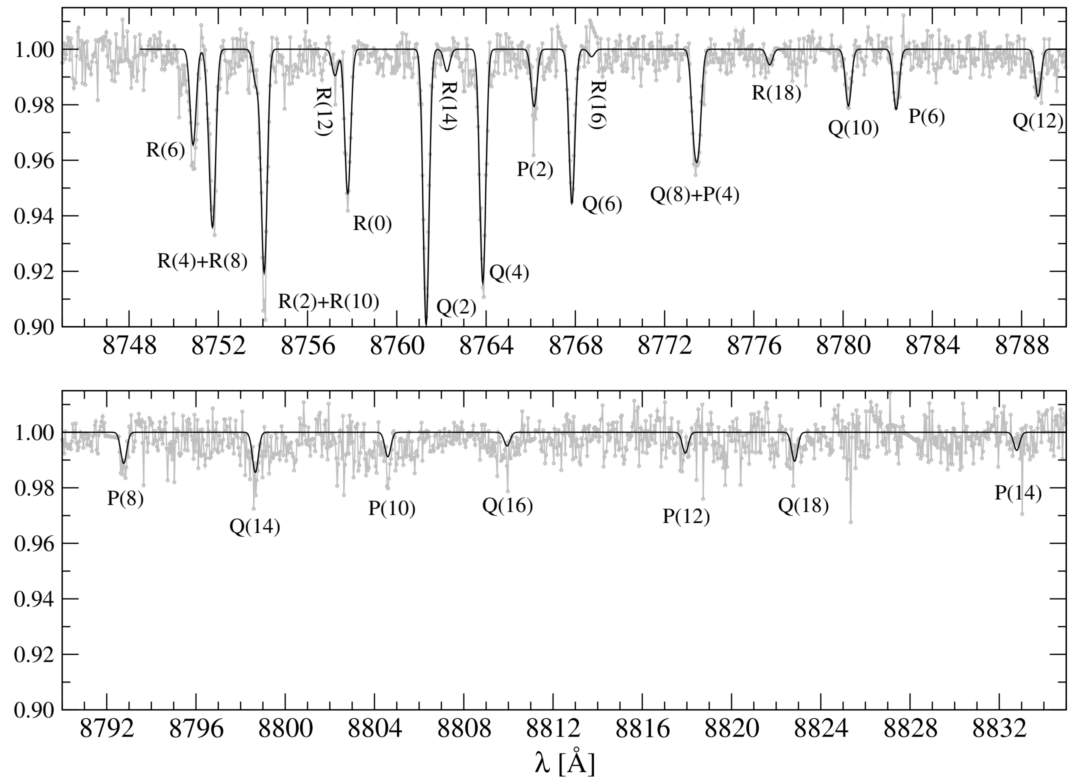

Fig. 2. The fit of the calculated profile of the Phillips (2–0) C_2 band to the observed one in the spectrum of HD 204827.

Evidently all the so-called "C_2 DIBs" are very weak in the spectrum of the star HD 34078 (AE Aur) where the C_2 band is relatively strong. In the same spectrum another molecule, CH, is also revealed by very strong spectral features (Krełowski et al. 1999). The weakness of the selected DIBs in the target where C_2 features are evidently strong casts serious doubts on whether the set of DIBs is related to the simple carbon molecule.

The Phillips (2–0) band of C_2 is usually quite weak and thus its features are difficult to measure. This makes the sample of objects in which it was observed well above the detection level necessarily small. Moreover, all the so-called "C_2 DIBs" are also very weak. The S/N ratio inside their shallow profiles is low and thus any correlation between such weak features must be considered as only a first step toward selecting DIBs that may behave in a similar fashion.

To measure the EWs of weak DIBs we have constructed average spectra involving all our targets. In such very high S/N spectra one can easily trace all the weak DIBs discussed in this paper. The average was then scaled up or down, until it was well-fitted according to a visual inspection, to the observed features in every individual spectrum. The factor established while fitting the average to any of the spectra was then used to multiply the EWs measured on average. This method

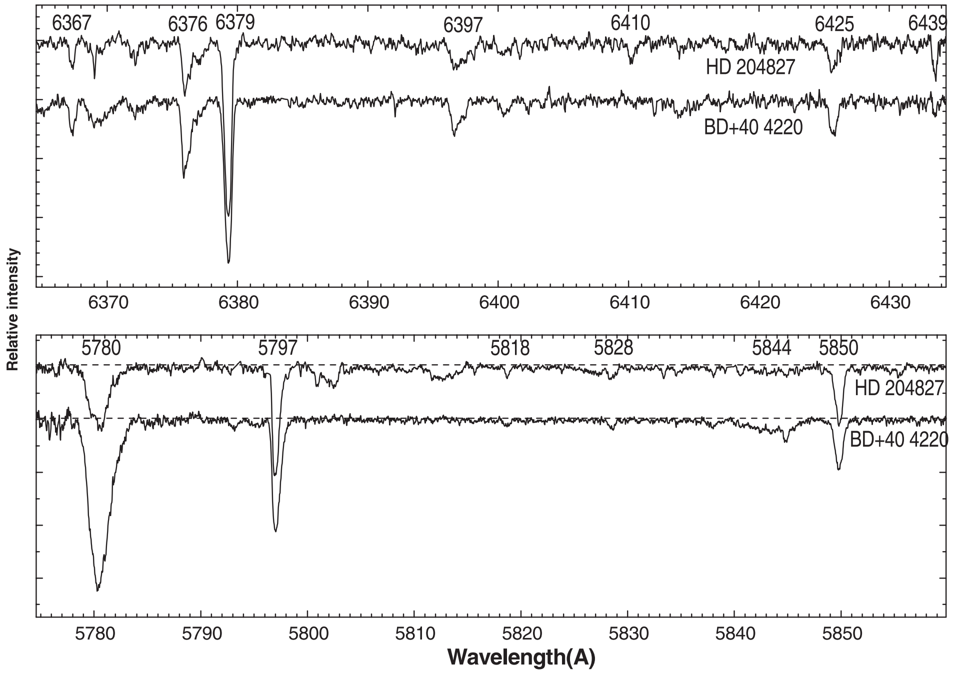

Fig. 3. A comparison of two spectral ranges observed in HD 204827 and BD+40 4220. Note that intensity ratios of several DIBs do not resemble those of color excesses ($E(B-V)$s are 1.08 and 1.99 respectively).

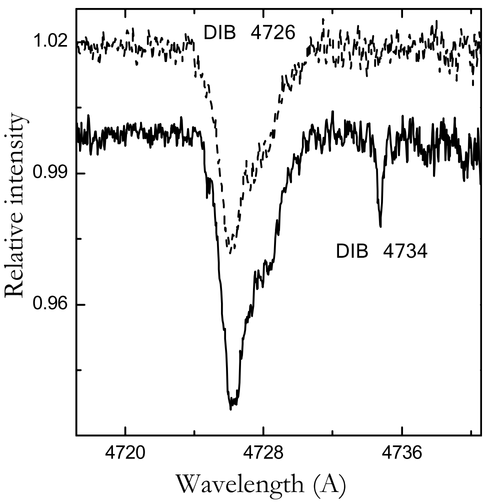

Fig. 4. The variable strength ratio of the strong 4726 DIB and its weak neighbour – 4734. The upper spectrum is the average of BD +59 2735, HD 34078, HD 204827, BD +60 493, HD 226868 and HD 186745 while the lower – of BD +59 456, HD 46149, BD +58 2580, HD 219287, HD 228779 and HD 235825.

allows us to avoid uncertainties which otherwise can make measurements uncertain such as: borders of any feature, continuum level, possible strong noise in the feature bottom etc. It makes the sample of measurements more homogeneous than if EWs are determined by integrating very weak and noisy DIB profiles. We are aware of the fact that DIB profiles may vary from object to object, but, unless very large Doppler splitting, such differences should not be visible in our $R = 30\,000$ spectra (Galazutdinov et al. 2002). Our attempts to measure the 5004 feature mentioned by Th03 failed. The feature is either very weak or blended with a stellar one which makes possible measurements unreliable.

3. Discussion

Assuming that the "C_2" DIBs are all related to the C_2 column densities one may also expect their mutual correlations. If any pair of the DIBs is really related then their strength ratio should be constant inside the measurement scatter. To check this in the case of the strongest "C_2" DIB and the weak new DIB 4734 we have constructed two averages. One of them involves six objects in which the second band seems present: BD +59 2735, HD 34078, HD 204827, BD +60 493, HD 226868 and HD 186745; we also averaged another 6 objects: BD +59 456, HD 46149, BD +58 2580, HD 219287, HD 228779 and HD 235825 in which we could barely trace the weak DIB. The result of the comparison is shown in Fig. 4; the strong 4726 DIB is of very similar strength in both averages while the weak 4734 feature is quite strong in one average and barely seen in the other. This shows that their intensity ratio is very variable and thus their common origin is doubtful. The average colour excesses, $E(B-V)$, are for the two samples 0.99 and 0.93 respectively (see Table 1), so the weak 4734 feature does not relate to $E(B-V)$ as well.

Our measurements of the "C_2" DIB EWs are compared to the C_2 column densities in Fig. 5. We present here 16 out of 18 Th03 "C_2 DIBs" i.e. the features which we consider as measured with a reasonably good precision. It is evident that the level of correlation substantially differs from feature to feature. The correlation apparently does not depend on DIB strength. This is important as otherwise one could expect that stronger DIBs, generally measured with higher precision, demonstrate more tight relations. The variable degree of correlation tells us

Table 3. The column densities ($\times 10^{13}$ cm^{-2}) of the C_2 $X^1\Sigma_g^+$ ($v'' = 0$) rotational levels (J''). The values written in boldface are derived from the (2–0) band of the C_2 $A^1\Pi_u - X^1\Sigma_g^+$ Phillips System. The values written in plain text were calculated from the Boltzmann distribution.

Star	$J''=0$	$J''=2$	$J''=4$	$J''=6$	$J''=8$	$J''=10$	$J''=12$	$J''=14$	$J''=16$	$J''=18$	$J''=20$	$N_{tot}(C_2)$
BD+59 2735	**0.11 ± 0.04**	**1.53 ± 0.11**	**1.67 ± 0.12**	**1.02 ± 0.14**	**0.66 ± 0.10**	**0.34 ± 0.13**	**0.73 ± 0.15**	**0.63 ± 0.19**	**0.40 ± 0.09**	0.10	0.05	7.25
BD+40 4220	**0.61 ± 0.10**	**2.79 ± 0.29**	**4.14 ± 0.42**	**2.73 ± 0.37**	**0.86 ± 0.13**	**1.84 ± 0.31**	**0.67 ± 0.24**	**0.83 ± 0.30**	**0.64 ± 0.27**	0.13	0.07	15.31
HD 13256	**0.18 ± 0.01**	**1.00 ± 0.05**	**0.93 ± 0.08**	**0.99 ± 0.15**	**0.26 ± 0.06**	**0.42 ± 0.03**	**0.24 ± 0.02**	**0.30 ± 0.04**	**0.18 ± 0.02**	0.04	0.02	4.56
HD 34078	**0.29 ± 0.06**	**1.03 ± 0.08**	**1.51 ± 0.06**	**1.64 ± 0.15**	**0.72 ± 0.09**	**0.86 ± 0.06**	**0.59 ± 0.15**	**0.50 ± 0.05**	**0.37 ± 0.08**	0.11	0.06	7.69
HD 204827	**1.97 ± 0.20**	**7.62 ± 0.58**	**6.42 ± 0.52**	**4.20 ± 0.52**	**2.02 ± 0.29**	**1.54 ± 0.36**	**1.30 ± 0.41**	**1.15 ± 0.45**	**0.48 ± 0.40**	0.31	0.16	27.17
HD 207538	**0.38 ± 0.11**	**1.63 ± 0.22**	**1.59 ± 0.11**	**1.36 ± 0.05**	**0.82 ± 0.05**	**0.74 ± 0.03**	**0.85 ± 0.07**	**0.46 ± 0.17**	**0.24 ± 0.06**	0.13	0.06	8.27
BD+59 451	**1.01 ± 0.27**	**3.01 ± 0.73**	**2.73 ± 0.71**	**1.62 ± 0.44**	**0.40 ± 0.13**	0.34	0.26	0.18	0.11	0.06	0.03	9.77
BD+59 456	**0.43 ± 0.12**	**1.88 ± 0.64**	**1.81 ± 0.91**	**1.62 ± 0.53**	**0.63 ± 0.36**	0.54	0.41	0.28	0.17	0.10	0.05	7.91
BD+60 594	**0.45 ± 0.10**	**1.02 ± 0.52**	**1.26 ± 0.43**	**0.73 ± 0.22**	0.71	0.61	0.46	0.31	0.19	0.11	0.06	5.92
HD 15785	**0.57 ± 0.04**	**1.45 ± 0.18**	**1.19 ± 0.14**	**1.02 ± 0.19**	0.99	0.84	0.64	0.44	0.27	0.15	0.08	7.65
HD 46149	0.21	0.95	**1.37 ± 0.24**	**1.39 ± 0.25**	**0.73 ± 0.24**	0.62	0.47	0.32	0.20	0.11	0.06	6.44
BD+58 2580	0.28	**1.21 ± 0.17**	**1.54 ± 0.19**	**1.33 ± 0.30**	**0.78 ± 0.22**	0.66	0.50	0.34	0.21	0.12	0.06	7.03
HD 210839	**0.15 ± 0.04**	**0.27 ± 0.02**	**0.77 ± 0.08**	**0.43 ± 0.09**	**0.26 ± 0.05**	0.22	0.17	0.12	0.07	0.04	0.02	2.54
HD 219287	**0.19 ± 0.03**	**0.79 ± 0.13**	**1.23 ± 0.17**	**0.69 ± 0.08**	0.67	0.57	0.44	0.30	0.18	0.10	0.05	5.23
HD 226868	**0.38 ± 0.12**	**1.07 ± 0.54**	**1.47 ± 0.31**	**0.76 ± 0.22**	**0.73 ± 0.03**	0.62	0.47	0.32	0.20	0.11	0.06	6.20
HD 235825	0.10	0.46	**0.50 ± 0.13**	**0.83 ± 0.24**	**0.58 ± 0.15**	**0.77 ± 0.28**	0.37	0.26	0.16	0.09	0.05	4.17
HD 186745	**0.63 ± 0.11**	**2.18 ± 0.29**	**3.62 ± 0.42**	**1.53 ± 0.26**	**1.12 ± 0.17**	**0.49 ± 0.19**	**0.69 ± 0.23**	**0.47 ± 0.20**	0.31	0.17	0.09	11.29
HD 206267	**0.61 ± 0.10**	**1.87 ± 0.29**	**1.99 ± 0.28**	**1.58 ± 0.32**	**0.96 ± 0.24**	**0.51 ± 0.25**	**0.49 ± 0.24**	0.42	0.26	0.15	0.08	8.93
HD 228712	**0.31 ± 0.05**	**0.86 ± 0.08**	**0.80 ± 0.06**	**0.66 ± 0.08**	**0.32 ± 0.03**	**0.19 ± 0.08**	**0.34 ± 0.04**	0.14	0.09	0.05	0.02	3.79
HD 228779	**0.55 ± 0.11**	**0.94 ± 0.12**	**3.27 ± 0.23**	**1.17 ± 0.06**	**0.66 ± 0.08**	0.56	0.43	0.29	0.18	0.10	0.05	8.21

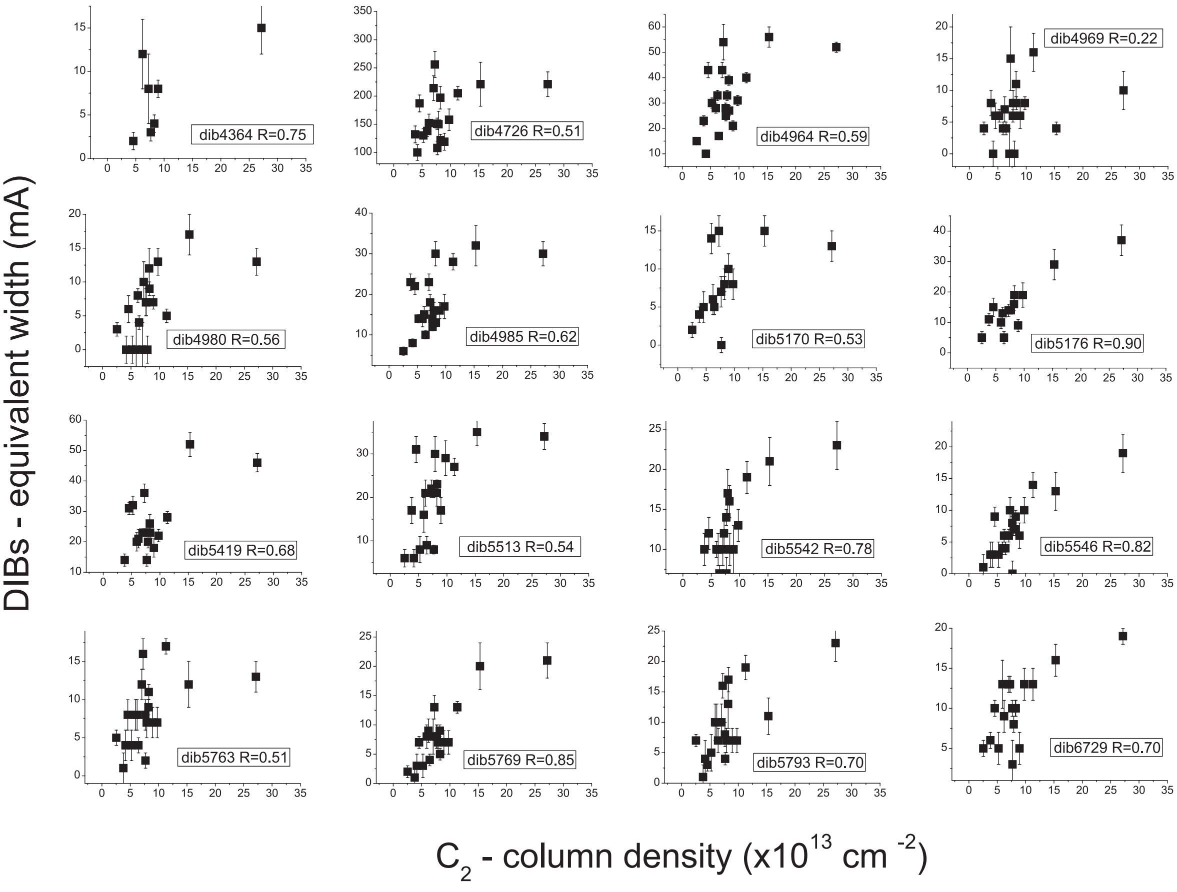

Fig. 5. The C_2 column density versus equivalent width of the selected DIBs (mÅ). The correlation coefficient is given inside each plot.

that this is not the case; the observed correlations show that different weak DIBs relate to a very different degree to C_2 column densities.

Four weak features: 5176, 5542, 5546 and 5769 seem to be well-correlated to the C_2 column density. They are the most likely "C_2 DIBs"; however, a much more extensive set of data would be necessary to prove this. On the other hand, DIBs such as 4726, 4969 and 5763 seem not to correlate with the carbon molecule at all. Their EWs are sometimes even higher than those of the well-correlated DIBs. Apparently we observe a real effect. All other observed DIBs lie between good and poor correlation.

Statistically meaningful samples of spectra where absorption features revealing atomic and molecular gas are detectable must be observed to test hypotheses concerning chemical reactions that take place in ISM and the preservation of some more or less complex species. If the latter are homonuclear (as C_2) their features are numerous but very sharp and shallow. A high signal-to-noise ratio is very important here. In the case of diffuse bands, blending of certain features is a serious problem. Members of blends like 5797+5795 or 6203+6205 (Porceddu et al. 1991; Krełowski et al. 1997) should be measured separately as their origin is clearly different. Moreover, DIB profiles are not exactly the same even if free of Doppler splitting (Galazutdinov et al. 2002) which makes the EW measurements more complicated. This is why some additional considerations are necessary to make sure that any two DIBs can be considered as belonging to the spectrum of a single species (Weselak et al. 2001).

The creation of the C_2 "family" of diffuse bands done by Th03 is certainly premature. Most of the selected features either evidently or likely do not correlate with the C_2 column density. Moreover their mutual strength ratios also seem to be variable which makes their membership of any single DIB family not conclusive. Any realistic relation between any two features requires a statistically meaningful sample of objects to be established. On the other hand a single object contradicting any proposed relation, if realistic (like HD 34078), may disprove it. Diffuse bands demonstrate once again the complexity of their identification.

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