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BD + 37°1160: a probable optical counterpart of the X-ray source 1H 0521 + 373*

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Abstract. We report X-ray, ultraviolet, optical and infrared observations of the two peculiar stars BD + 37°1146 and BD + 37°1160, included in the error box of the hard X-ray source 1H 0521 + 373 (4U 0515 + 38 ?). We propose the star BD + 37°1160 to be the optical counterpart of the X-ray source, because of its optical spectrum, showing rapidly variable emission features, its infrared excess emission and its remarkable similarity to X Per which also has similar hard X-ray emission spectrum.

Key words: Be stars – X-ray sources – UV radiation – X-ray binaries

1. Introduction

4U 0515 + 38 was first detected as a weak source of soft X-ray emission by the UHURU satellite, with an average flux of 1.2 μJy in the 2–6 keV range and no apparent variability (Forman et al., 1978). However, the source was not seen in the Ariel V and SAS 3 surveys (Cooke et al., 1978; Bradt et al., 1976), but it was later detected by HEAO1-A1 at a flux level of 0.6 μJy (1H 0521 + 373; Wood et al., 1984). The 90% error boxes for the most likely position as determined from the UHURU and HEAO1-A1 data do not overlap. However, within the limits of systematic uncertainties for the localization of weak X-ray sources, taking into account the space density of X-ray sources occurrence, the two positions are consistent with one single object.

A hard X-ray source (named HXR 0516 + 38) was detected in the same region with high statistical significance (8 and 14 σ, respectively) by two balloon experiments (Ubertini et al., 1982; Polcaro et al., 1984) operating in the energy range 20–100 keV. Due to the large field of view of the balloon borne telescopes, the inferred position uncertainties were much larger than those obtained in the soft X-ray observations and are thus consistent with both UHURU and HEAO1-A1 data.

The photon spectrum of the source in the hard X-ray region is best fitted by a power law of the form:

$$dN/dE = (1.7 \pm 0.3) \cdot 10^{-2}\, E^{-1.5 \pm 0.1}\ \mathrm{ph/(cm^2\, s\, keV)}$$

(see Fig. 1). 1H 0521 + 373 is located on the galactic plane towards the anticenter region ($l_{II} = 170.5°$, $b_{II} = 0.9°$). The hard X-ray spectral index $\alpha = -1.5 \pm 0.1$ is similar to those detected in the case of Active Galactic Nuclei (AGNs). However no extragalactic objects are present up to 19th mag (Uppsala Catalog, Nilson, 1973) in the overlapping region of various error boxes obtained in the low and high energy measurements. Moreover the extreme variability of the source in the soft X-ray as seen from the four surveys is not usual in AGNs and it is consistent with the behaviour observed for some of the galactic X-ray sources.

As regards the spectral similarity it was argued that the source was similar to X Per, the soft X-ray spectrum of which fits a thermal bremsstrahlung emission from a hot plasma, while the hard X-ray emission fits a power law (White et al., 1982). X Per is a widely separated, wind accreting binary system with a O9.7 (III-V) e primary and a 13.9 min pulsar companion. The same model is proposed for a number of low luminosity galactic systems such as 4U 1145-61, 4U 1258-61, γ Cas (White et al., 1983).

2. Optical candidates

The error boxes for the best fit position of the X-ray source as reported by various authors are shown in Fig. 2. Two peculiar stellar objects BD + 37°1146 and BD + 37°1160 were found to lie in the overlapping region of the error boxes.

The early type star BD + 37°1146 (= HD 34656), with a visual magnitude $V = 6.8$, is classified as O7 II(f) by Buscombe (1980). From previous spectroscopic observations, the star was inferred to be a multiple stellar system (Hardorp et al., 1963), however, the

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* Based on observations collected with the EXOSAT, ASTRON and IUE (VILSPA) satellites and Asiago, Loiano and T.I.R.G.O telescopes

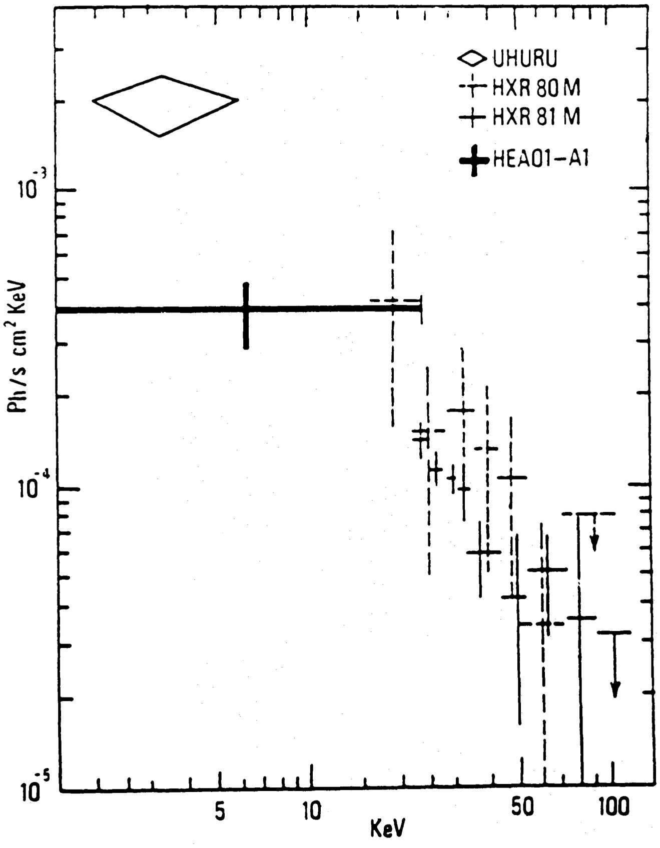

Fig. 1. The X-ray spectrum of HXR 0516+38 from the HXR 80 M experiment (Ubertini et al., 1982) and HXR 81 M experiment (Polcaro et al., 1984). The integral spectral points of 4U 0515+38 and 1H 0521+373 are also shown

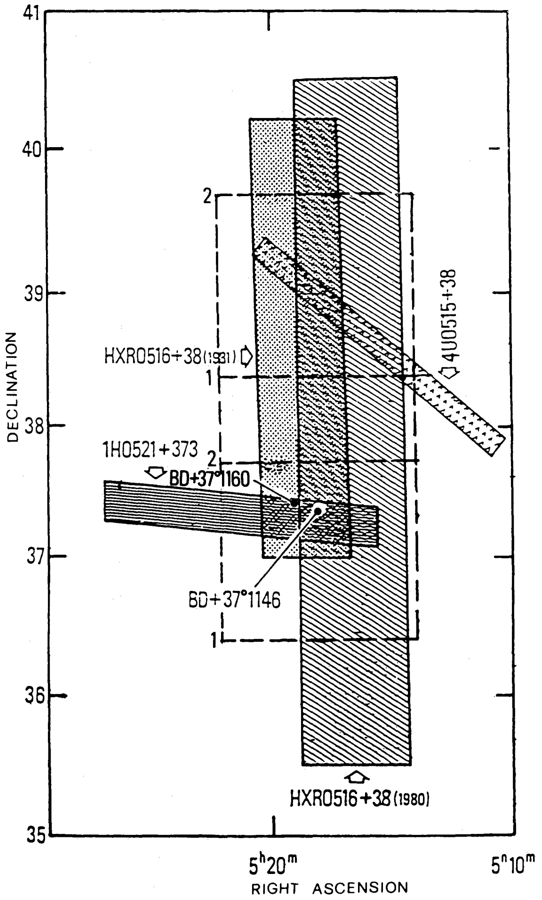

Fig. 2. The error boxes of 4U 0515+38, 1H 0521+373 and HXR 0516+38. The position of the stars BD+37°1146 and BD+37°1160 and the EXOSAT fields of view during 6 March 1985 observation are also shown

nature of the companion is unknown, allowing the possibility that it could be a compact object. The star has been observed in the region between 1300 and 2800 Å with the TD-1/S68 experiment (Jamar et al., 1976). In the optical, variability in line strengths and the stellar wind velocity have been reported by several authors (Cruz-Gonzales et al., 1974; Conti et al., 1977; Bohannan and Garmany, 1978).

The available information on BD+37°1160 (=HD 34921) is very scanty. The star was first observed by Merrill and Burwell (1933), who found a visual magnitude 7.4 and a Bøne spectral type; Buscombe (1980) later revised the values of the magnitude to $V=7.51$ and spectral type to B0 IV pe. In the IRAS Catalogue, the star has been also identified with the infrared source IRAS 051921+3737. A B-type optical counterpart for X-ray binary systems is a very likely scenario. In fact most of the optically identified variable galactic hard X-ray sources have optical companions with a B0e spectrum which often presents infrared excess.

In this paper we report detailed X-ray, UV, optical and infrared observations of the two stars and propose BD+37°1160 as the most likely optical counterpart candidate of the X-ray source 1H 0521+373.

3. Observations

In order to identify the optical counterpart of the X-ray source, we have observed the two stars with the EXOSAT Observatory (de Korte et al., 1981; Turner et al., 1981; Peacock et al., 1981). One month after the EXOSAT observation, BD+37°1146 was observed with the X-ray and UV detectors on board the ASTRON satellite (Boyarchuck et al., 1984; Golinskaya et al., 1984). We later performed UV measurements of BD+37°1160 with IUE satellite (Bogges et al., 1978). We also obtained optical spectra and *J*, *H*, *K*, *L* fluxes of both stars with Asiago, Loiano and T.I.R.G.O. observatories.

3.1. *Exosat*

The X-ray observations of the overlapping area of the 4U 0515+38, 1H 0521+373 and balloon borne telescopes error boxes were made on 6 March, 1985 by using the low and medium energy detectors on board EXOSAT Observatory. The entire region was divided into two parts as shown in Fig. 2.

The observation of the two fields started at 06:06 UT and 10:09 UT respectively and both lasted 14,400 s.

Image reconstruction of the first field obtained from the counts detected by the LE detector with 3Lx filter is shown in Fig. 3. Two sources of enhanced emission are clearly seen and are coincident with the position of the two stars. The best fit positions and the corresponding counting rates obtained through PPL, 3Lx and Al/P filters are reported in Table 1.

The data from the Medium Energy detectors are difficult to interpret due to marginal excess from the field, probably caused

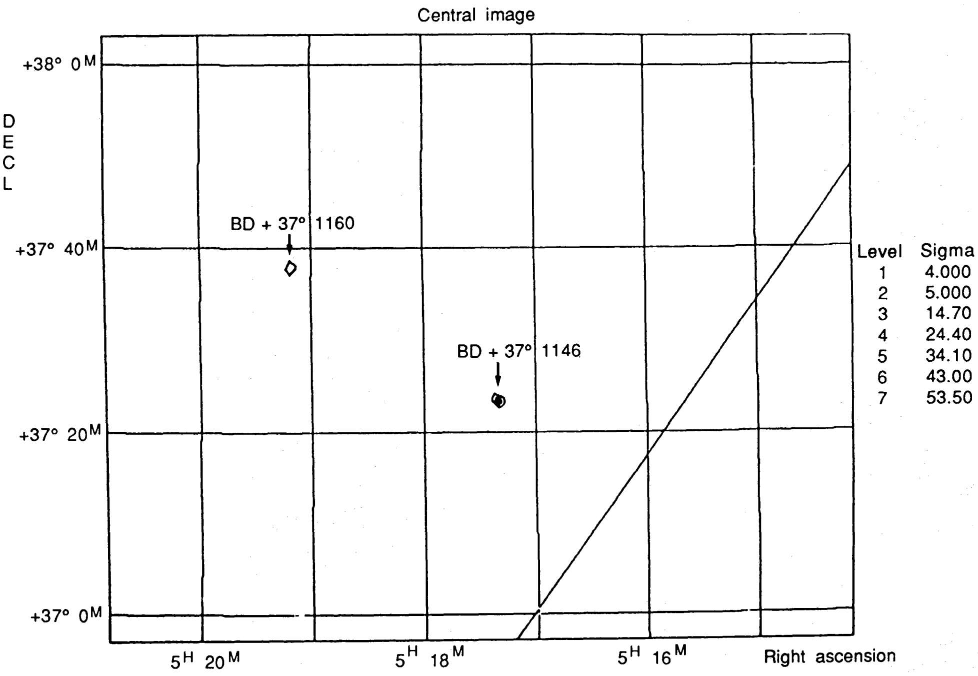

Fig. 3. Position of the sources detected by the EXOSAT LE instrument (3Lx filter). The line indicates the galactic plane

Table 1. Summary of the EXOSAT Observatory measurement on the overlapping area of the 4U 0515+38, 1H 0521+373 and HXR 0516+38 made on 6 March, 1985

Source	EXO 051719+3723.3	EXO 051910+3737.7
Identif.	BD+37°1146	BD+37°1160
R.A. (1950)	5h 17m 19.032s	5h 19m 10.0s
Decl (1950)	37° 23′ 20.72″	37° 37′ 44.31″
Spectrum	O 7 II (f)	B 0 IV pe
V	6.8	7.4
$E(B-V)$	0.4±0.1	0.42±0.05
Dist. (kpc)	2.0±0.2	1.7±0.1
Filter	Source count rate (ct/s)	
PPL	4.649E-01±4.63E-02	8.111E-02±1.99E-02
3Lx	8.326E-02±6.99E-03	1.685E-02±3.99E-03
Al/P	9.013E-05±1.54E-03	...

by the high detector background connected with the position of the satellite near to the perigee of the orbit and the high solar activity during the observations. We obtained an upper limit of 0.2 ct/s and 0.5 ct/s in the Ar and Xe detectors, respectively.

The equivalent effective area of LE telescope for UV radiation is difficult to evaluate since no reliable in-flight calibrations are available for stars of spectral type earlier than A (Chiappetti and Giommi, 1985). The observed excess counts seen for the two hot stars BD+37°1146 and BD+37°1160 are consistent with the expected UV contamination, estimated by using empirical relation (Chiappetti and Giommi, 1985). The shape of the summed signal of the PPL image is indeed typically dominated by UV photons. However the summed signal of the 3Lx image does indicate a partial contribution from the X-ray photon flux detected from the field. In any case, a bare indication of the soft X-ray flux from the first field is not sufficient to draw conclusions regarding the association of the hard X-ray source with any of the candidate stars.

No detectable sources were present on the second LE field with the 3Lx filter. In the PPL image the detected excess emission coincides with the open cluster NGC 1875, possibly arising from UV and very soft coronal X-ray emission from young stars. No hard X-ray excess was detected in the ME instrument.

An upper limit of 0.39 μJy in the 2–25 keV energy range was obtained from a 5° × 5° field of view centered on BD+37°1146, with the X-ray detectors on board ASTRON one month later the EXOSAT measurements (13 April, 1985).

3.2. *UV and optical measurements*

Ultraviolet spectra of the two stars have been collected with ASTRON and IUE satellites and the details will be given in the following subsections.

Concerning the optical region, high dispersion (7 Å mm^{-1}) echelle spectra of both stars were taken during the night of 22–23 December 1986 at the 182 cm Asiago telescope. Medium dispersion (30 Å mm^{-1}) spectra have been taken on 12–15 January 1989 at the 1.52 m Loiano telescope using the Boller and Chivens 26767 spectrometer with the EMI 9914 intensifier and Kodak II aO plates.

The plates were digitized using the Monte Porzio Observatory PDS, and the data were analyzed using the facilities and softwares of the Institute of Astronomy at Rome University "La Sapienza" (Rossi et al., 1985).

3.2.1. BD+37°1146

The spectrum of the star BD+37°1146, obtained at the Asiago telescope in the wavelength region between 5490 Å and 6721 Å, is

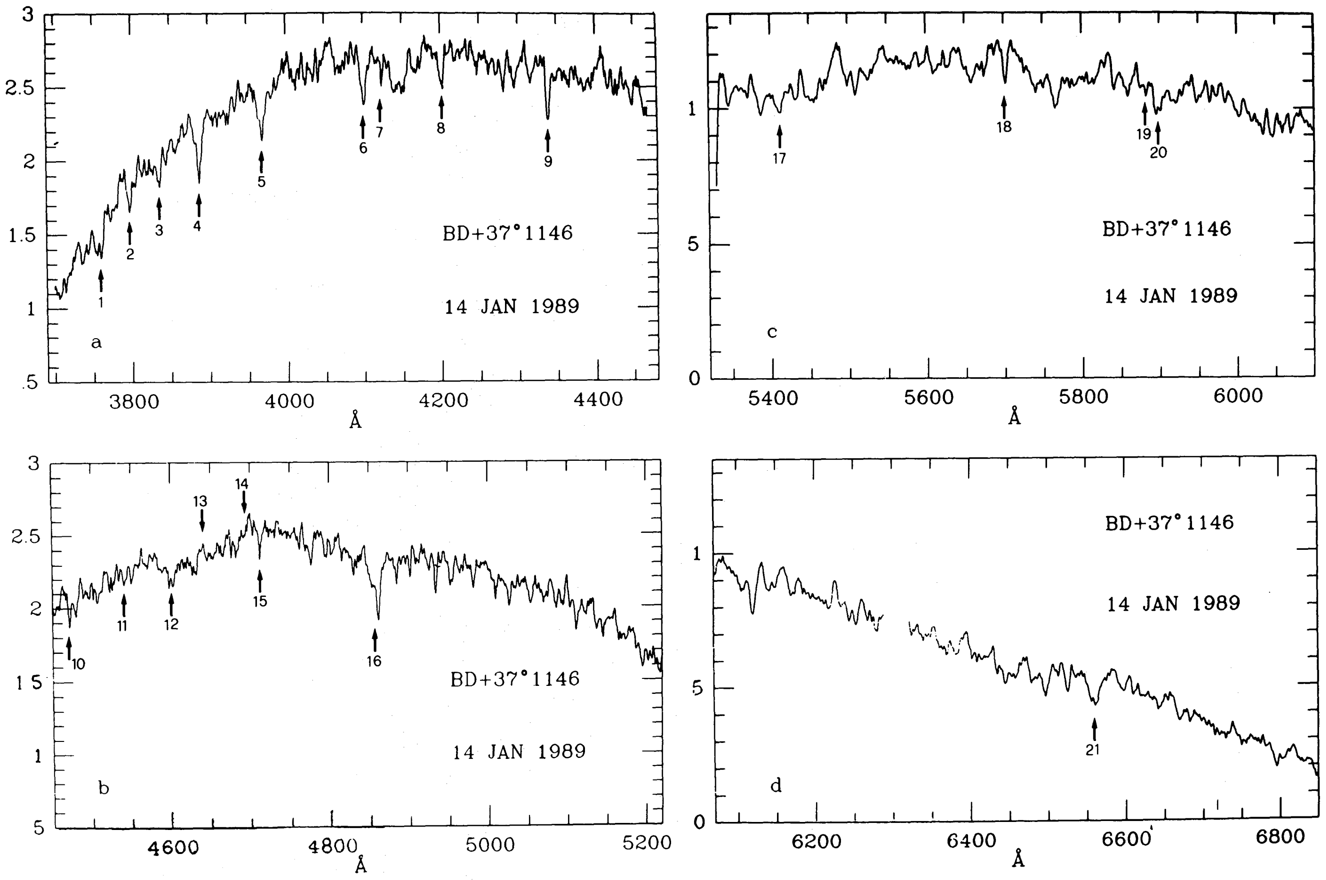

Fig. 4a–d. Optical spectrum of BD + 37°1146 (14–15 January 1989). **a** 3650–4500 Å, **b** 4500–5250 Å, **c** 5350–6100 Å, **d** 6100–6900 Å

typical of O star without any peculiar feature. The spectrum obtained at the Loiano telescope (Fig. 4) shows the presence of a weak emission of N III at 4634–40 Å and the neutralized He 4686, consistent with the O7(f) spectral classification given by Buscombe (1980). The list of the identified lines is given in Table 2.

Ultraviolet observation of the star in the wavelength region 1500–3500 Å, with a resolution of 30 Å, were made by using the telescope on board ASTRON satellite on April 13, 1985 (see Fig. 5). The spectrum is typical of an O type star (Dean and Bruhweil, 1985; Walborn et al., 1985), in which we identify He II 1640 Å, N IV 1718 Å, the blends of N III lines near 1750 Å and the 1850 Å Al III line.

From the 2200 Å interstellar band and the Seaton's extinction law (Seaton, 1979), we have derived $E(B-V)=0.4\pm 0.1$, from which a distance of 2.0 ± 0.2 kpc was deduced, assuming $M_V=-6.1$ (Conti and Underhill, 1988).

We note that the measured UV flux could explain most of the detected EXOSAT LE counting rate.

A more detailed analysis of the UV spectrum of BD + 37°1146 has been performed using the IUE archive images SWP 2776 and LWR 2470, taken in September 1978. The main features confirm the lines detected by ASTRON. The Si IV doublet at 1400 Å, C IV doublet at 1550 Å and N V at 1240 Å, typical of O7 bright giants are also visible (Fig. 6). The measured UV flux is constant, within the instrumental calibrations, in the 1978 and 1985 measurements.

The high resolution IUE spectrum of the star, recently published by Walborn et al. (1985) definitely confirms the conclusions reached above.

3.2.2. BD + 37°1160

The December 1986 Asiago optical spectrum of BD + 37°1160 shows hydrogen and helium emission lines; however, the low signal to noise ratio does not allow us to make clear conclusions on the star.

The optical spectrum of BD + 37°1160 taken in January 1989 at Loiano telescope is shown in Figs. 7–10. The main features have been identified using the line list by Moffat et al. (1973) for X Per, due to the extreme similarity of the two spectra. We report our line list in Table 3. The only remarkable difference between X Per and BD + 37°1160 is the stronger presence of S III in the spectrum of the first star. We want to remark the behaviour of the He lines: they vary from absorption to emission in a time scale of 20 minutes (see for example He II 5411, He I 5876 and 6678 – Figs. 9, 10 –). Variability in the Balmer lines was also detected.

A low resolution ultraviolet spectrum of BD + 37°1160 has been taken with IUE satellite on March 18, 1988 (Fig. 11). The $E(B-V)$ value 0.42 ± 0.05, derived from the 2200 Å interstellar band and Seaton's extinction law (Seaton, 1979), gives a distance of about 1.7 ± 0.1 kpc, using $M_V=-5$ (Allen, 1973), rather in agreement with the value of 1.9 kpc reported by

Table 2. List of the identified lines in the optical spectrum of BD+37°1146

n	Wavelength (Å)	Ion	Remarks
1	3770	H11	
2	3798	H10	
3	3835	H9	
4	3889	H8	
5	3970	H_ε	
6	4101	H_δ	
7	4121	He I	
8	4200	He II	
9	4340	H_γ	
10	4471	He I	
11	4542	He II	
12	4600	N II	
13	4634–40	N III	Weak emission
14	4686	He II	Neutralized
15	4713	He I	
16	4861	H_β	
17	5411	He I	
18	5696	C III	
19	5876	He I	
20	5890–96	Na D	i.s.
21	6561	H_α	

Buscombe (1980). The list of the identified lines is given in Talbe 4: they are mainly due to C III, N III, Si III, Fe III and Al III. Resonance lines of Si IV, C IV and Al II are also present. Si II, C II and O I lines have also been detected; they can be interpreted as interstellar or as shell absorption lines, formed in a circumstellar cool region (whose presence is inferred by our infrared measurements).

From its UV spectrum, the star should be classified as B0/B1 II/III, while, from the optical, a spectral type B0 IV pe, as given by the catalogues, can be confirmed.

It is interesting to remark the similarity of the UV spectrum of BD+37°1160 with those of HDE 245770 and especially of HD 102567, which are the optical counterparts of the transient X-ray sources A0535+26 and 4U 1145−61, respectively (Giovannelli et al., 1981; de Loore et al., 1981; de Loore et al., 1984).

3.3. Near-infrared observations

J, *H*, *K* and *L* photometry was carried out for the two stars in different observing runs (November 25, 1986, January 19, 1987 and March 6, 1989) with the 1.5 m Italian Infrared Telescope at Gornergrat (TIRGO), equipped with an InSb detector. The IR magnitudes corrected for air mass, and the relative 1 σ statistical errors are reported in Table 5.

Using the IR data of Table 5 and the interstellar reddening law of Rieke and Lebofsky (1985), we derived the energy distributions of the two stars. We will discuss their IR characteristics separately.

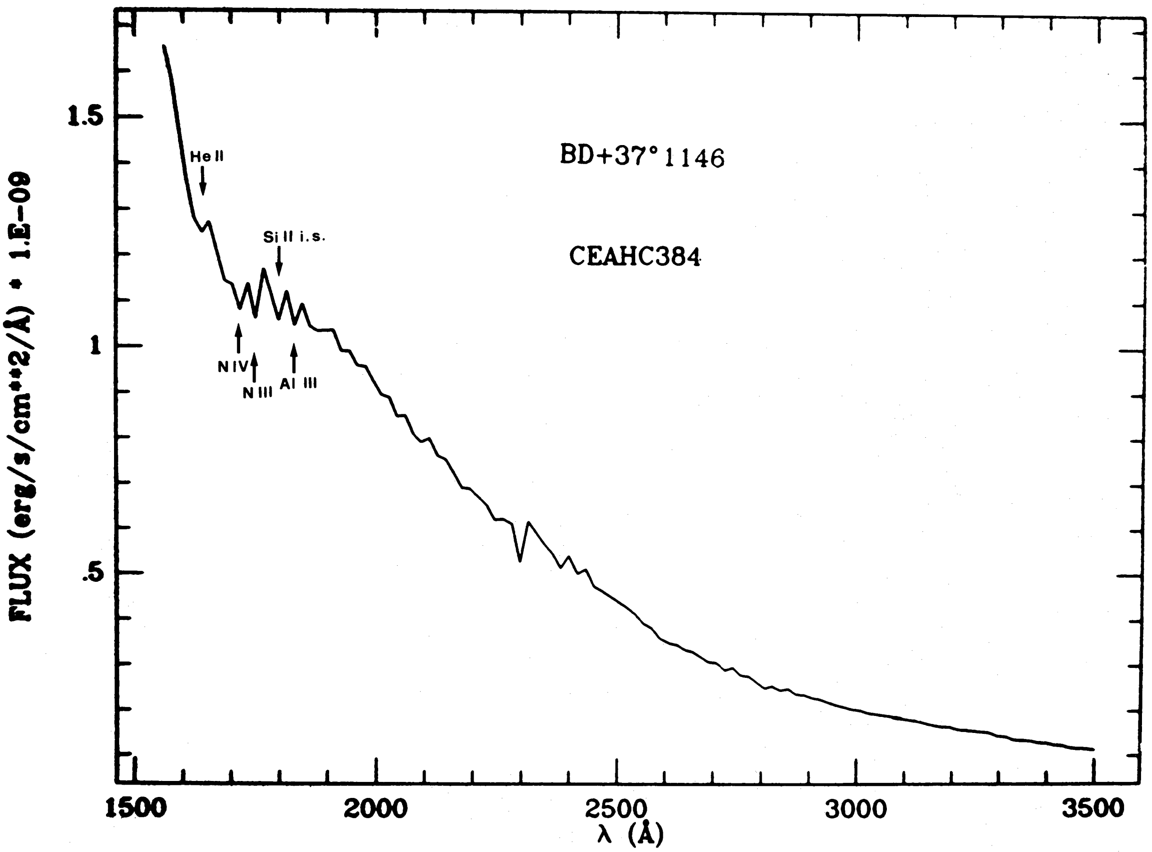

Fig. 5. Dereddened UV spectrum of BD+37°1146 as taken by ASTRON (13 April 1985)

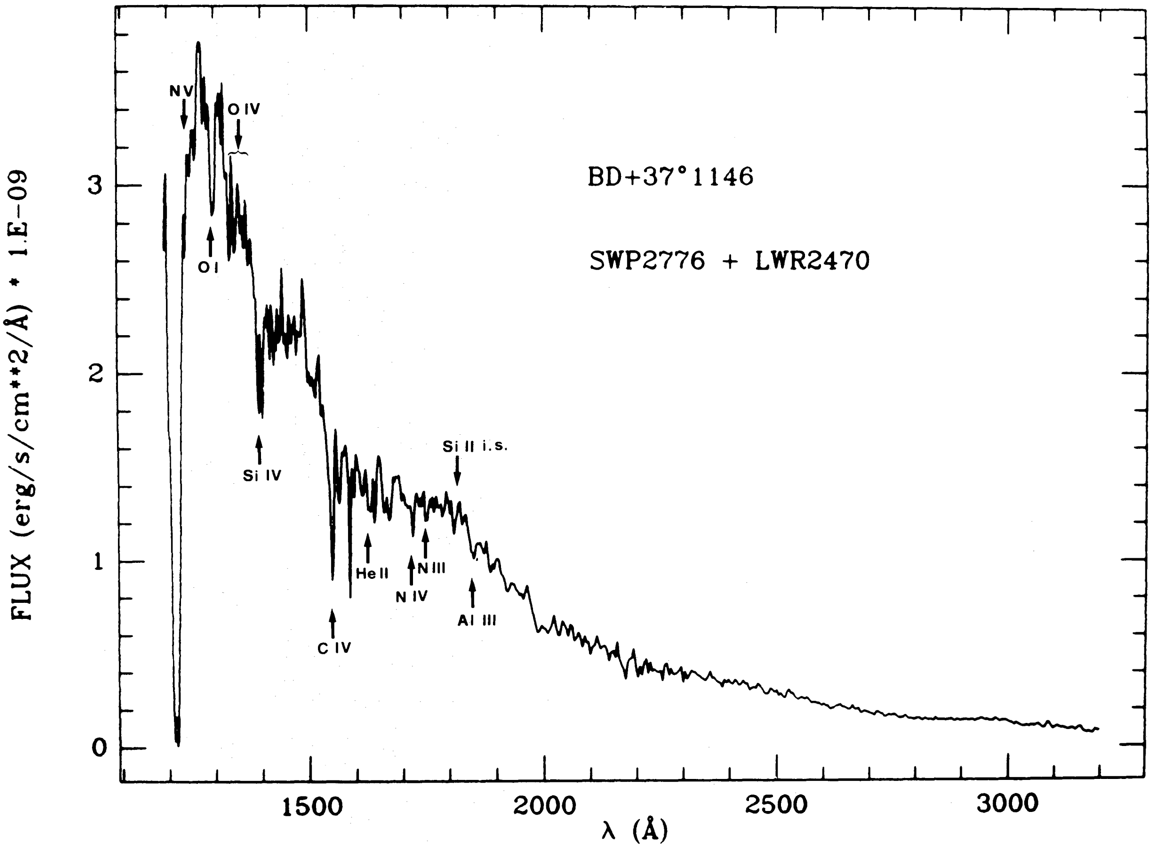

Fig. 6. Dereddened UV spectrum of BD+37°1146, taken by IUE (1978)

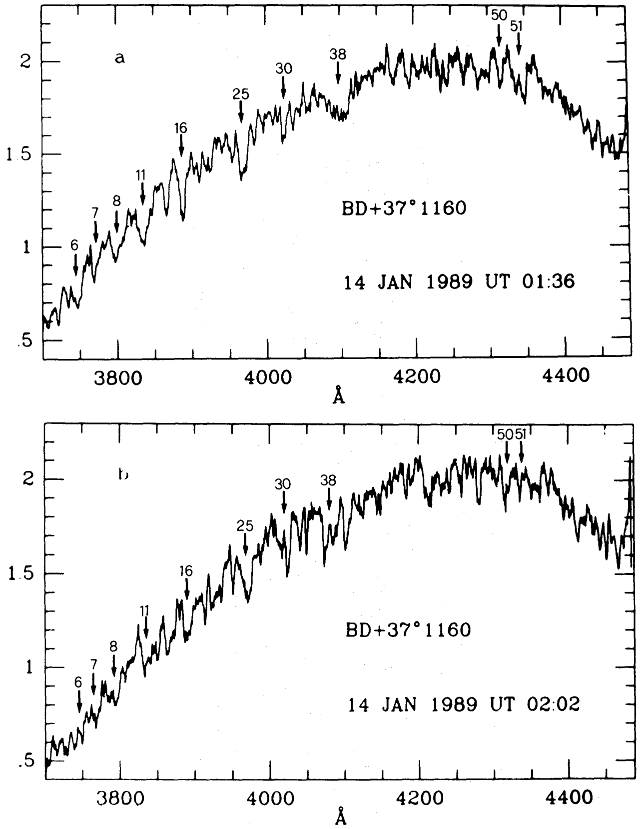

Fig. 7a and b. Optical spectrum of BD+37°1160: 3650–4500 Å

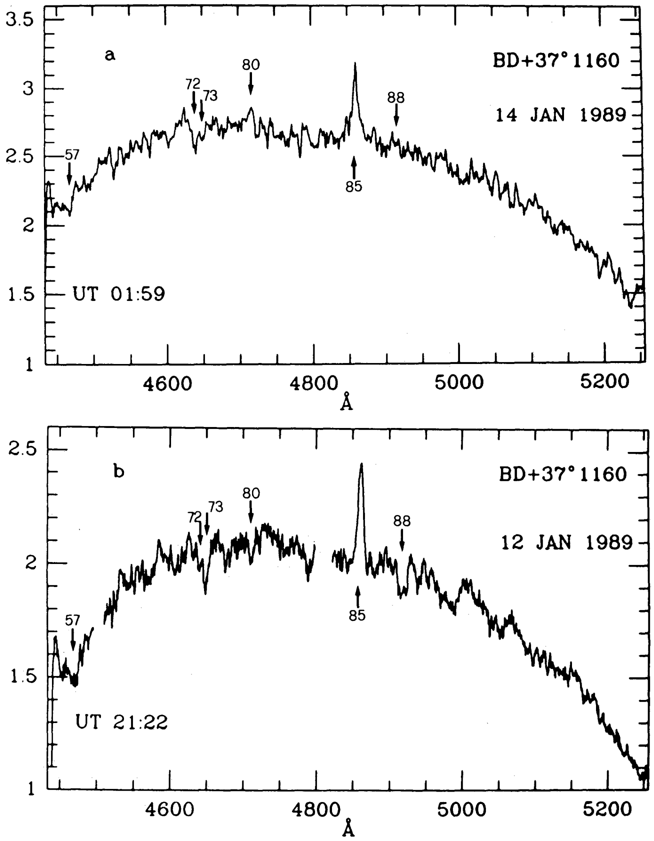

Fig. 8a and b. Optical spectrum of BD+37°1160: 4450–5250 Å

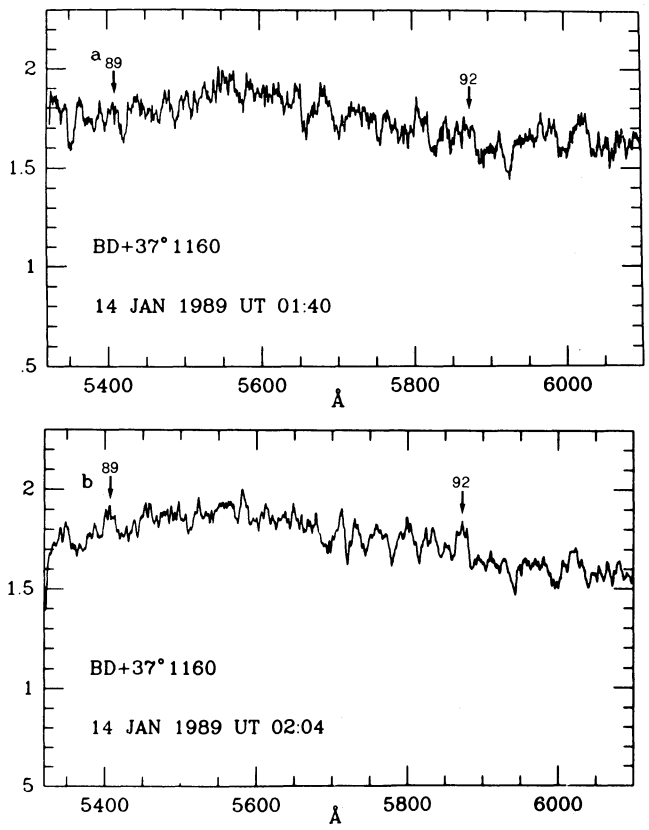

Fig. 9a and b. Optical spectrum of BD + 37°1160: 5300–6100 Å

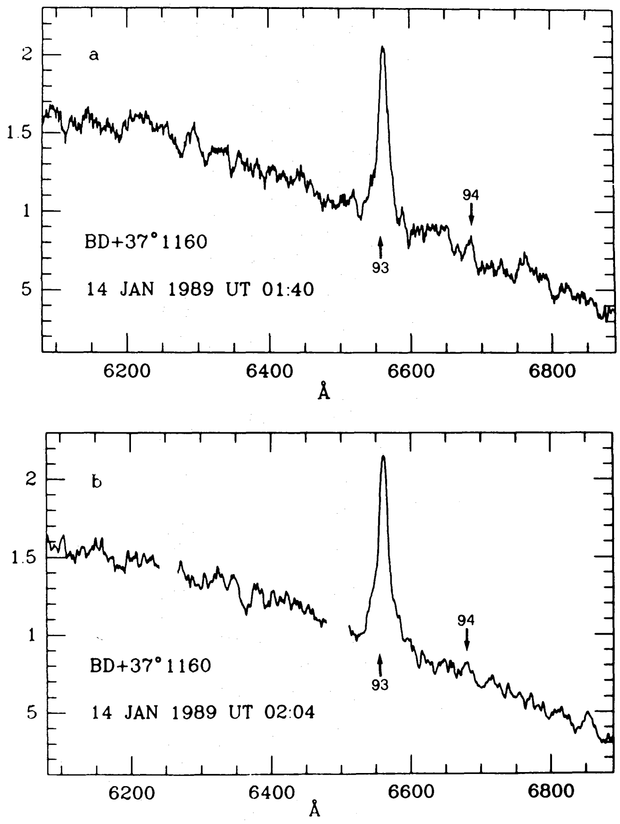

Fig. 10a and b. Optical spectrum of BD + 37°1160: 6100–6900 Å

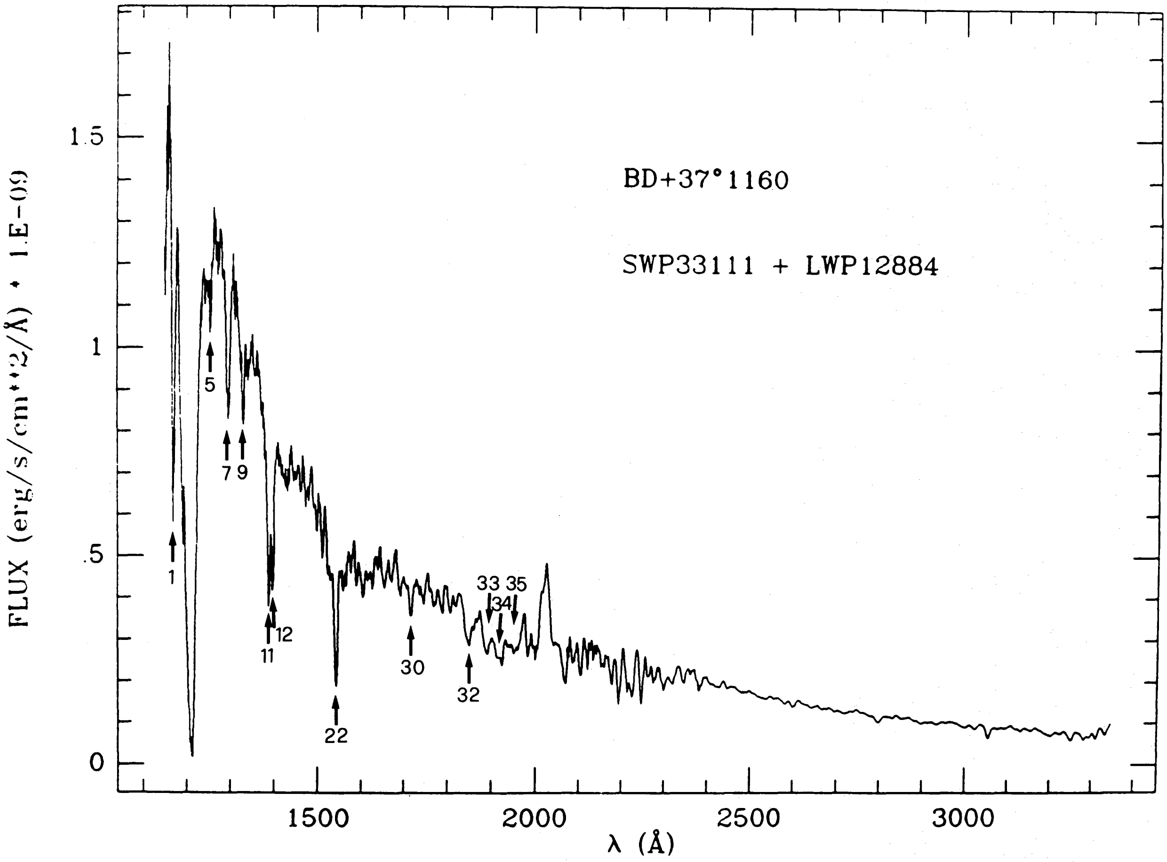

Fig. 11. Dereddened UV spectrum of BD + 37°1160, taken by IUE (18 March 1988)

Table 3. List of the identified lines in the optical spectrum of BD+37°1160

n	Wavelength (Å)	Ion	Remarks
1	3704	H16, He I	
2	3710	Ne I, S III	
3	3712–27	H15, H14, O II	
4	3734	H13	
5	3749	H12, O II	
6	3755–62	N III, O III O II, Si IV	
7	3770	H11	
8	3798	H10	
9	3807	(He I), Si III	
10	3820	He I	Variable (Em)
11	3835	H9	
12	3867	He I	Variable (Em)
13	3872	He I	Variable (Em)
14	3876	O II, C II	
15	3882	O II	
16	3889	H8	
17	3912	O II	
18	3919–24	C II, O II, Si III	
19	3926–29	He I, Si III	
20	3934	Ca II	i.s.
21	3939	N III	
22	3945	O II	
23	3954–56	O II, (N II)	
24	3962	S III, O III	
25	3965–73	He I, Ca II i.s. H_ε, O II	Variable
26	3983	O II	
27	3995	N II	
28	3999	N III, Si II	
29	4009	He I	Variable (Em)
30	4026	He I, (N II)	
31	4035	O II, N II	
32	4041–44	O II, N II	
33	4048	O II	
34	4056	C III	
35	4061–63	O II, (Ne III)	
36	4068–73	C III, O II, (N II)	
37	4084–89	O II, Si IV	
38	4090–4108	O II, N III H_δ, O II	Strongly variable
39	4116	Si IV	
40	4121	He I	Variable (Em)
41	4124	N II	
42	4127–28	S III	
43	4144	He I	
44	4200	He II	Variable
45	4242	O II	
46	4265	S III	
47	4281–86	O II	
48	4303–15	O II	
49	4317–20	O II	
50	4326–33	O II, (C III)	
51	4340	H_γ	Strongly variable partially filled-in or filled-in
52	4369–73	O II, Ne II C II, (Ar II)	
53	4388	He I	Variable (Em)
54	4406	O II	
55	4440	S III	
56	4452	O II	
57	4460–75	O II, He I	Variable (Em)
58	4481	Mg II	i.s.
59	4499–4502	S II, Na II	Blended with unidentified
60	4515	N III	
61	4517–19	Ne II, N III	
62	4528	N III, Al III, S III	
63	4542	He II, (Ne II)	Variable (Em)
64	4553	N II, Si III	
65	4568	Si III	
66	4600	N II, Ne II	
67	4608	N II, O II	
68	4611	O II	
69	4613–14	N II, O II Ne II	
70	4621	O II, N II (Fe III)	
71	4630–34	C II, N II, Si IV, Ne II	
72	4640–43	N II, O II N III	
73	4647–55	C III, O II, Si IV	
74	4661	O II	
75	4676–77	O II, S III	
76	4680–83	Ar II, N II Si III	
77	4686	He II	Variable (Em)
78	4691	O II	Blended with unidentified
79	4708–10	N II, O II Ne II	
80	4713	He I, N II	Variable (Em)
81	4721	N II	
82	4752	O II	
83	4788	N II	
84	4794	N II, Ne II	
85	4861	H_β	Strong emission saturated
86	4877	Ar II	
87	4880–82	Ar II, N III	
88	4921	He I	Variable
89	5411	He II	Variable (Em)
90	5696	C III, Al III, O III	
91	5778–80		i.s.
92	5876	He I	Variable (Em)
93	6561	H_α	Strong emission eq. w. = −21 Å
94	6678	He I	Variable (Em)

Table 4. List of the identified lines in the UV spectrum of BD+37°1160

n	Wavelength (Å)	Ion	Remarks
1	1175	C III	
2	1195	reseau mark	
3	1215	Lyman α	i.s.
4	1248	C III	
5	1261	Si II	i.s. or shell
6	1278	C I	i.s.
7	1296–1300	Si III	
		Si II	e.w. = 1.14 Å
		O I	i.s. or shell
8	1316	(Si III)	
9	1335–36	C II	i.s. or shell
10	1362–65	Si III	
11	1393	Si IV	e.w. = 4.00 Å
12	1401	Si IV	e.w. = 4.00 Å
13	1417	Si III	
14	1428	C III	
15	1450	Ti IV	
16	1461	Si III	
17	1467	Ti IV	
18	1477	O III, C III	
19	1500–02	Si III	
20	1527	Si II	i.s. or shell
21	1533	Si II	
22	1548–51	C IV	e.w. = 6.00 Å
23	1560	C I	i.s.
24	1592	O III	
25	1606–11	Mn IV	
		Fe II	i.s. or shell
26	1631	Fe II	i.s. or shell
		Si IV	
27	1640	He II	
28	1657	C I	i.s.
29	1671	Al II	i.s. or shell
30	1719–25	Al III, N IV	
31	1748–52	N III, Mn IV	
32	1852	Al III	
33	1894	Fe III	
34	1914	Fe III	
35	1925	Fe III	
36	2798	Mg II	i.s. e.w. = 2.7 Å

3.3.1. BD+37°1146

No IR excess up to 3.8 microns is observed in BD+37°1146. In fact the observed colour indices of J–H = −0.05, H–K = −0.02 and K–L = −0.04 of the O7 II(f) star BD+37°1146 are in agreement with the intrinsic ones (J−H = −0.07, H−K = −0.06, and K−L = −0.08) reported for a O-type supergiant star by Koorneef (1983), even if the star shows a possible infrared flux variability of ~0.1 mag.

3.3.2. BD+37°1160

The energy distribution of BD+37°1160, corrected for $E(B-V) = 0.42$, relative to the observations of November 1986 and January 1987 is shown in Fig. 12. *UBV* magnitudes are from Buscombe (1980).

The spectral points were compared with the stellar continuum best fit obtained for $T_{\rm eff} = 30{,}000$ K and $\log g = 3.5$ Kurucz's model (Kurucz, 1979) and normalized to the V magnitude (KM in the figure). The difference between the observed fluxes and the stellar continuum gives an IR-excess spectrum (open dots in the figure) of the type $S = a \cdot \nu^{\alpha}$ with $\alpha = 0.7$, typical for a thermal free-free emission from a circumstellar ionized gas.

From the observed IR excess at $\lambda = 3.8\,\mu$m, $S^{\rm exc}_{\lambda=3.8\,\mu m} = 0.97$ Jy, we derived a value of the electron density at the inner boundary of the envelope equal to $1.1 \cdot 10^{12}$ cm^{-3}, adopting the simple model for ionized envelopes described by Persi and Ferrari-Toniolo (1985).

A variability of about 0.2 mag in J, H, K bands has been detected in a time scale of two years (see Table 5). Since the IR excess emission comes from free-free process, this behaviour is likely to be associated to the variability of the ionized circumstellar envelope.

The star BD+37°1160 has been identified in the IRAS Point Source Catalogue with the source 051921+3737. The point source correlation coefficients at 25 and 60 microns suggest that the infrared source can be extended and the flux densities at 25, 60 and 100 micron, corrected according to the prescription given by Beichman et al. (1985), might indicate the presence of very cold dust in the circumstellar envelope. This fact should be very anomalous for a classical Be star. On the other hand, the far-IR emission could be due to a molecular cloud not associated with the star, being the source in a confused region.

4. Discussion

From the observations presented in Sect. 3, one can see that the X-ray measurement made with EXOSAT were not conclusive, even if a weak soft X-ray flux has been detected. No significant hard X-ray flux was detected by the ME experiment. These observations clearly show that 1H 0521+373 was in a faint state at the time of the observations. The same conclusion is supported by the upper limit of 0.39 μJy in the 2–25 keV region obtained from the X-ray detectors on board ASTRON one month later the EXOSAT measurements.

The detailed observations made in infrared, optical and ultraviolet bands clearly characterize the two objects.

BD+37°1146 appears to have a typical O(f) type spectrum, without any peculiar feature that could be associated with the hard X-ray emission. It is probably a faint coronal X-ray emission source, as it has been seen from many O stars (Cassinelli et al., 1981).

On the other hand, the detection of infrared excess and the consequent presence of a circumstellar envelope in BD+37°1160 could indicate its association with the X-ray source 1H 0521+373. Similar IR-excess spectrum has been observed in optical counterparts of several X-ray sources, such as X Per, γ Cas, and HDE 245770 (Persi et al., 1979; Persi and Ferrari Toniolo, 1985). The circumstellar envelope consisting of a cold matter and ionized gas is compatible with a model of a hot spot produced by the X-ray illumination of the shell (Anderson, 1981; Apparao and Tarafdar, 1986).

Long term variability in X-ray emission (as the low state during EXOSAT and ASTRON observations and earlier in the

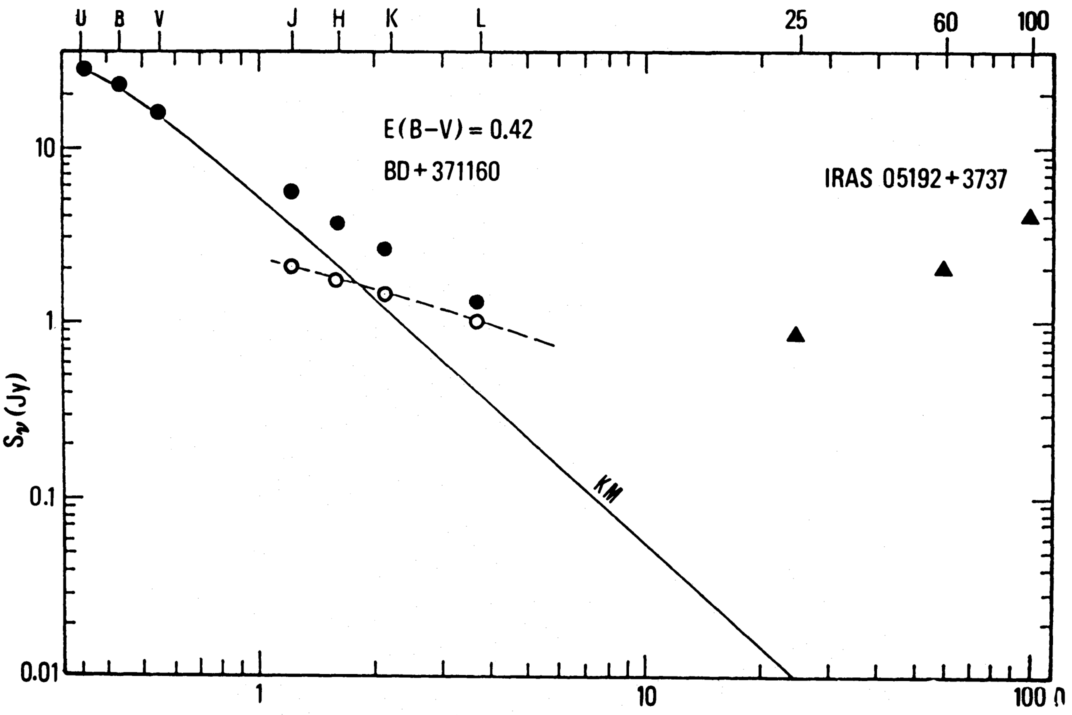

Fig. 12. Optical and infrared energy distribution of BD + 37°1160. The dashed line shows the infrared excess respect to the stellar continuum best fit obtained for $T_{\rm eff} = 30{,}000$ K and $\log g = 3.5$ Kurucz's model (KM)

Table 5. IR magnitudes and relative 1 σ statistical errors of BD + 37°1146 and BD + 37°1160

Star	Date	J	H	K	L
BD + 37°1146	Nov. 25, 1986	6.55	6.60	6.62	6.66
		±0.04	±0.03	±0.03	±0.17
BD + 37°1146	Jan. 19, 1987	6.70	6.71	6.70	6.24
		±0.04	±0.04	±0.04	±0.24
BD + 37°1160	Nov. 25, 1986	6.73	6.53	6.29	5.89
		±0.02	±0.02	±0.03	±0.03
BD + 37°1160	Jan. 19, 1987	6.74	6.53	6.31	5.80
		±0.04	±0.04	±0.04	±0.07
BD + 37°1160	Mar. 6, 1989	6.97	6.74	6.44	5.91
		±0.01	±0.02	±0.01	±0.03

Ariel V and SAS 3 surveys) is characteristic of some binary systems with Be star companion, and can be interpreted as due to changes in the shell phase of the primary star, as indicated by the variable infrared excess of BD + 37°1160.

The optical spectrum of BD + 37°1160 further strenghtens its association with the X-ray source. The rapidly variable He emission line can be due to modulation in the X-ray illumination from a compact companion.

Moreover, the UV spectrum of BD + 37°1160 is rather similar to that of HDE 245770 and HD 102567, which are optical counterparts of the transient X-ray sources A0535 + 26 and 4U 1145 − 61, respectively. Both these X-ray sources have been found to have in some cases hard X-rays excesses (Polcaro et al., 1983; White et al., 1983) similar to that detected in the sky region of 1H 0521 + 373.

If BD + 37°1160 is the optical counterpart of 1H 0521 + 373, its X-ray luminosity during the ON-state is about $4\cdot 10^{33}$ erg s^{-1}, assuming an isotropic flux and a distance of 1.7 kpc. The derived L_X/L_0 ratio of the system is therefore of order of $5\cdot 10^{-4}$. This figure is in good agreement with the value expected for a massive detached X-ray binary (e.g. Charles, 1982), as it seems to be the case of BD + 37°1160/1H 0521 + 373.

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