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

doi:10.1017/S1743921313015688

Automated Extraction of DIBs from Cool Star Spectra

H.-Ch. Chen[1], R. Lallement[1], L. Puspitarini[1], P. Bonifacio[1], C. Babusiaux[1] and V. Hill[2]

[1]GEPI Observatoire de Paris, CNRS, Université Paris-Diderot, Place Jules Janssen, F-92195 Meudon Cedex, France
email: `hui-chen.chen@obspm.fr`

[2]Université de Nice Sophia Antipolis, CNRS, Observatoire de la Côte d'Azur, Laboratoire Cassiopée, B.P. 4229, 06304 Nice Cedex 4, France

Abstract. We have developed a method allowing to extract DIBs from cool star spectra, based on combinations of stellar synthetic, telluric transmission (when necessary), and DIB profile models. It is applicable when the star temperature, surface gravity and metallicity have been previously estimated. Such a method aims at extracting extensive data from stellar spectroscopic surveys such as the Gaia-ESO Survey in progress at the VLT. The method has been applied to several strong DIBs detected towards stars from various programs and located at various distances from the solar neighborhood to the Galactic Bulge. Here we illustrate the extraction of the 8620 Å DIB, and compare its strength to the one of the 6284 Å band, both for nearby and bulge stars.

Keywords. ISM: lines and bands, Methods: data analysis

1. Introduction

Interstellar (IS) absorption lines or diffuse interstellar bands (DIBs) are usually extracted from early-type star spectra because they are characterized by smooth continua. However, this introduces a strong limitation on the number of available targets, and unfortunately limits studies of the DIB response to the radiation field and in general to the IS clouds physical properties, while such studies may bring additional constraints in the search for the DIB carriers (e.g., Vos *et al.* 2011). It also reduces potential studies of the IS matter by means of the DIBs, i.e., the use of DIBs for IS mapping in the same way gaseous lines have been already used (Vergely *et al.* 2010). Here we present a new method of DIB measurement that is appropriate to cool star spectra. We have applied this method to three widely studied DIBs: 6196.0, 6204.5, and 6283.8 Å in 219 target stars located in the Galactic bulge (Chen *et al.* 2013). Here, we put particular emphasis on the 8620 Å DIB.

2. Method

Data in the DIB spectral region is fitted to the convolved combination of two (or three) models: (i) a synthetic stellar spectrum, (ii) a DIB model and (iii) a synthetic telluric transmission when necessary.

(i) The synthetic spectrum of the background star is based on stellar parameters that are provided independently. Since most of the stellar surveys aim at determining those parameters, they are often available. The stellar models were computed based on an ATLAS 9 model atmosphere, using the SYNTHE suite (Kurucz 2005, Sbordone *et al.*

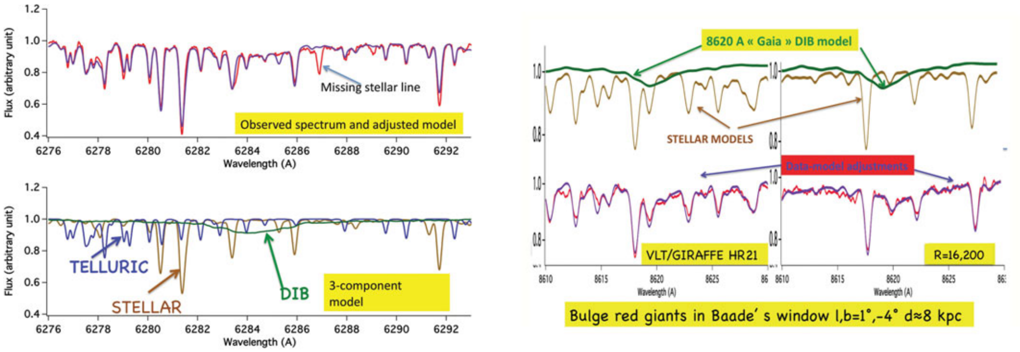

Figure 1. (Left) Illustration of the DIB fitting method: the 6284 Å band. The observed spectrum (red) and the adjusted model (blue) are shown at top. The individual contributions: synthetic stellar spectrum, DIB template, and synthetic telluric transmission are shown at bottom. (Right) Examples of DIB extraction for the 8620 Å band. The stellar and DIB models are shown at top. The data and adjusted model are displayed at bottom. The target stars are two red giants seen towards the bulge (left and right respectively).

2004, Sbordone 2005). For each target star we computed the synthetic spectrum that corresponds to the effective temperature, gravity, and metallicity. In each case several values of the micro-turbulence velocity were calculated and the best-fitting value was retained. The stellar radial velocity is taken into account by Doppler-shifting the computed spectrum by the appropriate value, when known, or adjusted.

(ii) The DIB shape has been preliminarily deduced from the extraction of DIB absorptions in nearby hot star spectra, using the most reddened stars (Puspitarini *et al.* 2013).

(iii) The atmospheric transmission model is to be used when the spectral regions are contaminated by atmospheric lines. This is true even if the resolution does not allow to distinguish those telluric lines, since neglecting them may bias the determination of the DIB equivalent widths. The synthetic telluric transmissions were computed by means of the LBLRTM code (Line-By-Line Radiative Transfer Model, Clough *et al.* 2005), using the molecular database HITRAN (HIgh-resolution TRANsmission molecular absorption, Rothman *et al.* 2009).

Figure 1 illustrates this method of DIB fitting in the case of the strong 6284 Å band, and distinguishes the three separate contributions. Note that one stellar line is clearly missing from the stellar model. This was observed similarly for all target stars, demonstrating that further work is needed to improve the stellar model. Here however the impact of this unique line is small.

3. Example of results for the 8620Å DIB

We show in Figure 1 (right) two examples of DIB extraction from the spectrum of a bulge giant (VLT+Giraffe+HR21 mode) and for the 8620 Å DIB. The telluric transmission is negligible in this region. As a validity test of the method we also extracted the 8620Å DIB from independent data at lower resolution and for the same targets. We then compared the results, i.e. the EWs of the 8620 DIB as determined from the independent HR21 (R = 16200) and LR08 (R = 6500) exposures. The two determinations were found to agree within the uncertainties associated to the stellar model and the noise (see Figure 2 left and middle). For the same target stars, we also extracted the strong 6284 Å DIB from HR13 observations. Figure 2 (right) shows preliminary results on the

https://doi.org/10.1017/S1743921313015688 Published online by Cambridge University Press

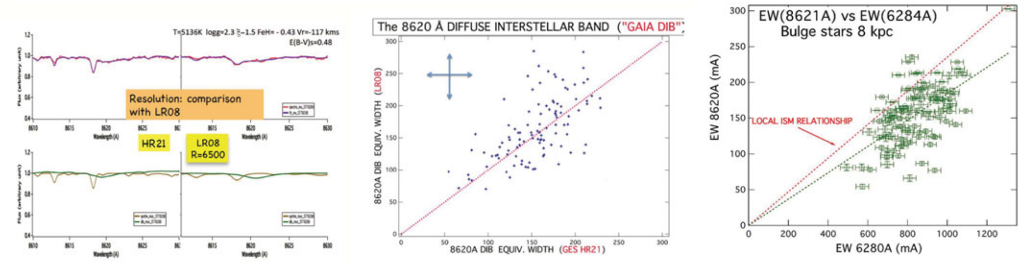

Figure 2. Left: two 8620 Å adjustments for the same target using independent high (HR21) and low (LR08) resolution modes. Middle: relationship between the HR21 and LR08 EWs of the 8620 Å DIB. Right: comparison between the 8620 Å and the 6284 Å EWs.

comparison between the measurements for those two different DIBs. We superimpose an average linear relationship between the two DIBs, for nearby stars. This relationship is derived by combining the Munari *et al.* (2008) and the Raimond *et al.* (2012) DIB-extinction relationships that apply to the two DIBs respectively and eliminating the extinction. The ratio between the two DIBS does not seem to vary strongly from the solar neighborhood to the Galactic Bulge. These preliminary results are encouraging, however more work is needed to eliminate ambiguous cases and improve the line lists.

Acknowledgements

We thank financial support from ANR through the STILISM project. H-C C. thanks support from the Region IdF DIM-ACAV.

References

Chen, H.-C., Lallement, R., Babusiaux, C., *et al.* 2013, *A&A*, 550, A62

Clough, S. A., Shephard, M. W., Mlawer, E. J., *et al.* 2005, *Journal of Quantitative Spectroscopy and Radiative Transfer*, 91, 233

Kurucz, R. L. 2005, *Memorie della Societa Astronomica Italiana Supplementi*, 8, 14

Munari, U., Tomasella, L., Fiorucci, M., *et al.* 2008, *A&A*, 488, 969

Puspitarini, L., Lallement, R., & Chen, H.-C. 2013, *A&A*, 555, A25

Raimond, S., Lallement, R., Vergely, J. L., Babusiaux, C., & Eyer, L. 2012, *A&A*, 544, A136

Rothman, L. S., Gordon, I. E., Barbe, A., *et al.* 2009, *Journal of Quantitative Spectroscopy and Radiative Transfer*, 110, 533

Sbordone, L., Bonifacio, P., Castelli, F., & Kurucz, R. L. 2004, Memorie della Societa Astronomica Italiana Supplementi, 5, 93

Sbordone, L. 2005, *Memorie della Societa Astronomica Italiana Supplementi*, 8, 61

Vergely, J.-L., Valette, B., Lallement, R., & Raimond, S. 2010, *A&A*, 518, A31

Vos, D. A. I., Cox, N. L. J., Kaper, L., Spaans, M., & Ehrenfreund, P. 2011, *A&A*, 533, A129