Looking for 6614 $\AA$ DIB in circumstellar environments

Ramón Luna Molina, Miguel Ángel Satorre Aznar
Departamento de Física Aplicada, Escuela Politécnica Superior de Alcoy
03801 Alcoi, Alicante, Spain
Pedro García Lario
Research and Scientific Support Department of ESA. European Space Astronomy Centre, Villafranca del Castillo, Madrid, Spain

Abstract: We present the results of a systematic search for 6614 $\AA$ Diffuse Interstellar Band in a selected sample of post-AGB stars observed with optical spectroscopy. These stars are shown to be ideal targets to study this old astrophysical problem. Our results suggest that the carrier(s) of this band may not be present in the circumstellar environments of these evolved stars.

1 Introduction

Diffuse Interstellar Bands (DIBs, hereafter) are bands of variable strength and width of still unknown origin which appear overimposed on the spectra of bright but heavily reddened stars. Since their discovery, now more than 80 years ago, they have been associated to the interstellar medium, because their strength appear to be well correlated with the observed extinction.

Currently, nearly 300 DIBs are catalogued (Galazutdinov et al. 2000) extending from ultraviolet to near infrared wavelengths (3600-12000 $\AA$), one of the most strong and studied ones is this found at 6614 $\AA$.

Many carriers have been proposed, but for none of them convincing arguments exist so far (for a review see Fulara & Krelowski 2000). The most promising hypothesis are: (i) long carbon chains, like polyacetylenes (Douglas 1977); (ii) PAH cations (Allamandola et al. 1999; Salama et al. 1999); or (iii) fullerenes (Foing & Ehrenfreund 1994).

There are strong evidences that the relative strength of DIBs are correlated with the properties of the clouds in the line of sight. This environmental dependence may reflect an interplay of ionization, recombination, dehydrogenation and destruction of chemically stable, carbonaceous species (Salama et al. 1996).

Since circumstellar shells are sources of replenishment of the interstellar medium, it seems reasonable to expect that DIB carriers may also be present in some of these

shells. In particular, the suspected connection between DIB carriers and some carbon-rich compounds can be investigated attending to the usually known chemistry and physical properties of these circumstellar shells.

A first attempt to detect Diffuse Circumstellar Bands was carried out by Le Bertre & Lequeux (1993) using a sample containing a mixture of carbon-, oxygen- and nytrogen-rich mass-losing stars. However, they failed to reach any firm conclusion from the results obtained. In particular, they did not detect any band in the spectra of sources with strong PAH emission at mid-infrared wavelengths, contrary to their expectations. In contrast, strong DIBs were observed toward other carbon-rich sources, as well as toward most of their oxygen-rich and nytrogen-rich sources in the sample.

Observationally, the detection of Diffuse Bands (DBs, hereafter) around evolved stars is hampered by the fact that most mass-losing stars are usually strongly variable stars, surrounded by very cool extended atmospheres where molecules are the dominant source of opacity. These stars are very difficult to model and DBs are hardly detected against the forest of features attributed to molecular transitions which appear overimposed on the stellar continuum. This has prevented the systematic search for DBs in evolved stars in the past.

2 Studying DBs in circumstellar environments

Fortunately, an alternative exists which have so far not yet been explored. These are the post-AGB stars, rapidly evolving stars in the transition from the Asymptotic Giant Branch (AGB) to the Planetary Nebula (PN) stage. While in the early post-AGB stage, these stars are still surrounded by the relatively thick circumstellar shells formed during the previous mass-losing AGB phase. Their central stars show a wide variety of spectral types ranging from M to B in which seems to be an evolutionary sequence in their way to become PNe. And the chemical composition of the gas and dust in the shell can easily be determined from observations at optical, infrared, mm/submm or radio wavelengths. In addition, they are located in many cases at relatively high galactic latitudes, which favours the potential circumstellar origin of the features observed.

In order to make a systematic study of the presence of this band in post-AGB stars, we carefully selected a sample of 33 sources displaying all kind of spectral types from G to B1 and covering a wide range of galactic latitudes. It contains a mixture of C-rich and O-rich stars with a well determined value of the colour excess E(B-V), as a reddening indicator.

The sample was then split in two subgroups according to whether the overall extinction observed is predominantly interstellar or circumstellar in origin. High resolution spectra taken at various telescopes covering the spectral range 4000 - 10000

$\mathring{A}$ (many of them originally taken for chemical abundance analysis purposes at the VLT and kindly provided by Hans van Winckel and collaborators).

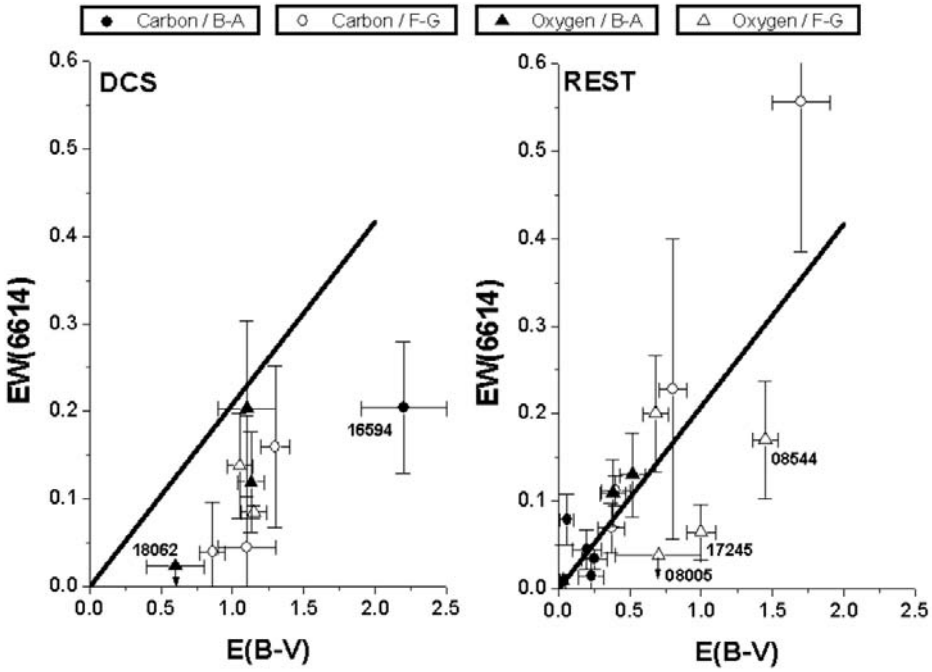

Figure 1: Equivalent width of the 6614 $\mathring{A}$ feature as a function of the total reddening observed in the direction of the sources in our sample. Sources dominated by circumstellar extinction (left) are compared to those for which interstellar extinction seems to be the dominant contributor to the observed reddening. The solid line represents the correlation found in field stars, and is shown for comparison. Different symbols are used for C-rich and O-rich stars and for early-type (B-A) stars and intermediate-late (F-G) type stars.

3 Results and discussion

In this work, 6614 $\mathring{A}$ DB was investigated in detail. Table 1 lists the wavelength corresponding to this features; its typical FWHM, as a way to characterize their broadness; and its sensitivity to the reddening, measured as EW/E(B-V), re-derived by us from the analysis of a sample of field stars compiled by Thorburn et al. (2003). In Figure 1 we show the strength obtained for this feature versus the extinction E(B-V). As we can see, the strengths of the 6614 $\mathring{A}$ DB is found to be well correlated with the interstellar extinction only in those sources showing little circumstellar contribution

DB ($\AA$)	FWHM ($\AA$)	EW/E(B-V) ($\AA$/mag)
6614	1.2	0.21

Table 1: Main characteristics of 6614 ($\AA$) Diffuse Interstellar Band.

to the overall reddening, while the DB is weak or absent in sources dominated by circumstellar reddening.

Our results suggest that the carrier(s) of this DB must not be present in the circumstellar shells of post-AGB stars. At least, not under the environmental conditions needed to excite the transitions which we identify as DBs in the interstellar medium. In particular, we do not find any evidence of the carbonaceous nature of the carrier(s), something generally accepted in the literature.

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