First Evidence of DIB Carriers in the Circumstellar Shell of a Carbon Star

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The origin of the diffuse interstellar bands (DIBs) represents one of the longest standing unsolved problems in astronomy. Although it is well established that they originate in the interstellar medium, no convincing identification of the responsible agent(s) has yet been made. They could be produced by large molecules, e.g. the fashionable polycyclic aromatic hydrocarbons (PAHs), or by atoms adsorbed on interstellar grains. A search for DIB features in stars with circumstellar dust shells (CDSs), carried out twenty years ago, was unsuccessful. It was therefore inferred that the DIB agents are not present in the circumstellar environments of late-type stars. Since then sky surveys have been made in the infrared range and have revealed the existence of numerous red long-period variables, very often enshrouded inside dense CDSs; most of these objects are miras evolving through the asymptotic giant branch (AGB). There is growing evidence that these sources are among the main contributors to the replenishment of the interstellar medium. In these conditions, the absence of DIBs in the spectra of late-type stars appears puzzling. With the new instruments and better detectors available today, it seems worth to readdress observationally this problem.

However, the search for DIB features in late-type star spectra is difficult: one should extract features with probably small equivalent widths against a complex background of blended lines coming from the star. An ideal case one would dream of would be that of a binary system made of an early-type star close to a late-type star either inside its CDS or on the other side of it with respect to us. In such a case, one would be able to probe the circumstellar environment by its absorption effects on the early-type spectrum. The companion should be bright enough in order to allow acquisition of spectra with a good signal to noise ratio. In practice, this means that white dwarfs are excluded; therefore, if the two objects are physically associated, the companion should be less evolved which means that it can be neither a supergiant nor a star earlier than B2. The line of sight to the companion should pass very near the late-type star in order that the extinction is significant, but not too much if one wants to get the spectrum of the companion separately. Practically, with the present instrumentation, it means a distance between 1 and 2–3″ for miras up to ~2 kpc.

It does not seem that a systematic search for such cases has ever been done. It is difficult to estimate their probability of occurrence as it depends on many factors, related to the formation and evolution of binary systems, which are still not well known. However, we can suspect that it is not too small since, serendipitously, one such case was found. In a detailed presentation of observations obtained on CS776 [1], it is shown that this carbon star has a companion of type A3. The companion is physically associated to CS776 and at a distance of slightly less than 2″; it is significantly reddened (A_B ~ 2). A kinematic distance of 1.3 kpc can be deduced from 2.6 mm CO observations; the projected separation of the companion and the carbon star is therefore ~2000 AU. From the mapping of interstellar extinction around CS776, it appears that there is no significant intervening material; therefore, the reddening of the companion should be due to the circumstellar material lost by CS 776.

The companion of CS776 was observed in April 1989 at the ESO 1.5-m telescope equipped with its recently improved spectrograph [2]. A slit-width of 1.5″ was used; the detector was an RCA CCD (ESO No. 13) with pixel size 15 μm. The companion spectrum could be registered separately from the one of CS776 thanks to the combination of good seeing conditions (< 1″) and excellent optical quality of the refurbished telescope and instrument. For comparison, a bright unreddened star of spectrum A3 was also observed. A division of the object spectrum by the unreddened star spectrum allows the cancellation of the stellar features and an easy search for features due to agents in the CS776 circumstellar shell. Also, care was taken to observe both objects at same airmass for cancelling effectively

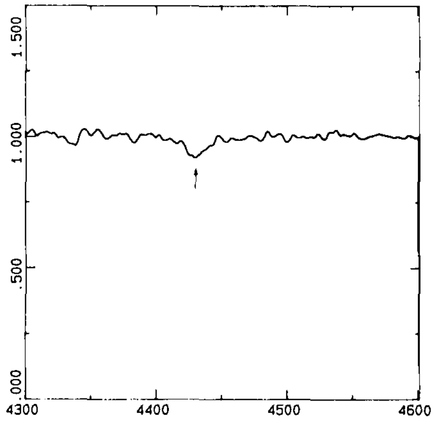

Figure 1: *4300–4600 Å spectrum obtained in April 1989 at the ESO 1.5-m telescope; spectral resolution is ≈ 7 Å (FWHM). The position of the feature at 4430 Å is marked.*

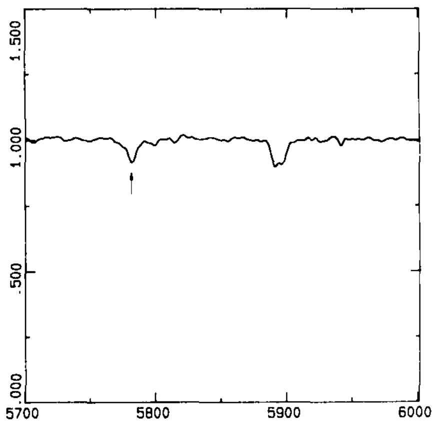

Figure 2: *5700–6000 Å spectrum; the position of the feature at 5780 Å is marked. The sodium doublet at 5890 Å is almost resolved.*

EDITORIAL NOTE

"Discovery of a Low Mass B[e] Supergiant in the SMC" by M. Heydari-Malayeri, ESO (*The Messenger* 58, 37)

Due to a most regrettable incident, a manuscript by Dr. M. Heydari-Malayeri, ESO, La Silla, prepared for the European journal *Astronomy & Astrophysics*, was published in the December 1989 issue of the *Messenger*. The error occurred as a result of a highly unlikely string of individual events during the editorial process. Although publication in our journal automatically excludes publication of the same manuscript in *Astronomy & Astrophysics*, we have been pleased to learn that the editors of *Astronomy & Astrophysics* have decided to make an exception in this particular case and to publish Dr. Heydari-Malayeri's article (with a few, minor changes) in one of the forthcoming issues of that journal. I have expressed my sincere apologies to all involved and immediately taken the steps necessary to avoid such mistakes in the future.

R. M. West, *Messenger* editor

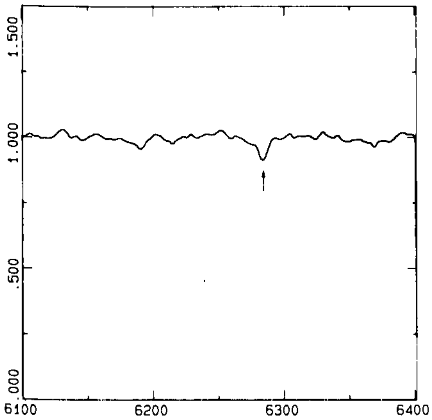

Figure 3: *6100–6400 Å spectrum. The position of the feature at 6284 Å is marked.*

telluric features; this is important for the DIB at 6284 Å which is affected by an O_2 atmospheric band. Grating No. 21 was used in the range 3860–6690 Å. The spectral resolution was ~7 Å (FWHM). The strongest certain DIBs [3] were searched for in the ratioed spectrum. In this spectrum, the DIB at 4430 (Fig. 1), 5780 (Fig. 2) and 6284 Å (Fig. 3) are clearly detected, but not the one at 5797 Å (Fig. 2).

The presence of DIB carriers in a carbon star CDS is of importance. It suggests that at least some of them are carbon-rich and gives support to the hypothesis that some type of PAHs are responsible agents. If PAHs are indeed DIB carriers, it means that the carbon star CDSs are among the sites of formation of PAHs; carbon-rich planetary nebulae were already known as sites of formation of PAHs (see for instance [4]). The ratio of the equivalent widths of 5780 to 5797 Å is ~2 in the interstellar medium [3]; the non-detection of 5797 Å in the CS776 companion spectrum gives support to the principle of dividing DIBs into families [5]. A recent work carried out at ESO [6] shows that the DIB carriers and the 2175 Å feature carriers (most probably small graphite grains) do not share the same origin. The presence of DIB carriers around CS776 suggests that graphite grains or their progenitors are not formed there, and lets little room for the existence of pure-carbon dust in carbon-rich CDSs. It is worth to remind that, around carbon stars, there is unambiguous observational evidence of *only* SiC and MgS grains.

Finally, most studies of DIBs are made at high-spectral resolution (R > 10,000). This is required if one wants to separate the components due to several intervening clouds but limits the sample of observable objects to bright ones and the sample of DIBs to narrow ones. However, the mere detection of DIBs does not necessitate such spectral resolution and the advantages of working at a lower resolution (~1000) are obvious.

References

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PHL 1222: an Interacting Quasar Pair?

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The "By-Product" of a Survey

The origin of quasars and Active Galactic Nuclei (AGN) is one of the outstanding problems of modern extragalactic astronomy. Mergers and gravitational interactions between galaxies are probably more frequent at large redshifts, and may lead to the appearance of quasars and other AGN. As a matter of fact, there is now an increasing body of evidence – from observations and computer simulations – that gravitational interactions between galaxies may be somehow responsible for the onset and fueling of the nuclear activity (e.g., Hernquist 1989, and references therein).

Three close pairs of quasars or AGN at large redshifts have been discovered recently: PKS 1614+051, QSO + AGN, at z = 3.215 (Djorgovski et al. 1985, 1987a), PKS 1145–071, QSO + QSO, at z = 1.345 (Djorgovski et al. 1987b), and QQ 1343+266, QSO + QSO, at z = 2.030 (Crampton and Cowley 1987). In these three systems we may be witnessing the triggering events responsible for the nonthermal activity in both objects, i.e., the birth of pairs of AGN at redshifts where the comoving density of quasars was close to its maximum. Their further study, and discoveries of more such systems, can help us to better understand the processes responsible for the origin and maintenance of nonthermal activity in the cores of galaxies.

We report here the discovery of a close pair of quasars, possibly the most interesting system of its kind, known as PHL 1222 = UM 144 = QSO 0151+048. It is composed of a close physical pair of QSOs with similar redshifts, $z \simeq 1.91$, and separated by 3.3 arcsec (Meylan et al. 1989, 1990).

The discovery of such pairs of quasars is the by-product of a survey for gravitationally lensed quasars. We are conducting such an optical imaging survey, with a spectroscopic follow-up for the promising cases. A sample of known QSOs has been selected on the basis of apparently large absolute luminosities and high redshifts. So far, this survey has yielded one close pair of possibly interacting quasars, PKS 1145-071 (Djorgovski et al. 1987b), one very probable gravitational lens, UM 425 (Meylan and Djorgovski 1989), several other promising lens candidates, and several cases of foreground or associated galaxies within a few arcsec from the quasars (Djorgovski and Meylan 1989, and Meylan et al. 1990). Our survey has now merged into the ESO Key Programme for Gravitational Lensing (Surdej et al. 1989).

PHL 1222: the Initial Observations

The quasar PHL 1222 = UM 144 = QSO 0151+048 (Burbidge 1968) is one