The Diffuse Interstellar Bands
Proceedings IAU Symposium No. 297, 2013
J. Cami & N. L. J. Cox, eds.

doi:10.1017/S174392131301572X

DIBs Broadening with Increased Abundance of Vibrationally Excited H_2 Molecules

P. Gnaciński[1] and J. Krełowski[2]

[1]University of Gdańsk, ul. Wita Stwosza 57, 80-952 Gdańsk, Poland
email: fizpg@univ.gda.pl

[2]Nicolaus Copernicus University, ul. Gagarina 11, 87-100 Toruń, Poland
email: Jacek.Krelowski@astri.uni.torun.pl

Abstract. The analysis of DIB profiles was used in various attempts to discover the DIBs carriers. The broadening of the 6196 Å DIB with increasing C_2 rotational temperature was reported by Kaźmierczak *et al.* (2009). We present the broadening of the 4763, 5780 and 6614 Å DIBs connected with higher abundance of vibrationally excited hydrogen molecule. The DIBs broadening is also correlated with increasing H_2 rotational temperature on the ν=2 vibrational level. The broadening may be caused by growing population of higher rotational levels in the DIB carrier. Some DIBs, like 4964 Å, do not show any width changes with higher population of vibrationally excited H_2.

Keywords. ISM: molecules, ISM: lines and bands, ultraviolet: ISM

The ultraviolet radiation field from an early spectral-type star can populate the vibrationally excited H_2 levels (hereafter H_2^*) in interstellar clouds. The absorption spectral lines of interstellar H_2^* are placed in the ultraviolet spectral range observed by STIS (Space Telescope Imaging Spectrograph) onboard the HST (Hubble Space Telescope). Objects with highly populated vibrationally excited H_2 levels are very rare, since such cases are restricted to interstellar clouds situated in vicinities of hot stars (the star–cloud distance must be less than 1 pc). An example of H_2^* absorption lines in the ultraviolet STIS spectrum of HD 37903 is presented in figure 1.

The observations of vibrationally excited H_2 in the interstellar matter give us a rare opportunity to estimate the ultraviolet radiation flux in the interstellar clouds. We used a parameter $X(H_2^*)=N(H_2^*)/N(\text{total } H_2)$ as an indicator of UV radiation field toward HD 37903, HD 147888 and HD 37061. The H_2^* toward these stars was detected by Meyer *et al.* (2001). The H_2^* column densities toward these stars were derived by Gnaciński (2009, 2011, 2013).

The spectra of all three analyzed stars show only one interstellar Doppler component in the lines of K I and/or the CH molecule. The column densities of unobserved rotational levels toward HD 37061 and HD 147888 were calculated from the rotational temperatures

Table 1. Rotational temperature of para–H_2 on ν=2 vibrational level and relative abundance of vibrationally excited molecular hydrogen.

star	Para-H_2 rotational temperature on ν=2	$X(H_2^*)$ from ν=1–5 and J=0–13
HD 37061	2088 ± 231 K	8.0E-06 ± 6.4E-06
HD 37903	1779 ± 210 K	2.4E-06 ± 7.8E-07
HD 147888	791 ± 128 K	5.6E-07 ± 9.9E-08

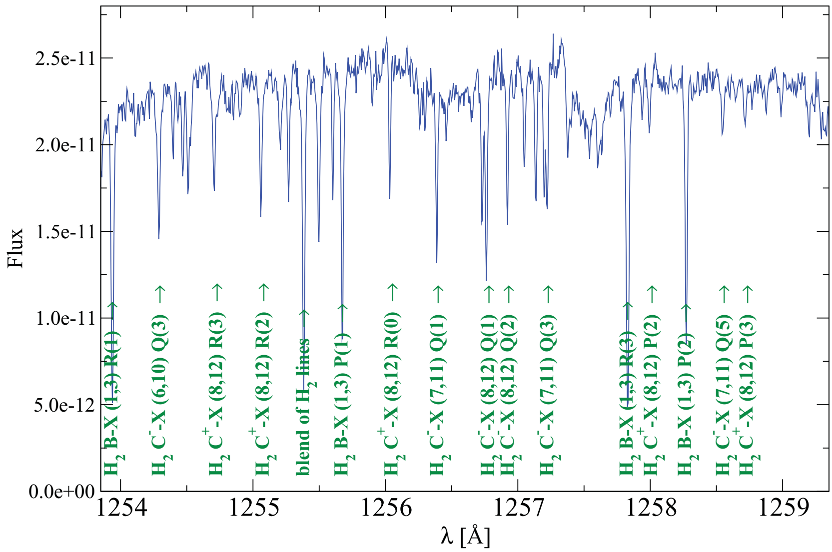

Figure 1. Fragment of HST STIS spectrum of HD 37903. All absorption lines seen on this plot are H_2 lines originate from vibrationally excited levels.

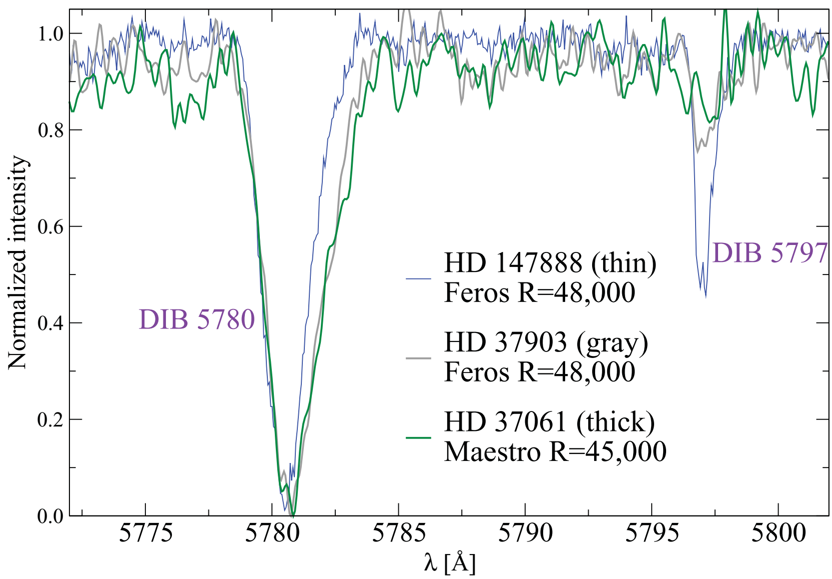

Figure 2. Broadening of the 5780 Å DIB. The spectra were normalized to common depth of the 5780 Å DIB.

separately for ortho– and para–H_2. The column densities were calculated up to rotational number J=13 and for vibrational levels ν=0–5.

We have also calculated the rotational temperature of para-H_2 on the ν=2 vibrational level. The latter was chosen because it was observed toward all three objects and the errors of column densities were relatively low. The derived rotational temperature correlates with our $X(H_2^*)$ parameter as can be seen in Table 1.

https://doi.org/10.1017/S174392131301572X Published online by Cambridge University Press

The objects with higher populations of vibrationally excited H_2^* levels (highest $X(H_2^*)$) and higher para-H_2 rotational temperature on ν=2 vibrational level have the DIBs 4763, 5780 and 6614 noticeably broader (see Figure 2). Widths of other DIBs, like 4964, seem to be insensitive to the $X(H_2^*)$ parameter. All DIBs are relatively weak if $X(H_2^*)$ is high.

The star radiation that populates the vibrationally excited H_2^* levels seems also to populate higher rotational levels in the DIBs carriers. The sensitivity of DIBs to the $X(H_2^*)$ parameter may lead to distinguish DIB families with common reaction to the radiation field.

Acknowledgements

Based on observations made with ESO Telescopes at the La Silla Paranal Observatory under programme ID 076.C-0164(A) and 076.C-0431(A) and on observations made using the Maestro spectrograph of the Terskol Observatory (Russia) fed with the 2 m telescope. The authors are very grateful to the staff members of these observatories for the experienced help. This work was supported by NCN (Polish National Science Center) grants DEC-2012/05/D/ST9/03912 and 5820/B/H03/2011/40.

References

Gnaciński, P. 2009, *Acta Astron.*, 59, 325
Gnaciński, P. 2011, *A&A*, 532, A122
Gnaciński, P. 2013, *A&A*, 549, A37
Kaźmierczak, M., *et al.* 2009, *A&A*, 498, 785
Meyer, D., *et al.* 2001, *ApJ*, 553, L59

https://doi.org/10.1017/S174392131301572X Published online by Cambridge University Press