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A multiwavelength study of LS II+34^{0}26: a hot post-AGB star in the process of becoming a planetary nebula*

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Abstract. We present the results from a multiwavelength analysis of LS II+34^{0}26, recently identified as a low mass post-AGB star and not a massive population I B-type star, as previously thought. We confirm that the central star is a carbon-poor post-AGB star surrounded by a very low excitation and compact nebula.

Spectroscopic monitoring carried out since 1991 reveals variations which suggest that this star has had a mass loss episode in the period 1993–1995. The asymmetric profiles in a few absorption lines in high resolution optical spectra indicate the presence of complex motions in the outer layers of the atmosphere. The radial velocity variations (several tens of km s^{-1}) observed in spectra taken in a single epoch can be attributed to stellar pulsation. For a few lines stronger variations over the years (up to 70 km s^{-1}) can be explained if these lines are formed in the outflow.

The anomalous extinction observed in the UV suggests that part of the reddening is of circumstellar origin and that the standard interstellar extinction law is not applicable. On the other hand, the absence of a significant near infrared excess in LS II+34^{0}26 suggests that the mass loss enhancement corresponds to a short-lived episode of modest intensity.

Although non-LTE effects prevent the accurate determination of the atmospheric parameters and abundances of LS II+34^{0}26, a comparative analysis with LS IV$-12^0$111 indicates that both stars are very similar. Both are identified as low mass carbon-poor hot post-AGB stars belonging to the halo population of our Galaxy.

Key words: Planetary nebulae: LS II+34^{0}26 – stars: LS II+34^{0}26 – stars: AGB and post-AGB – stars: abundances – stars: mass loss

1. Introduction

Only with the advent of IRAS, it has been possible to efficiently recognize stars in the post-AGB stage of their evolution. Post-AGB stars are characterized by the presence of very cold detached dust shells, as a consequence of the strong mass loss experienced in the recent past during the AGB phase. Thus, they are easily detectable in the far infrared.

Most of the surveys carried out in the past to detect new objects in this short-lived ($\sim 10^3 - 10^4$ yrs) evolutionary phase concentrated on optically bright stars with intermediate spectral types (Parthasarathy & Pottasch 1986; Lamers et al. 1986; Pottasch & Parthasarathy 1988; Hrivnak et al. 1989) and very little attention was paid to the detection of post-AGB stars showing hotter effective temperatures.

However, in the last few years an increasing number of hot post-AGB stars have been found, extending the observed sequence of spectral types to those corresponding to hotter effective temperatures (Parthasarathy & Pottasch 1989; Conlon et al. 1991; McCausland et al. 1992; Oudmaijer 1996). This may represent an evolutionary sequence, since at the end of the AGB phase, it is expected an increase of the effective temperature of the central star as it evolves in the H-R diagram at a constant luminosity. Many of them were detected at high galactic latitudes, and probably represent the fraction of low mass post-AGB stars which evolve so slowly that they may not be able to fully ionize the material surrounding the central star before this

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* Based partially on observations collected with the International Ultraviolet Explorer (IUE) at the Villafranca Satellite Tracking Station of the European Space Agency, Spain

is diluted into the interstellar medium. This is supported by the fact that their spectral energy distribution can only be explained if they evolved off the AGB about 1000 years ago, which is significantly longer than what is found for other post-AGB stars. In a few cases, nebular emission lines are observed, indicating that at least a fraction of the envelope is ionized, confirming their identification as transition objects which could be considered either hot post-AGB stars or very low excitation planetary nebulae (PNe, hereafter).

LS II+34^{0}26 (= V1853 Cyg = IRAS 20462+3416) was first suggested to be a post-AGB star by Parthasarathy (1993a), based on the characteristics of its far infrared IRAS emission, global energy distribution, low gravity, high velocity and high galactic latitude. Previously, it was considered to be a young massive Population I star located at 17.8 kpc from the Sun (Turner & Drilling 1984). The recent detection of nebular emission lines in the optical spectrum of LS II+34^{0}26 indicates that the star can also be considered a very low excitation PN (Parthasarathy 1993b). In a recent Paper by Smith & Lambert (1994), high resolution optical spectra of LS II+34^{0}26 are discussed, from which they conclude that the star is in the post-AGB stage. The authors found clear differences in the spectra taken in 1993 with the spectrograms obtained by Turner & Drilling (1984) in 1977 and 1981, when only a weak Hβ emission was seen, together with Hγ and Hδ clearly in absorption, suggesting that the star may be rapidly evolving into the PN stage.

In this Paper we study this star more in detail using additional optical data acquired by us at several epochs in the period 1991-1995, and extending the observations to the UV and the near infrared. From the analysis of these data we confirm the identification of this star as a new member of the group of low-mass hot post-AGB stars located at high galactic latitudes. Whether this star must be considered one of the hottest post-AGB stars known or a very low excitation compact PN, we leave it to the reader's preference.

2. Observations and data reduction

The ultraviolet (UV, hereafter) spectra were obtained using the IUE satellite from Villafranca Satellite Tracking Station (Madrid, Spain). Low resolution spectra (6 Å) were taken at two different epochs, in April 1993 (SWP47529 + LWP25396) and April 1994 (SWP50587 + LWP27935). All of them are well exposed and not saturated. Line-by-line images have been inspected against spurious features which have been removed. The IUE spectra have been processed using the standard IUE processing system at VILSPA (IUESIPS). The photometric calibration has been carried out following Bohlin et al. (1980) for the SWP and Cassatella et al. (1992) for the LWP. The UV fluxes have also been corrected for camera sensitivity degradations using the most recent tables implemented in the processing at VILSPA in 1995.

In November 1991, low resolution optical spectroscopy was undertaken at Calar Alto Observatory in Almería (Spain) using a Boller & Chivens Spectrograph at the 2.2 m telescope equipped with a GEC CCD detector, with a spectral resolution of 2.52 Å/pixel, covering the spectral range from 3900 to 6800 Å. Additional low resolution spectroscopy was acquired in June 1995 at the 2.5 m Isaac Newton Telescope (INT), operated by the Instituto de Astrofísica de Canarias at the Observatorio del Roque de los Muchachos (La Palma, Spain). At this telescope we used the IDS Spectrograph attached to the Cassegrain focus and the R300V grating, with a resolution of 1.58 Å/pix, covering with two spectra the regions between 3700 and 5400 Å and between 5500 and 7200 Å.

High resolution spectroscopy centered at 5050 Å, 5650 Å, 6150 Å, 6330 Å, 8710 Å and Hα was also carried out at the 2.5 m Isaac Newton Telescope (INT) in July 1993 and August 1993, again using a GEC CCD detector. The effective resolving power was $\sim$20000 using the H1800V grating. This gives a spectral coverage of around 300 Å per exposure. Additional high resolution spectra of LS II+34^{0}26 covering only the region centered around Hα were obtained in August 1994 and June 1995 using the same telescope and instrumentation. Both low and high dispersion spectra have been processed using standard IRAF routines. The data reduction process includes bias and flat-field corrections, sky subtraction and wavelength calibration. Absolute flux calibration was performed only for the low resolution spectra.

3. Results

3.1. Extinction and stellar temperature

In Table 1 we show the most recent photometric data available for LS II+34^{0}26 from the optical to the near infrared, together with the IRAS photometry in the far infrared. The near infrared data are from García-Lario et al. (1997) and were obtained with the 1.5 m CST telescope at the Observatorio del Teide (Spain) in October 1992. The optical data were kindly provided by Landolt (private communication) and were obtained with the 1.3 m telescope at the Kitt Peak National Observatory (USA) in October 1993.

The global energy distribution of LS II+34^{0}26 (see Fig. 1 of Parthasarathy 1993a) is very representative of a post-AGB star, with its characteristic two peaks, one in the optical and the other in the infrared.

The strong peak observed in the far infrared is interpreted as thermal emission from cold dust present in the circumstellar envelope as a consequence of the strong mass loss experienced by the central star at the end of the thermal pulsing AGB phase. A fit to the fluxes observed in the 25 μm and 60μm bands, which are more reliable, gives a temperature $T_d \sim$ 145 K for the dust in the shell, similar to the values found in other post-AGB stars.

The optical peak is produced by the emission coming from the central star. The continuum observed in the optical spectra taken in November 1991 and June 1995 corresponds to a blackbody emission at 19500 $\pm$ 500 K, with an estimated value for the reddening of $E(B-V)$ = 0.36. This is the same value derived from the optical photometry, considering the intrinsic $(B-V)_0 = -0.18$ expected from a star with a spectral type

Table 1. Non-simultaneous photometric data for LS II+34^{0}26 (see text for references).

Band	Magnitude
V	10.97 ± 0.01
$B-V$	+0.19 ± 0.02
$U-B$	−0.78 ± 0.03
$V-R$	+0.16 ± 0.02
$R-I$	+0.16 ± 0.02
$V-I$	+0.32 ± 0.02
Band	Magnitude
K	10.31 ± 0.03
$H-K$	0.13 ± 0.06
$J-H$	0.13 ± 0.06
Band	Flux
12μm	0.29: ± 0.02 Jy
25μm	13.68 ± 0.55 Jy
60μm	12.12 ± 0.85 Jy
100μm	5.93 ± 0.53 Jy

B1Ia (Fitzgerald 1970), and the observed $(B-V)$ = 0.18. Our determination of $E(B-V)$ is very similar to that previously reported by Turner & Drilling (1984), who derived $E(B-V)$ = 0.38 from their UBV photometry, adopting $(B-V)_0 = -0.20$ for a B1.5 supergiant.

The stellar-like colours observed in the near infrared are also consistent within the errors with the emission expected from a B1Ia-type supergiant star affected by a moderate reddening. The absence of a significant excess in this wavelength range indicates that there is not too much hot dust in the envelope.

The determination of the extinction and the stellar temperature from the UV data is, however, not so straightforward. Although the features observed in the IUE spectra and the slope of the UV continuum are consistent with the spectral type B1Ia derived from the optical data, the removal of the 2200 Å interstellar dip suggests a much lower value for the extinction of $E(B-V)$ = 0.25±0.03. If we try to compare the dereddened UV energy distribution of LS II+34^{0}26 with those of little reddened bright B1Ia,b supergiants which have direct effective temperature determinations from Underhill (1979a, 1979b) our fit indicates that, while there is a remarkable similarity in the slope observed from 2500 Å to 3200 Å, a strong UV deficiency is found at shorter wavelengths. This deficiency is confirmed through comparison with a grid of theoretical flux distributions calculated under the LTE assumption with the ATLAS9 code (Kurucz 1993) for temperatures between 21000 K and 15000 K, surface gravities log g ranging from 2.5 to 3.5 and a solar metallicity. Whereas the 20000 K model normalized at 1550 Å matches properly the flux of LS II+34^{0}26 beyond 2500 Å, shortwards the dereddened flux is much lower than predicted. A cooler model of temperature 16000 K fits the slope from 1200 Å to 2000 Å very well but underestimates the flux level of LS II+34^{0}26 from 2000 Å to 3200 Å by 40%. The flux deficiency shortwards of 2000 Å could partially be due to a gravity effect as already noted by Humphries et al. (1975).

Table 2. Absorption lines identified in LS II+34^{0}26

λ (Å)	Ion	W_λ (mÅ)
4906.817	O II	99
4921.931	He I	200
4924.080	S II	–
4925.343	S II	150
4943.006	O II	73
5002.703	N II	41
5005.150	N II	49
5010.621	N II	42
5015.678	He II	70
5045.099	N II	109
5047.280	S II	–
5160.026	O II	77
5639.477	Si II	61
5666.629	N II	101
5676.017	N II	111
5679.558	N II	153
5686.213	N II	33
5696.604	Al III	176
5710.766	N II	78
5722.730	Al III	134
5739.734	Si III	247
6402.246	Ne I	210
6578.052	C II	303
6582.880	C II	–
6678.154	He I	330
6721.358	O II	137

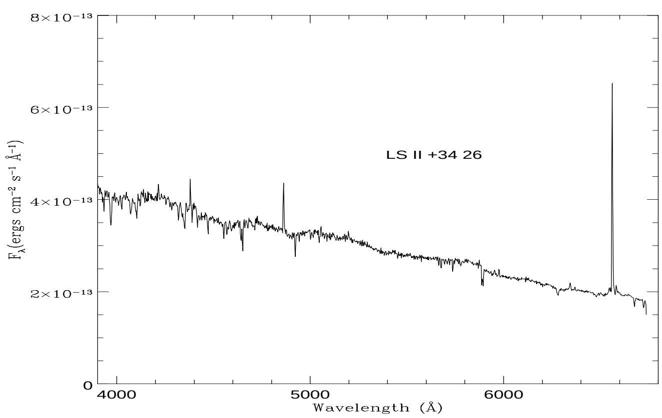

Fig. 1. Low resolution optical spectrum of LS II+34^{0}26 taken in November 1991

These authors compared the energy distribution of supergiants with those of main-sequence stars and found evidence for a small UV deficiency (less than 20%) in supergiant stars with respect to dwarfs for a given T_{eff}. Unfortunately, models with gravities lower than 2.5 are not available for early B stars and we cannot check whether the observed far-UV deficiency is due to a very low gravity.

3.2. Spectroscopic monitoring: radial velocity variations

A visual comparison of the low resolution optical spectra taken in November 1991 and June 1995 reveals no significant

Table 3. Heliocentric radial velocities derived from absorption and emission lines

	Absorption lines			Emission lines		
Date	Ion	v_r (km s^{-1})	Lines	Ion	v_r (km s^{-1})	Lines
August 1992	C II	−79	2	[N II]	−82	1
	O II	−70	1	[S II]	−77	2
July 1993	C II	−92	2	[N II]	−74	1
	O II	−61	1	[S II]	−80	2
				Si II	−78	2
August 1993	S II	−94	3	Si II	−72	1
	Si III	−65	1			
	N II	−61	8			
	Si II	−60	1			
	Al III	−58	2			
July 1994	C II	−115	2	[N II]	−71	2
	O II	−55	1	[S II]	−72	2
August 1994	C II	−136	2	[N II]	−75	2
	O II	−67	1	[S II]	−78	2
June 1995	C II	−56	1	[N II]	−73	1
	O II	−70	1	[S II]	−70	2

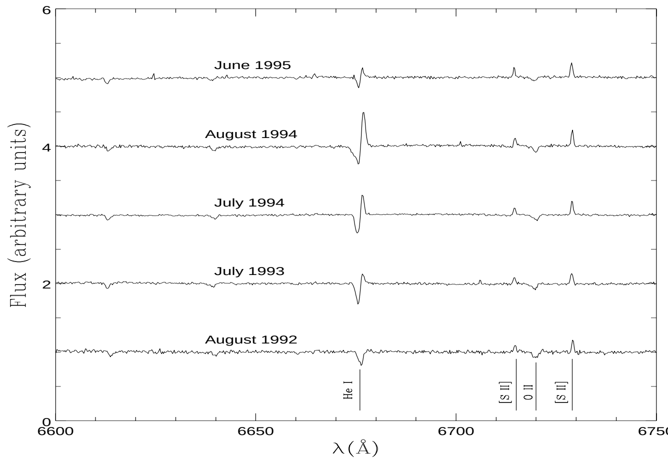

Fig. 2. High resolution normalized optical spectra of LS II+34^{0}26 where we can see the strong changes observed in the He I λ6678 Å profile

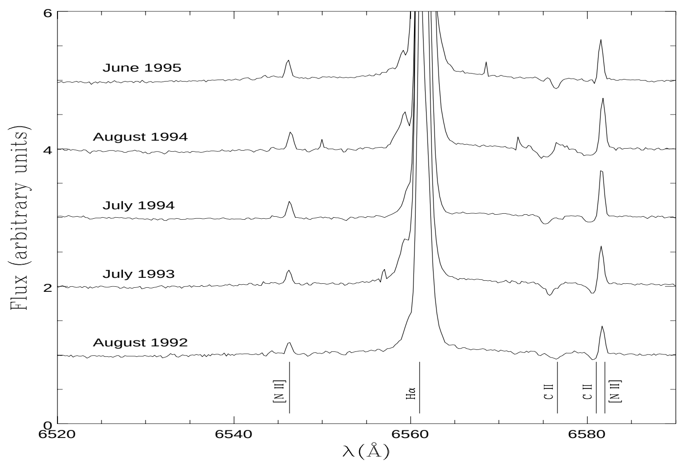

Fig. 3. High resolution normalized optical spectra of LS II+34^{0}26 where we can see the spectral region around Hα and the changes observed in the C II λ6578.052 Å and C II λ6582.880 Å lines

colour changes from epoch to epoch. The optical spectrum of LS II+34^{0}26 is characterized by strong Balmer emission overimposed on a blue stellar continuum, together with very weak permitted and forbidden nebular emission lines. They appear more prominent in the high resolution spectra taken in 1993, where it is also possible to detect P-Cygni profiles affecting the recombination lines of hydrogen and helium. The stellar continuum shows only a few photospheric absorption features representative of a B-type stellar spectrum (see Table 2). On the other hand, the low excitation characteristics of the nebular emission lines observed in the optical spectra are consistent with T$_{eff}$ $\leq$ 25000 K, since no [O III] emission at λ4959 Å and λ5007 Å is observed. From the ratio [S II] λ6717 Å / λ[S II] 6731 Å = 0.50 we derive an electronic density n$_e$ $\sim$ 10^4 cm^{-3}. Similar high densities are observed in other young and compact PNe. The detection of permitted emission lines of Si II in our spectra, together with the previously reported detection of permitted lines of C II and Fe III and forbidden emission from [Fe II] (Smith & Lambert 1994) suggests the presence of an inner region, very close to the central star, with even higher densities.

One of the most intriguing aspects of LS II+34^{0}26 is the remarkable radial velocity variations found in the absorption lines detected in the high resolution optical spectra available. In some cases, the velocity differs by more than 30 km s^{-1} from ion to ion in spectra taken in a single epoch. In addition, we also detect strong variations in the radial velocity of some individual lines from epoch to epoch and changes in the P-Cygni profiles affecting the recombination lines of hydrogen and helium, as we will discuss later.

In Table 3 we show the heliocentric radial velocities derived from absorption and emission lines corresponding to different ions in different epochs.

As we can see, most of the values corresponding to the absorption lines are in the range −58 to −65 km s^{-1} but some individual lines appear strongly blue-shifted in spectra taken in a single epoch.

The dispersion in the radial velocities observed can be attributed to complex motions in the outer atmosphere where these lines are formed, and are also probably responsible for the asymmetric profiles observed. The same kind of radial velocity variations were previously reported by Smith & Lambert (1994). They found a mean value of −58.7 km s^{-1} from the photospheric absorption lines while Turner & Drilling (1984) reported a much higher value of −88 km s^{-1}.

Quasi-periodic ($\sim$ 4 days) small amplitude variations ($\sim$ $0.1 - 0.2$ mag) in the optical flux have previously been reported by Turner & Drilling (1984). It is tempting to speculate that these photometric variations could be connected with those observed in the radial velocities of the absorption lines. Several hypothesis, like binarity or shock waves in the atmosphere due to pulsation, have been suggested to explain this behaviour.

Remarkably, the velocity derived from the nebular emission lines (see Table 3) seems to be constant over the years within the errors. A mean value of -75 ± 6 km s^{-1} is found, identical to the velocity obtained from the permitted emission lines of Si II in our spectra. This value should give a better approach to the actual radial velocity of the star, since the emission lines are not affected by a possible orbital motion of the central star around an invisible companion or by the effect of pulsation. The fact that lines corresponding to different ions show different radial velocities in individual spectra favours the hypothesis of pulsation against binarity.

Similar radial velocity variations have also been observed in other post-AGB stars, such as 89 Her (Waters et al. 1993), and they have also been attributed to stellar pulsation. It has been argued that the resulting shock structure may help driving material away from the star, heating and extending the atmosphere and thus, making easier for the star to lose mass.

3.3. Stellar wind: a mass loss event?

Evidence of a stellar wind is provided by the detection of strong P-Cygni profiles affecting the recombination lines of hydrogen and helium. As we can see in Fig. 2, the intensity of the wind seems to be variable over the years, as deduced from the temporal evolution of the He I line at λ6678 Å, where the effect of the variable wind is best observed. In this figure we can see how this line appears in absorption in August 1992, while the P-Cygni profile first becomes evident in July 1993 and reaches its maximum strength in the spectrum taken in August 1994 with $v_\infty \sim -235$ km s^{-1}. Simultaneously, the absorption component becomes broader as a consequence of the acceleration of the terminal velocity of the wind, abruptly decreasing again in June 1995. The same behaviour is observed in the rest of recombination lines present in the spectrum. Note, in contrast, how the nebular emission lines of [S II] at $\lambda\lambda$6717,6731 Å, also present in this figure, remain unaffected by the changes in the stellar wind, as expected, as well as the photospheric absorption line of O II at λ6721 Å, for which we did not detect significant radial velocity variations over the years, as we can see in Table 3.

Additional information can be extracted from the analysis of the temporal evolution of the absorption and emission lines in the spectral range shown in Fig. 3. In this figure, we can see how the absorption lines of C II at $\lambda\lambda$6578,6583 Å, unlike the O II line at λ6721 Å previously shown in Fig. 2, are strongly affected by the variations in the stellar wind. This can naturally be explained if these lines are formed in the outflow, since they appear broader and strongly blue-shifted (up to 70 km s^{-1}) in August 1994, following the same trend observed for the recombination lines of hydrogen and helium. Although not so evident as in the case of the He I line at λ6678 Å, the strong Hα emission is also affected by a variable P-Cygni profile. Unfortunately, in this case the intensity of the emission does not allow a detailed analysis. Finally, no significant changes are observed again from epoch to epoch in the nebular emission lines of [N II] at $\lambda\lambda$6548, 6584 Å, as expected. Note that the small variations affecting the [N II] line at λ6584 Å are produced by the variable overlap with the nearby C II line at λ6583 Å and not by intrinsic changes in the nebular emission line.

The presence of a strong stellar wind can also be deduced from the analysis of the UV spectra taken in 1993 and 1994. From the center of the blue-shifted absorption observed in the Si IV lines around λ1400 Å we derive a velocity of the stellar wind of -990 km s^{-1}. A similar value (-800 km s^{-1}) is obtained from the C IV λ1550 Å line. From the blue edge of this line the terminal velocity of the wind is found to be around -1700 km s^{-1}.

3.4. Atmospheric parameters and abundance analysis

As a first approach, the observed spectral features have been compared with the results of LTE radiative transfer calculations using model atmospheres generated by the ATLAS9 code of Kurucz (1993). The best fits are obtained for values between T$_{eff}$ = 18000 K; log g = 2.5 and T$_{eff}$ = 22000 K; log g = 3.0, assuming a microturbulent velocity of v_T = 14 km s^{-1}, which is the usual value observed in similar stars (McCausland et al. 1992).

Although there are not too many absorption lines available in our spectra, a rough chemical abundance analysis has been carried out assuming LTE conditions and considering the whole range of temperatures and gravities above cited. The main conclusion reached is that LS II+34^{0}26 might be carbon deficient by ~ -0.5 dex, while nitrogen and oxygen abundances seem to be solar.

However, previous analysis carried out by McCausland et al. (1992) on a sample of young B-type stars indicate that non-LTE effects may be important when determining the chemical abundances, and that the assumption of LTE conditions is a good aproximation only if we restrict our analysis to lines with small equivalent widths (below 150 mÅ), which are formed in deeper layers of the stellar atmosphere. Unfortunately, this is not the case for many of the absorption lines detected in LS II +34^{0}26. Nitrogen and oxygen abundances are not seriously affected by this problem, but our low carbon abundance determination is based on the measurement of just one single C II line at λ6578 Å, which is associated to a large equivalent width and seems to have its origin in the outflow, as we have previously shown, and it may be affected by non-LTE effects.

In order to test whether the low carbon abundance found in LS II+34^{0}26 is real, we show in Fig. 4 the dereddened UV spectrum of LS II+34^{0}26 together with those of the standard B1Ia supergiant star HD 150168 and LS IV$-$12^{0}111, a star recently identified by Conlon et al. (1993) as a carbon-poor (~ -0.8 dex) low mass hot post-AGB star, with very similar

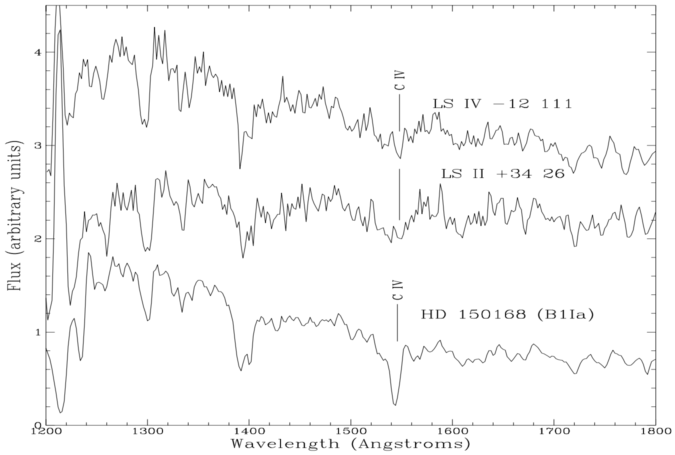

Fig. 4. IUE dereddened low resolution spectra of LS II+$34^0$26 and LS IV$-12^0$111, together with the spectrum of HD 150168, a B1Ia standard supergiant shown for comparison. Note the weakness of the C IV line at λ1550 Å in LS II+$34^0$26 and LS IV$-12^0$111 in comparison with the strength of this line in the standard supergiant and the strong similarity in the rest of the absorption features.

characteristics to those of LS II+$34^0$26 from the UV to the far infrared, as we will discuss in Sect. 4.

The strong similarity of the UV continuum of LS II+$34^0$26 with that of the B1Ia spectrum of the supergiant star HD 150168 provides an independent proof for the classification of this post-AGB star as an early B supergiant. Both show strong absorption lines at λ1298 Å (Si III) and λ1396 Å (Si IV) and many other spectral features which are remarkably similar. Note, however, the much weaker C IV line absorption at λ1550 Å in LS II+$34^0$26 and LS IV$-12^0$111, which confirms the carbon-poor nature of these two stars.

4. Discussion

The spectral changes observed in LS II+$34^0$26 are probably due to a short-lived episode of mass loss which was not yet active in August 1992 and reached the maximum intensity in August 1994. The last spectrum taken in June 1995 still shows some activity but at a much lower level.

Post-AGB mass loss may play an important role on shortening the transition times predicted by the models for these stars to become PNe. Strong evidences of episodic mass loss ejection have also been found recently in other transition objects, like IRAS 17423$-$1755 (Riera et al. 1995). In some cases these episodes are followed by strong spectral variations, as observed in SAO 243756 (Oudmaijer 1996). The most spectacular case known so far is that of SAO 244567 (= Hen 3$-$1357), now a PN, while just 20 years ago it was a B-type post-AGB star with just a very faint emission in the Balmer lines (Parthasarathy et al. 1993, 1995). The changes observed are interpreted as the consequence of short-lived episodes of enhanced mass loss experienced by these stars in the recent past.

We do not know yet what is the mechanism which triggers post-AGB mass loss and the frequency and duration of these episodes as a function of the characteristics of the evolving star, but they are expected to be more intense and frequent in those with massive progenitors. It is possible that the evolution of post-AGB stars on their way to become PNe occur in steps which are induced by this episodic mass loss. This means that the detection of spectral changes in a post-AGB star does not necessarily mean that the star is a rapidly evolving massive object, but just that it has recently undergone one of these mass loss episodes.

LS II+$34^0$26 and LS IV$-12^0$111 are probably in a very similar evolutionary stage. The global energy distribution of both stars from the UV to the far infrared is remarkably similar. The UV continuum of LS IV$-12^0$111 is well fitted by a B-type continuum with an effective temperature T_{eff} = 19000 K and a surface gravity log g = 3.00, very similar to the values found for LS II+$34^0$26. Like LS II+$34^0$26, it also shows an incipient compact nebular emission with very low excitation characteristics.

From the analysis of the far infrared emission observed in LS IV$-12^0$111, again using the 25 μm and 60 μm IRAS bands for the fit, we derive a temperature for the dust in the shell which is slightly hotter (T_d = 175 K). If we assume that this temperature is connected with the time elapsed since the end of the AGB phase, this would mean that LS II+$34^0$26 evolved off the AGB a longer time ago than LS IV$-12^0$111. On the other hand, the effective temperature of both central stars is very similar now. From this we conclude that the central star of LS II+$34^0$26 is more slowly evolving towards hotter effective temperatures in the H-R diagram on its way to become a new PN. According to the models, this would mean that LS II+$34^0$26 has a lower progenitor mass.

The absence of any significant near infrared excess in both stars indicates that the duration and intensity of the mass loss episodes by them experienced in the recent past were not enough to efficiently form and heat dust grains in the circumstellar envelope, in agreement with what one would expect from the suspected low mass of their progenitor stars.

The anomalous UV extinction observed in LS II+$34^0$26 has also been found in LS IV$-12^0$111, although not so marked. The extinction derived from the removal of the UV bump at 2200 Å in LS IV$-12^0$111 is $E(B-V)$= 0.30$\pm$0.05, which is slightly lower than the value of 0.37 derived by Conlon et al. (1993) from data taken in the optical. This anomaly has also been found in other post-AGB stars (Lamers et al. 1986; Parthasarathy et al. 1989) and in some low mass metal-poor young PNe, like SwSt 1 (de Freitas Pacheco & Veliz 1987). The lower UV extinction is usually attributed to the fact that part of the reddening may be circumstellar in origin. The dust grains formed in these shells do not follow the standard galactic reddening law, which is only applicable to interstellar dust grains, probably because of their different chemical composition and size (Waters et al. 1989; Buss et al. 1989; Muci et al. 1994). First, the formation of large dust grains could be favoured in the relatively quiet circumstellar environments of these slowly evolving low mass post-AGB stars, since they are not affected by strong radiation fields or by violent stellar winds. They are expected to produce a significant reddening in the optical range, while the extinction induced in the UV range would be negligible. In addition, hydrogenated amorphous carbonaceous grains and/or graphitic grains have been suggested to be the main responsible for the bump observed in the UV at 2200 Å (Mathis 1994; Mennella et al. 1996). Thus, the extinction derived from the UV data in a carbon-poor circumstellar shell will also be lower.

Several scenarios can be invoked to explain the carbon depletion observed in LS II+34^{0}26 and other hot post-AGB stars. Carbon and other heavier elements are expected to be formed during the thermal pulsing phase on the AGB through α-capture processes in what it is called the "third dredge-up" (Iben & Renzini 1983). The underabundance of carbon in these hot post-AGB stars suggests that they left the AGB without experiencing this third dredge-up. On the other hand, it is well known that carbon may also be removed by hot bottom-burning and transformed into nitrogen through the CNO cycle in the inner atmosphere (D'Antona & Mazzitelli 1996). However, this is only expected to occur in stars with high mass progenitors (M $\geq$ 4 M$_\odot$), while hot post-AGB stars are suspected to be the result of the evolution of very low mass stars. Alternatively, these post-AGB stars may be members of the halo population of our Galaxy, since most of them are located at very high galactic latitudes and show a very low metallicity. Then, their low carbon abundance would just be a reflection of the original abundances in the environment where they were formed. Other supergiant stars found at high galactic latitudes, like HR 4912 (Lambert et al. 1983) and HR 7671 (Luck et al. 1990) also show carbon depletions of ~ -1.0 dex. If this is the case, they could be the precursors of objects like the carbon-poor ([C/H] = -1.5) low excitation halo PN DDDM-1 (Clegg et al. 1987).

5. Conclusions

From the above results, we confirm that LS II+34^{0}26 is a low mass post-AGB star already showing the characteristics of a very low excitation compact PN and not a high mass Population I young star, as previously thought.

Taken together, our data suggest that LS II+34^{0}26 may have undergone a mass loss episode during the period 1993-1995. However, additional monitoring is needed to determine whether this is a short-lived event which has already ended or the star is continuously experiencing a variable mass loss.

The star is very similar to LS IV$-12^0$111 and other metal-poor low mass hot post-AGB stars recently discovered. They all show a low gravity, high-velocity and high galactic latitude and a cold dust shell with infrared colours very similar to those observed in well evolved PNe. Consistent with its identification as a possible member of the halo population of our Galaxy, carbon seems to be underabundant, although the metal-poor condition still needs to be checked.

The anomalous UV extinction may be explained as a consequence of the presence of large dust grains in the circumstellar envelope and might also be favoured by the suspected carbon-poor composition of the grains.

The radial velocity variations found are more likely due to stellar pulsations and not to the orbit of the star in a binary system. The stronger variations found in the C II lines are easily explained if they are formed in the stellar outflow.

The absence of a significant near infrared excess indicates that mass loss episodes have not been frequent in the recent past or, at least, the mass loss has not been strong enough to produce the efficient formation and heating of the dust grains.

The strong spectral changes detected in this and other low mass post-AGB stars as a consequence of short periods of enhanced mass loss suggest that post-AGB mass loss can play an important role in shortening the transition times between the end of the AGB phase and the formation of a new PN. It is important to remark that this might explain the detection of very low luminosity PNe, not predicted by the models which assume that mass loss is not active during the post-AGB phase.

It is clear that follow-up observations of this and similar transition objects which have only very recently been discovered will be crucial to understand these and many other questions which are still open in the study of the process of formation of PNe.

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