High resolution spectroscopy of the hot post-AGB stars: IRAS13266-5551 (CPD-55 5588) and IRAS17311-4924 (Hen3-1428) *

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Abstract. The high resolution spectra covering the wavelength range 4900 Å to 8250 Å of the hot post-AGB stars IRAS13266-5551 (CPD-55 5588) and IRAS17311-4924 (Hen3-1428) reveal absorption lines of C II, N II, O II, Al III, Si III and Fe III and a rich emission line spectrum consisting of H I, He I, C II, N I, O I, Mg II, Al II, Si II, V I, Mn I, Fe III, [Fe II] and [Cr II]. The presence of [N II] and [O I] lines and absence of [O III] indicate low excitation nebulae around these stars. The components of Na I absorption lines indicate the presence of neutral circumstellar envelopes in addition to the low excitation nebulae around these two hot post-AGB stars. The Hα lines show P-Cygni profiles indicating ongoing post-AGB mass loss. From the absorption lines, we derived heliocentric radial velocities of 65.31 ± 0.34 km s⁻¹ and 27.55 ± 0.74 km s⁻¹ for IRAS13266-5551 and IRAS17311-4924 respectively. High galactic latitude and large radial velocity of IRAS13266-5551 indicate that it belongs to the old disk population. Preliminary estimates for the CNO abundances in IRAS13266-5551 are obtained.

Key words. Stars: AGB and post-AGB — Stars: early-type — Stars: abundances — Stars: evolution
1. Introduction

From the study of IRAS sources with far-IR colours similar to that of planetary nebulae (PNe) several cool and hot post-AGB stars have been discovered (Parthasarathy and Pottasch, 1986; Parthasarathy et al., 2000a, Parthasarathy et al., 2001) forming an evolutionary sequence in the transition region from the tip of the AGB to the early stages of PNe (Parthasarathy, 1993a, b). IRAS13266-5551 (CPD-55 5558) and IRAS17311-4924 (Hen3-1428) were identified as hot post-AGB stars (Table 1) based on their far-IR flux distribution, high galactic latitudes and B-supergiant spectra in the optical (Parthasarathy & Pottasch, 1989; Parthasarathy, 1993a; Parthasarathy et al., 2000a). The UV (IUE) spectra of these stars show C II (1335 Å), Si IV (1394 Å, 1403 Å), C IV (1550 Å) and N IV (1718 Å) lines typical of the central stars of PNe. The C IV (1550 Å) resonance lines are blue shifted indicating stellar wind velocities of $-1821$ km s$^{-1}$ (CPD-55 5558) and $-1066$ km s$^{-1}$ (Hen3-1428) respectively (Gauba and Parthasarathy, 2003). The “30 µ feature”, SiC emission at 11.5 µ, and UIR band at 7.7 µ were detected in the ISO spectrum of IRAS17311-4924 (Gauba and Parthasarathy, 2004). These features have been detected in the circumstellar dust shells of carbon rich AGB stars (C-stars), post-AGB stars, proto-planetary nebulae (PPNe) and planetary nebulae (PNe) (see e.g. Hony et al., 2002; Hrivnak et al., 2000, 2002). Loup et al. (1990) detected CO emission in IRAS17311-4924 typical for circumstellar shells around evolved objects.

High resolution optical spectra of only a few hot post-AGB stars have been analysed. These include IRAS01005+7910 (Klochkova et al., 2002), IRAS18062+2410 (SAO85766, Parthasarathy et al., 2000b; Arkhipova et al., 2001a; Mooney et al., 2002, Ryans et al., 2003), IRAS19590-1249 (LSIV−12°111, McCausland et al., 1992; Conlon et al., 1993a; Ryans et al., 2003) and IRAS20462+3416 (LSII+34°26, Parthasarathy, 1993b; García-Lario et al., 1997; Arkhipova et al., 2001b). The optical spectra of these stars show absorption lines due to C II, N II, O II, Si II, Si III, Fe III etc. Emission lines of He I, Fe I, II and III, N I, Ni I, O I have also been detected. Nebular emission lines of [O II], [N II], [S II] etc., detached cold circumstellar dust shells, OB-supergiant spectral types, high galactic latitudes and chemical composition indicate that these are PPNe (Parthasarathy et al., 1993c, 1995 and 2000b). IRAS13266-5551 and IRAS17311-4924 are found to be similar to the objects mentioned above. In this paper we report an analysis of their high resolution spectra.

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Table 1. Details of the stars

| IRAS      | Name       | RA (2000) | DEC (2000) | l     | b       | Sp.Type       | V  | B-V     | IRAS Fluxes (Jy.) |
|-----------|------------|-----------|------------|-------|---------|---------------|----|---------|-------------------|
| 13266-5551| CPD-55 5588| 13:29:50.8| -56:06:53  | 308.30| +6.36   | B1Ibe         | 10.68 | 0.31   | 0.76 35.90 35.43 11.66 |
| 17311-4924| Hen3-1428  | 17:35:02.4| -49:26:26.4| 341.41| -9.04   | B1He          | 10.68 | 0.40   | 18.34 150.70 58.74 17.78 |

Photometry is from: "Reed (1998) and "Kozok (1985).
Spectral types are from Parthasarathy et al. (2000a).

2. Observations

High resolution (R ~ 30,000) spectra of IRAS13266-5551 and IRAS17311-4924 from 4900 Å to 8250 Å were obtained on 22nd June, 2002. Each object was observed twice during the night. The echelle spectrograph at the f/7.8 Ritchey-Chretien focus of the Victor M. Blanco 4m. telescope of the Cerro Tololo Inter-American Observatory (CTIO), Chile was used for the purpose. The spectra were recorded using a Tektronix 2048X2048 CCD. The slit width was 150 µ corresponding to 1” on the sky. Appropriate number of bias frames and flat fields were observed. A Th-Ar comparison lamp was used for wavelength calibration.

As these are hot stars, spectra in the blue would contain more number of absorption lines. However, our observing program and the spectrograph setup did not allow us to go shortward of 4900 Å. Therefore, the analysis reported in this paper is based on the spectra covering the wavelength range 4900 Å to 8250 Å.

3. Analysis

The spectra were processed using standard IRAF routines. They were corrected using data in the overscan region of the CCD chip. The other reduction steps included trimming, bias subtraction, flat field correction, correction for scattered light and wavelength calibration. The two sets of reduced spectra for each object were then combined to increase the signal-to-noise (S/N) ratio. The final S/N ratios for IRAS13266-5551 and IRAS17311-4924 were estimated to be ~ 120. The reduced spectra were continuum normalised and the equivalent widths (Wλ) of the absorption and emission lines were measured. Whenever required, deblending was done to obtain gaussian fits to the blended line profiles. The continuum normalised spectra are presented in Appendices A and B (Figs. A and B). The line identifications (Tables 2a, 2b, 2c, 2d, 3a, 3b, 3c and 3d) are based on the Moore multiplet table (1945) and the linelists of Parthasarathy et al. (2000b) and Klochkova et al. (2002). Unidentified lines are denoted by “UN”. Night sky emission lines (atmospheric emission) were identified from Osterbrock and Martel (1992) and Osterbrock et al. (1996) and are listed as “atmos.” in the tables. The laboratory wavelengths, log (gf) values and excitation potentials (χ) are from the linelist compiled by Ivan Hubeny and retrieved from the directory /pub/hubeny/synplot by anonymous ftp from tlusty.gsfc.nasa.gov.
3.1. Description of the spectra

The high resolution optical spectra of IRAS13266-5551 and IRAS17311-4924 show absorption lines due to C II, N II, O II, Ne I, Al III and Si III. The O I triplet at \( \sim 7773 \) Å was detected in both stars. Both stars show a rich emission line spectrum with lines of C II, Mg II, Al II, Si II, Fe III and [Cr II] in emission. Emission lines of N I, O I, [O I], V I, Mn I and [Fe II] in IRAS17311-4924 were also detected. The presence of low excitation nebular lines of [N II] in the spectra of both stars and the absence of [O III] 5007 Å indicate that photoionisation has just started.

The He I lines in the two stars show a variety of profiles. They appear in absorption, in emission and also show P-Cygni profiles indicating post-AGB mass-loss. The He I(4) 5015.678 Å and He I(45) 7281.349 Å emission lines in IRAS13266-5551 are superposed on the corresponding absorption components. The asymmetric nature of these emission lines suggests that they may have P-Cygni profiles. The presence of high excitation lines of He I and low excitation emission lines of Na I (see Sec. 3.4) and V I indicate a range of temperatures for the circumstellar material around these stars. The circumstellar envelope around these stars may be extended and the outermost regions may be cooler. The H\( \alpha \) lines in both stars show P-Cygni profiles. The emission peak of the line in IRAS17311-4924 is asymmetric.

3.2. Radial velocities

Heliocentric radial velocities (\( V_r \)) for the well defined absorption and emission lines are presented in Tables 2a, 2b, 2d, 3a, 3b and 3d. The radial velocities of the Fe III (5) absorption lines in IRAS13266-5551 are relatively larger than the rest and those of the Ne I absorption lines in IRAS17311-4924 are relatively smaller suggesting that these lines may be formed in different regions in the atmospheres of these stars. Therefore, in estimating the mean heliocentric radial velocities, we have excluded the above lines. The radial velocity of C II (2) 6578.052 Å absorption line has also been neglected (see footnote to Table 2a). We obtained mean radial velocities of 65.31 \( \pm \) 0.34 km s\(^{-1}\) and 27.55 \( \pm \) 0.74 km s\(^{-1}\) from the absorption lines in IRAS13266-5551 and IRAS17311-4924 respectively. The mean heliocentric radial velocities of the emission lines are 58.32 \( \pm \) 0.65 km s\(^{-1}\) and 32.74 \( \pm \) 0.43 for IRAS13266-5551 and IRAS17311-4924 respectively. In estimating the mean radial velocity of the emission lines we have excluded the radial velocity measurements of the forbidden lines. The errors given here refer to the probable errors of estimation. Figs. 1 a and b show the overall radial velocity trend for the absorption and emission lines with respect to the equivalent widths (\( W_\lambda \)) and lower excitation potentials of these lines.

The mean heliocentric radial velocity from absorption lines in the case of IRAS17311-4924 corresponds to \( V_{\text{LSR}} = 31.13 \) km s\(^{-1}\). This value may be compared with the velocity (\( V_{\text{LSR}} = \)) of 36 km s\(^{-1}\) derived from CO observations of the star by Loup et al. (1990).
3.3. Wind velocities from the P-Cygni profiles

We estimated wind velocities from the well defined and unblended blue absorption edges of the P-Cygni profiles of He I, C II and Fe III (Tables 2c and 3c). The absorption components of the H$_\alpha$ P-Cygni profiles are affected by the broad wings of the H$_\alpha$ emission components (Fig. 3) and hence could not be used to estimate the wind velocities in these stars. The absorption component of He I(\lambda 7281.349 Å) P-Cygni profile in IRAS17311-4924 may be affected by atmospheric absorption lines in this region. The wind velocities in IRAS17311-4924 increase with the LEP of the species involved.

3.4. Diffuse interstellar bands (DIBs)

DIBs are absorption features in the spectra of reddened stars and have their origin in the interstellar and circumstellar medium. They are typically broader than expected from the Doppler broadening of turbulent gas motions in the interstellar and circumstellar medium. DIB at 5780.410 Å was identified in the spectra of IRAS13266-5551 and IRAS17311-4924.
also exhibited DIBs at λλ 5797.030 Å, 6195.990 Å, 6203.060 Å and 6613.630 Å. Their heliocentric radial velocities ($V_r$, Tables 2a and 3a) rule out the possibility of circumstellar origin. From the strength of the band at 5780.410 Å ($W_\lambda = 169.6$ mÅ for IRAS 13266-5551 and 109.9 mÅ for IRAS17311-4924), we estimate interstellar $E(B-V) \approx 0.35$ and 0.20 respectively (Herbig, 1993). At the galactic latitude and longitude of these stars, using the Diffuse Infrared Background Experiment (DIRBE)/IRAS dust maps (Schlegel et al., 1998), we estimated interstellar extinction values of 0.53 and 0.22 respectively. Herbig (1993) concludes that although the DIB strengths increase linearly with $E(B-V)$, there is a real dispersion about the mean relationship. For example from their data, HD144470 and HD37061 both have about the same DIB strengths despite large differences in their values of $E(B-V)$, 0.22 and 0.56 respectively.

### 3.5. Na I D$_2$ and Na I D$_1$ lines

The Na I D$_2$ and Na I D$_1$ lines in the spectra of IRAS13266-5551 and IRAS17311-4924 show both absorption and emission components (Fig. 2, Tables 2d and 3d). Comparing the radial veloc-
ities of these components with the average radial velocities for each star (Sec. 3.2), it is evident that the absorption components 1, 2 and 3 in IRAS13266-5551 and component 1 in IRAS17311-4924 are of interstellar origin. Components 4 and 2 in IRAS13266-5551 and IRAS17311-4924 respectively may be of circumstellar origin indicating the presence of neutral circumstellar envelopes in addition to the cold detached dust shells and low excitation nebulae.

Radial velocities of the emission components of the Na I lines are very close to the mean radial velocity of emission lines in IRAS13266-5551 (= +58.32 km s\(^{-1}\)) and IRAS17311-4924 (= +32.74 km s\(^{-1}\)). However, the emission components of the Na I lines may be disturbed by closely located absorption components and therefore the velocities derived from the Na I emissions may be in error.

### 3.6. \(H_\alpha\) profile and mass loss rate

\(H_\alpha\) profiles of the two stars are shown in Fig. 3. The wavelengths were converted to velocity units relative to the laboratory wavelength of the \(H_\alpha\) line, 6562.817 Å. The zero point was then adjusted for the heliocentric radial velocity of each star. The wings of \(H_\alpha\) can be seen up to about 220 and 180 km s\(^{-1}\) in IRAS13266-5551 and IRAS17311-4924 respectively.

The P-Cygni profile of \(H_\alpha\) indicates ongoing mass-loss. Model calculations by Klein and Castor (1978) predicted a tight relationship between the \(H_\alpha\) luminosity of the stellar wind and mass loss rate. The \(H_\alpha\) luminosity is related to the equivalent width of the \(H_\alpha\) emission line (see e.g. Conti and Frost, 1977; Ebbets, 1982). The equivalent widths of the \(H_\alpha\) emission components are 6.902 Å and 9.872 Å in IRAS13266-5551 and IRAS17311-4924 respectively (Tables 2c and 3c). Modelling the \(H_\alpha\) profiles to derive the mass loss rates of post-AGB stars would be the subject of a future paper. Here, we may compare our \(H_\alpha\) profiles with the B1.5Ia star, BD-14\(^{\circ}\) 5037. The observed equivalent width of the \(H_\alpha\) emission component in this star is 7.4 Å. From the \(H_\alpha\) profile, Leitherer (1988) derived a mass loss rate of 1.58X10\(^{-6}\) M\(_{\odot}\) yr\(^{-1}\).

### 3.7. Expansion velocities

Nebular expansion velocities were estimated from the FWHM of the \([O \, I]\) and \([N \, II]\) (6548.1 Å) emission lines using \(V_{\text{exp}}=0.50 \text{ FWHM}\) (Table 4). The mean expansion velocity for IRAS17311-4924 from \([O \, I]\) lines is 11.99 km s\(^{-1}\). The higher velocity from \([N \, II]\) is due to the fact that \([N \, II]\) emission dominates in the outermost ionised layers of the nebulae and \(V_{\text{exp}}\) increases with radial distance from the central stars (see e.g. Weinberger, 1989).

Based on CO observations Loup et al. (1990) and Nyman et al. (1992) estimated expansion velocities of 11 km s\(^{-1}\) and 14.1 km s\(^{-1}\) respectively in the case of IRAS17311-4924.

Radial velocity of absorption component 2 of the Na I profile (18.30 km s\(^{-1}\), see Table 3d) in IRAS17311-4924 is comparable with the expansion velocity of the star reaffirming its possible circumstellar origin.
Fig. 2. Na I D$_2$ and Na I D$_1$ lines in the spectra of (a.) IRAS13266-5551 and (b.) IRAS17311-4924. The various absorption and emission components of the lines have been labelled.

### 3.8. Atmospheric parameters and abundances

The presence of He I lines and the absence of He II lines in IRAS13266-5551 and IRAS17311-4924 indicates $18000 \, K \leq T_{\text{eff}} \leq 25000 \, K$ (Miroshnichenko et al., 1998). We used Kurucz’s WIDTH9 program and the spectrum synthesis code, SYNSPEC (Hubeny et al., 1985) along with solar metallicity Kurucz (1994) model atmospheres to derive the atmospheric parameters and elemental abundances under the LTE approximation.
The usual criterion for determining the effective temperature ($T_{\text{eff}}$), gravity ($\log g$) and micro-turbulent velocity ($\xi_t$) of a star, is to obtain a zero slope respectively in plots of (i) log abundances for a particular species Vs. lower excitation potentials of that species (ii) log abundances for two species of a particular element (e.g. Fe II and Fe III) Vs. lower excitation potentials and (iii) log abundances for a particular species Vs. equivalent widths.
The maximum number of absorption lines in the spectrum of IRAS13266-5551 are those of N II. The majority of the N II lines are strong with $W_\lambda \geq 100$ mÅ. Besides, the observed N II lines fall in a narrow range of lower excitation potentials (Tables 2a and 3a). This coupled with the lack of two ionisation species of any element does not allow us to employ the usual criterion for determining $T_{\text{eff}}$, $\log g$ and $\xi_t$. Hence, for IRAS13266-5551 we obtained abundances of C II, N II, O II, and Fe III with the WIDTH9 program for various combinations of $T_{\text{eff}}$, $\log g$ and $\xi_t$. We covered $18000 \, \text{K} \leq T_{\text{eff}} \leq 24000 \, \text{K}$ and $5 \, \text{km s}^{-1} \leq \xi_t \leq 45 \, \text{km s}^{-1}$. From the Kurucz (1994) model atmospheres, the $\log g$ value was limited to a minimum of 3.0. For each combination of these parameters, we then synthesised the spectrum using SYNSPEC. The best fit to the observed spectrum was obtained for $T_{\text{eff}} = 23000 \, \text{K}$, $\log g = 3.0$, $\xi_t = 10 \, \text{km s}^{-1}$ (Fig. 4).

IRAS17311-4924 has fewer absorption lines. The maximum number (8) of absorption lines that we find in our spectrum are those of N II and Ne I. While the N II lines are strong with $W_\lambda \geq 100$ mÅ, the Ne I lines are very sensitive to NLTE effects (see Sec. 3.8.5 below). Due to the small number of C II, N II and O II lines and the lack of iron lines, we were unable to estimate the atmospheric parameters and metallicity. The star suffers significant circumstellar extinction, $E(B-V)_{C, S} = 0.39$ (Gauba and Parthasarathy, 2003) and the circumstellar extinction law in the UV was found to be linear in $\lambda^{-1}$. Hence, the $(B-V)$ color of the star cannot be used for temperature estimation. An estimate of the temperature and gravity may be made from the spectral type of the star. Parthasarathy et al. (2000b) classified it as B1IIm which corresponds to $T_{\text{eff}} = 20300 \, \text{K}$ and $\log g = 3.0$ (Lang, 1992).

### 3.8.1. He I lines

We used the 5047.738 Å He I (47) absorption line in IRAS13266-5551 and estimated the helium abundance in this star (Table 5a). The estimated abundance is somewhat uncertain since only one line has been used in the analysis. The helium enrichment may indicate the evolved nature of the central star.

### 3.8.2. C II lines

We observed 12 C II absorption lines in IRAS13266-5551 and 6 C II absorption lines in IRAS17311-4924. Some of these lines are weak and are blended with other lines. The ISO spectrum of IRAS17311-4924 (Gauba and Parthasarathy, 2004) indicated carbon-rich circumstellar dust. The presence of carbon lines and their strengths compared to that of standard stars in the UV (Gauba and Parthasarathy, 2003) and optical spectra of this star indicate normal or slight overabundance of carbon.
Fig. 4. Regions showing the C II, N II and O II absorption lines in the observed spectrum (dotted line) of IRAS13266-5551 plotted along with the synthetic spectrum (solid line) for the derived atmospheric parameters \( T_{\text{eff}} = 23000 \, \text{K}, \log g = 3.0, \xi_t = 10 \, \text{km s}^{-1} \) and elemental abundances (Table 5a) of the star.

3.8.3. N II lines

Since strong lines \( W_{\lambda} \geq 100 \, \text{m} \AA \) are usually affected by microturbulence, the use of these lines in determining the atmospheric parameters of the star may contribute to systematic errors. Hence
N II lines with $W_A > 100$ mÅ have been excluded from the abundance analysis of IRAS13266-5551.

### 3.8.4. O I triplet and O II lines

The equivalent widths of the O I triplet in the spectra of the hot post-AGB stars, LSII+34°26 (B1.5 Ia, García-Lario et al., 1997; Arkhipova et al., 2001b) and IRAS01005+7910 (Klochkova et al., 2002) are 0.95 Å and 0.75 Å respectively. The (total) equivalent widths of the O I triplet in IRAS13266-5551 and IRAS17311-4924 are 0.741 Å and 1.479 Å respectively (Tables 2a and 3a). The O I triplet at $\lambda7773$ Å is known to be sensitive to NLTE effects. For the atmospheric parameters of IRAS13266-5551, using LTE analysis, we attempted to synthesise the O I triplet with the SYNSPEC code. This required oxygen abundances (log $\epsilon$(O)) in excess of 10.5. In contrast, the derived oxygen abundance using LTE analysis for the O II lines in IRAS13266-5551 is 8.78 (Table 5a). Such large discrepancies between the oxygen abundances derived from the O I triplet and the O II lines has also been observed in the hot post-AGB star IRAS01005+7910 (Klochkova et al., 2002).

The O II lines at 5161.349 Å ($W_A = 188.3$ mÅ), 5208.14 ($W_A = 81.1$ mÅ) and 6723.222 Å ($W_A = 168.5$ mÅ) in IRAS13266-5551 may also have significant NLTE effects. We could not obtain a good fit to these lines and they were excluded from the abundance analysis.

### 3.8.5. Ne I lines

The derived neon abundance for IRAS13266-5551 is unusually high (Table 5a). However, we could still not obtain a good fit to the majority of Ne I lines in the spectrum of this star. Auer and Mihalas (1973) showed that for stars in the range B2 to B5 the neon abundance deduced from LTE analyses is systematically in error by about a factor of five. They computed equivalent widths of Ne I lines ($\lambda\lambda$ 5852.5 Å to 6598.9 Å) for $15000 \leq T_{\text{eff}} \leq 22500$ K, log $g = 3.0$ and 4.0 and solar neon abundance. For $T_{\text{eff}} = 22500$ K, log $g = 3.0$, they found that the LTE equivalent widths were almost a factor of three smaller than the NLTE equivalent widths of these lines.

### 3.8.6. Al III and Si III lines

Only two lines of Al III and one of Si III were identified in each of the two stars. These lines are very strong (ref. Tables 2a and 3a) in both the stars. e.g. in IRAS13266-5551, Si III, 5741.264 Å has $W_A = 392.9$ mÅ. Using WIDTH9 and spectrum synthesis we derived log $\epsilon$(Al) = 7.91 ± 0.34 and log $\epsilon$(Si) = 9.23 for IRAS13266-5551. However, these abundances may be an overestimate.
3.8.7. S II lines

S II absorption lines were identified in IRAS13266-5551. Since all except one S II line (5475.025 Å) were identified as blends, we used the spectrum synthesis code SYNSPEC to estimate the sulphur abundance in this star (Table 5a). This value may therefore be treated as an upper limit.

3.8.8. Iron lines

From the Fe III absorption lines, we estimated $[\text{Fe}/\text{H}] = -0.17$ in the case of IRAS13266-5551. The iron lines in IRAS17311-4924 only appear in emission or as P-Cygni profiles.

3.8.9. Estimated errors

The standard deviations ($\sigma$) measure the scatter in the abundances due to individual lines of a species. Table 5a gives the value of $\sigma$ for each species as estimated using WIDTH9. The true error, i.e. the standard deviation of the mean $\sigma/\sqrt{n}$, would be smaller for species with a greater number of lines (n).

Kurucz’s solar metallicity models in the range $18000 \, \text{K} \leq T_{\text{eff}} \leq 25000 \, \text{K}$ are available only in steps of $\Delta T_{\text{eff}} = \pm 1000 \, \text{K}$ and $\Delta \log g = \pm 0.5$. Hence, the temperature ($T_{\text{eff}}$) and gravity ($\log g$) of IRAS13266-5551 are estimated to an accuracy of $\pm 1000 \, \text{K}$ and $\pm 0.5$ respectively. Table 5b gives the uncertainties in the abundances due to uncertainties in the model atmospheric parameters taking $\Delta T_{\text{eff}} = +1000 \, \text{K}$, $\Delta \log g = +0.5$ and $\Delta \xi_t = +1 \, \text{km s}^{-1}$. The quadratic sum of the uncertainties due to the model parameters is given by $\sigma_m$ (Table 5b).

4. Discussion and conclusions

From LTE analysis of the high resolution optical spectrum of IRAS13266-5551 we find the atmospheric parameters to be $T_{\text{eff}} = 23000 \, \text{K} \pm 1000 \, \text{K}$, $\log g = 3.0 \pm 0.5$ and $\xi_t = 10 \, \text{km s}^{-1}$. The lines of Ne I, a few O II lines and the O I triplet indicate that NLTE effects may be significant in these stars. Also, being hot stars it is important to obtain observations shortward of 4900 Å. The absorption lines in the blue may significantly improve our estimates of the stellar parameters and elemental abundances. Eg. Mooney et al. (2002), Klochkova et al. (2002) and Ryans et al. (2003) have obtained observations from $\sim 3700 \, \text{Å}$ onwards. Recently, from NLTE analysis of the absorption lines in the blue region, Ryans et al. (2003) estimated the atmospheric parameters of two hot post-AGB stars, IRAS18062+2410 (SAO85766) and IRAS19590-1249 (LSIV-12°111). A similar analysis is required for IRAS13266-5551 and IRAS17311-4924. Hence, we would like to emphasise that our LTE analysis based on lines longward of 4900 Å is only a first approximation.

We estimated heliocentric radial velocities ($V_r$) of $+65.31 \pm 0.34 \, \text{km s}^{-1}$ and $+27.55 \pm 0.74 \, \text{km s}^{-1}$ for IRAS13266-5551 and IRAS17311-4924 respectively.
Preliminary estimates of the CNO abundances in IRAS13266-5551 indicate that these elements are overabundant with $[\text{C}/\text{Fe}]=+0.45$, $[\text{N}/\text{Fe}]=+0.48$ and $[\text{O}/\text{Fe}]=+0.26$ suggesting that the products of helium burning have been brought to the surface as a result of third dredge-up on the AGB. A comparison with average CNO abundances for mainsequence B-stars from the Ori OB1 association (Table 5a; Kilian, 1992) also indicates that IRAS13266-5551 is an evolved star and has gone through the dredge-up episodes during its evolution. We could not estimate the atmospheric parameters and chemical abundances for IRAS17311-4924.

McCausland et al. (1992) and Conlon et al. (1993b) derived the chemical composition of several high galactic latitude hot post-AGB stars. In addition to being metal-poor, these stars showed severe carbon deficiency. Similar carbon depletions were also reported in other hot post-AGB stars at high galactic latitudes e.g. LSII+34°26 (García-Lario et al., 1997), PG1323-086 and PG1704+222 (Moehler and Heber, 1998) and SAO85766 (Parthasarathy et al., 2000b). In contrast, the hot post-AGB star, IRAS01005+7910 (Klochkova et al., 2002) was found to be carbon-rich. For, IRAS13266-5551 we estimated $\text{C}/\text{O} \sim 0.78$.

Finally, from our optical spectra we conclude that IRAS13266-5551 and IRAS17311-4924 are most likely in the post-AGB phase of evolution. These stars are unlikely to be luminous blue variables (LBVs). Their spectra are very similar to the hot post-AGB stars IRAS18062+2410 (SAO85766; Parthasarathy et al., 2000b) and IRAS01005+7910 (Klochkova et al., 2002). LBVs are usually found in the galactic plane and are often associated with star forming regions. IRAS13266-5551 and IRAS17311-4924 on the other hand, are at high galactic latitudes and are not associated with any star forming region. Further, whereas, LBVs are characterised by large amplitude light variations, these stars may show small amplitude, irregular light variations similar to that found in the high galactic latitude rapidly evolving hot post-AGB star, SAO85766 (Arkhipova, 1999, 2000). Photometric monitoring of these stars is required.
Table 2a. Absorption lines in IRAS13266-5551 (CPD-55 5588)

| $\lambda_{\text{obs}}$ (Å) | $\lambda_{\text{lab}}$ (Å) | Ident. | W$_{\lambda}$ (Å) | log (gf) | $\chi$ (eV) | $\Delta \lambda$ (Å) | $V_{t}$ km s$^{-1}$ |
|---------------------------|-----------------------------|--------|------------------|----------|-----------|----------------|-------------------|
| 4942.394                  | 4941.105                    | O II (33) | 0.0498          | 0.080    | 26.55–29.06 | 1.289          | +63.03           |
| 4944.33                   | 4943.003                    | O II (33) | 0.0901          | 0.370    | 26.56–29.07 | 1.327          | +65.31           |
| 4957.005                  | 4955.738                    | O II (33) | 0.0437          | -0.420   | 26.56–29.06 | 1.267          | +61.47           |
| 4995.447                  | 4994.360                    | N II (24, 64) | 0.028          | -0.080   | 20.94–23.42 |                |                  |
| 5002.728                  | 5001.474                    | N II (19) | 0.222           | 0.450    | 20.65–23.13 |                | blend            |
| 5003.995                  | 5002.703                    | N II (4)  | 0.0665          | -1.020   | 18.46–20.94 |                | blend            |
| 5006.535                  | 5005.150                    | N II (19, 6) | 0.1499         | 0.610    | 20.66–23.14 |                |                  |
| 5008.656                  | 5007.328                    | N II (24) | 0.0494          | 0.160    | 20.94–23.41 | 1.328          | +64.33           |
| 5011.923                  | 5010.621                    | N II (4)  | 0.1593          | -0.520   | 18.46–20.94 | 1.302          | +62.72           |
| 5046.411                  | 5045.099                    | N II (4)  | 0.1784          | -0.330   | 18.48–20.94 | 1.312          | +62.79           |
| 5049.117                  | 5047.738                    | He I (47) | 0.1329          | -1.600   | 21.22–23.67 | 1.379          | +66.73           |
| 5075.435                  | 5073.592                    | N II (10) |                | -1.280   | 18.49–20.94 |                |                  |
|                          |                            | + 5073.903 | Fe III (5)    |          | -2.557    | 8.65–11.09   |                |                  |
| 5088.355                  | 5086.701                    | Fe III (5) | 0.0372          | -2.590   | 8.65–11.09 | 1.654          | +82.32           |
| 5129.21                   | 5127.387                    | Fe III (5) | 0.0390          | -2.218   | 8.65–11.07 | 1.823          | +91.43           |
| 5134.133                  | 5132.947                    | C II (16) | 0.102           | -0.240   | 20.70–23.12 |                |                  |
|                          |                            | + 5133.281 | C II (16)    |          | -0.200    | 20.70–23.12 |                |                  |
| 5144.795                  | 5143.494                    | C II (16) | 0.045           | -0.240   | 20.70–23.11 | 1.301          | +60.65           |
| 5146.582                  | 5145.165                    | C II (16) | 0.0896          | 0.160    | 20.71–23.12 | 1.417          | +67.39           |
| 5152.49                   | 5151.085                    | C II (16) | 0.0781          | -0.200   | 20.71–23.12 | 1.405          | +66.60           |
| 5157.759                  | 5156.111                    | Fe III (5) | 0.0398          | -2.018   | 8.64–11.04 | 1.648          | +80.66           |
| 5161.349                  | 5160.026                    | O II (32) | 0.1883          | -0.660   | 26.56–28.96 | 1.323          | +61.69           |
| 5208.14                   | 5206.715                    | O II (32) | 0.0811          | -0.860   | 26.56–28.94 | 1.425          | +66.87           |
| 5220.938                  |                            | UN        | 0.133           |          |           |                |                  |
| 5455.271                  | 5453.790                    | S II (6)  | 0.1352          | 0.560    | 13.67–15.94 |                |                  |
|                          |                            | + 5454.215 | N II (29)    |          | -0.740    | 21.15–23.42 |                |                  |
| 5475.025                  | 5473.602                    | S II (6)  | 0.0982          | -0.120   | 13.58–15.85 | 1.423          | +62.76           |
| 5497.073                  | 5495.655                    | N II (29) | 0.0767          | -0.170   | 21.16–23.42 | 1.418          | +62.18           |
| 5641.593                  | 5639.980                    | S II (14) | 0.0480          | 0.330    | 14.07–16.26 |                |                  |
|                          |                            | + 5640.549 | C II (15)    |          | -0.750    | 20.70–22.90 |                |                  |
| 5648.699                  | 5646.979                    | S II (14) | 0.0426          | 0.110    | 14.00–16.20 |                |                  |
|                          |                            | + 5648.070 | C II (15)    |          | -0.450    | 20.70–22.90 |                |                  |
| 5668.134                  | 5666.629                    | N II (3)  | 0.2938          | 0.010    | 18.47–20.65 | 1.505          | +64.45           |
| 5677.53                   | 5676.017                    | N II (3)  | 0.2524          | -0.340   | 18.46–20.65 | 1.513          | +64.74           |
| 5681.04                   | 5679.558                    | N II (3)  | 0.3913          | 0.280    | 18.48–20.67 | 1.482          | +63.05           |
| 5687.75                   | 5686.213                    | N II (3)  | 0.1746          | -0.470   | 18.47–20.65 | 1.537          | +65.86           |
| 5698.092                  | 5696.603                    | Al III (2) | 0.3473          | 0.230    | 15.64–17.82 | 1.489          | +63.19           |
| 5712.274                  | 5710.766                    | N II (3)  | 0.1726          | -0.470   | 18.48–20.65 | 1.508          | +63.99           |
| 5724.268                  | 5722.730                    | Al III (2) | 0.2174          | -0.070   | 15.64–17.81 | 1.538          | +65.39           |
| 5741.264                  | 5739.734                    | Si III (4) | 0.3929          | -0.160   | 19.72–21.88 | 1.53           | +64.74           |
Table 2a.

| $\lambda_{\text{obs}}$ (Å) | $\lambda_{\text{lab}}$ (Å) | Ident. | $W_{\lambda}$ (Å) | log (gf) | $\chi$ (eV) | $\Delta \lambda$ (Å) | $V_r$ (km s$^{-1}$) |
|---------------------------|---------------------------|--------|-----------------|-----------|-----------|----------------|-----------------|
| 5780.631                  | 5780.410                  | DIB    | 0.1696          |           |           | 0.221          | −3.76           |
| 5797.34                   | 5797.030                  | DIB    | 0.0998          |           |           | 0.310          | +0.81           |
| 5835.532                  | 5833.938                  | Fe III (114) | 0.1198       | 0.616 | 18.51–20.63 | 1.594          | +66.74          |
| 5933.462                  | 5931.782                  | N II (28) | 0.0428       | 0.050 | 21.15–23.24 | 1.68           | +69.74          |
| 5943.301                  | 5941.654                  | N II (28) | 0.0756       | 0.320 | 21.16–23.25 | 1.647          | +67.93          |
| 6144.637                  | 6143.063                  | Ne I (1) | 0.0606       | −0.350 | 16.62–18.64 | 1.574          | +61.64          |
| 6196.062                  | 6195.990                  | DIB    | 0.0214          |           |           | 0.072          | −11.74          |
| 6203.327                  | 6203.060                  | DIB    | 0.0221          |           |           | 0.267          | −2.32           |
| 6381.399                  | 6379.617                  | N II (2) | 0.0587       | −0.920 | 18.47–20.41 | 1.782          | +68.57          |
| 6403.899                  | 6402.246                  | Ne I (1) | 0.1314       | 0.360 | 16.62–18.55 | 1.653          | +62.23          |
| 6483.787                  | 6482.049                  | N II (8) | 0.2212       | −0.160 | 18.50–20.41 | 1.738          | +65.21          |
| 6508.432                  | 6506.528                  | Ne I (3) | 0.0275       | 0.030 | 16.67–18.58 | 1.904          | +72.56          |
| 6579.07                   | 6578.052$^*$              | C II (2) | 0.0855       | 0.120 | 14.45–16.33 | 1.018          | +46.43          |
| 6613.856                  | 6613.630                  | DIB    | 0.0832          |           |           | 0.226          | −4.98           |
| 6642.826                  | 6640.994                  | O II (4) | 0.0825       | −0.890 | 23.42–25.29 | 1.832          | +67.53          |
| 6723.222                  | 6721.358                  | O II (4) | 0.1685       | −0.590 | 23.44–25.29 | 1.864          | +67.97          |
| 6781.99                   | 6779.942                  | C II (14) | 0.0355       | 0.040 | 20.70–22.53 |               |                |
| + 6780.595                | 6780.595                  | C II (14) | −0.360       |       | 20.70–22.53 |               |                |
| 6785.831                  | 6783.907                  | C II (14) | 0.0458       | 0.320 | 20.71–22.54 | 1.924          | +69.85          |
| 6787.210                  | 6787.210                  | C II (14) | −0.360       |       | 20.70–22.53 |               | weak            |
| 6791.465                  | 6791.465                  | C II (14) | −0.250       |       | 20.70–22.53 |               | weak            |
| 6800.687                  | 6800.687                  | C II (14) | −0.330       |       | 20.70–22.54 |               | weak            |
| 7034.428                  | 7032.413                  | Ne I (1) | 0.0485       | −0.250 | 16.62–18.38 | 2.015          | +70.73          |
| 7773.521                  | 7771.944                  | O I (1)  | 0.273        | 0.320 | 9.14–10.74  |               | blend           |
| 7776.411                  | 7774.166                  | O I (1)  | 0.396        | 0.170 | 9.14–10.74  |               | blend           |
| 7777.68                   | 7775.388                  | O I (1)  | 0.072        | −0.050 | 9.14–10.74  |               | weak            |

Radial velocity of the C II(2) 6578.052 Å absorption line indicates that it may have a P-Cygni profile with a weak emission component, similar to C II(2) 6582.882 Å (see Table 2c).
Table 2b. Emission lines in IRAS13266-5551 (CPD-55 5588)

| $\lambda_{\text{obs}}$ (Å) | $\lambda_{\text{lab}}$ (Å) | Ident. | $W_{\lambda}$ (Å) | log (gf) | $\chi$ (eV) | $\Delta \lambda$ (Å) | $V_r$ (km s$^{-1}$) |
|-----------------------------|-----------------------------|--------|------------------|----------|-------------|----------------------|----------------|
| 5015.678†                   |                             | He I (4) | -0.820           | 20.62 – 23.09 |
| 5042.128                    | 5041.024                    | Si II (5) | 0.0913           | 10.07 – 12.52 |
| 5057.172                    | 5055.984                    | Si II (5) | 0.1503           | 10.07 – 12.52 |
| 5199.059                    |                             | UN      | 0.0281           |           |
| 5201.333                    |                             | UN      | 0.0263           |           |
| 5467.921                    | 5466.55                     | S II (11)| 0.0346           | 13.62 – 15.88 |
| 5516.046                    |                             | UN      | 0.0924           |           |
| 5921.673                    | 5920.124                    | Fe III (115) | 0.0420         | 18.78 – 20.88 |
| 5955.113                    | 5953.613                    | Fe III (115) | 0.0371         | 18.79 – 20.87 |
| 5958.987                    | 5957.559                    | Si II (4) | 0.1042           | 10.07 – 12.15 |
| 5980.413                    | 5978.90                     | Fe III (117) | 0.3632         | 18.73 – 20.80 |
|                             | +5978.930                   | Si II (4) | 0.000            | 10.07 – 12.15 |
| 6000.962                    | 5999.30                     | Fe III (117) | 0.0328         | 18.73 – 20.79 |
| 6033.913                    | 6032.30                     | Fe III (117) | 0.0666         | 18.73 – 20.78 |
| 6096.85                     | 6095.37                     | C II (24) | 0.0226           | 22.47 – 24.50 |
| 6100.046                    | 6098.62                     | C II (24) | 0.0280           | 22.47 – 24.50 |
| 6227.758                    | 6226.130                    | Al II (10) | 0.0100          | 13.07 – 15.06 |
| 6233.21                     | 6231.718                    | Al II (10) | 0.0421          | 13.07 – 15.06 |
| 6241.053                    |                             | UN      | 0.0398           |           |
| 6244.939                    | 6243.355                    | Al II (10) | 0.0281          | 13.08 – 15.06 |
| 6300.392                    | [O I] (1F) (atmos.)         | 0.0728     |           |           |
| 6348.553                    | 6347.091                    | Si II (2) | 0.2767         | 8.12 – 10.07   |
| 6363.881                    | [O I] (1F) (atmos.)         | 0.0222     |           |           |
| 6372.811                    | 6371.359                    | Si II (2) | 0.1369           | 8.12 – 10.07   |
| 6463.481                    | atmos.                      | 0.0399     |           |           |
| 6547.435                    | 6545.80                     | Mg II (23) | 0.0303         | 11.58 – 13.47   |
| 6549.576                    | 6548.1                      | [N II] (1F) | 0.0209         | 1.452 + 53.14   |
|                             | 6583.6†                     | [N II] (1F) | 1.476 + 52.39  |
| 6732.171                    |                             | UN      | 0.0259           |           |
| 6853.447                    |                             | UN      | 0.0463           |           |
| 7043.729                    | 7042.048                    | Al II (3) | 0.0818           | 11.32 – 13.08 |
| 7058.222                    | 7056.612                    | Al II (3) | 0.0619           | 11.32 – 13.07 |
| 7063.996                    |                             | UN      | 0.016            |           |
| 7065.332                    | 7063.642                    | Al II (3) | 0.0471           | 11.32 – 13.07 |
| 7067.219                    | 7065.188                    | He I (10) | 0.5544          | 20.87 – 22.62  |
|                             | +7065.719                   | He I (10) |                | 20.87 – 22.62  |
| 7233.203                    | 7231.332                    | C II (3) | 0.316            | 16.33 – 18.05   |
| 7238.37                     | 7236.421                    | C II (3) | 0.488            | 16.33 – 18.05   |
|                             | 7281.349†                   | He I (45) | -0.840          | 21.22 – 22.92   |

†: the He I(4) 5015.675 Å and He I(45) 7281.349 Å emission lines are superposed on the corresponding absorption profiles of these lines. The asymmetric nature of these emission lines suggests that they may have P-Cygni profiles. ∗: [N II] (1F) 6583.6 Å is blended with the emission component of C II (2) 6582.882 Å P-Cygni profile.
Table 2b. contd...

| $\lambda_{\text{obs.}}$ (Å) | $\lambda_{\text{lab.}}$ (Å) | Ident. | $W_\lambda$ (Å) | log (gf) | $\chi$ (eV) | $\Delta \lambda$ (Å) | $V_r$ (km s$^{-1}$) |
|-----------------------------|-----------------------------|--------|-----------------|----------|-------------|------------------|-----------------|
| 7316.384                    | atmos.                      | 0.0237 |                 |          |             |                  |                 |
| 7379.562                    | UN                          | 0.0736 |                 |          |             |                  |                 |
| 7413.63                     | atmos.                      | 0.0258 |                 |          |             |                  |                 |
| 7464.238                    | UN                          | 0.0624 |                 |          |             |                  |                 |
| 7468.316                    | atmos.                      | 0.0306 |                 |          |             |                  |                 |
| 7497.305                    | UN                          | 0.0161 |                 |          |             |                  |                 |
| 7504.157                    | UN                          | 0.0123 |                 |          |             |                  |                 |
| 7514.875                    | UN                          | 0.0569 |                 |          |             |                  |                 |
| 7564.141                    | UN                          | 0.0178 |                 |          |             |                  |                 |
| 7712.676                    | atmos.                      | 0.0276 |                 |          |             |                  |                 |
| 7717.028                    | atmos.                      | 0.0126 |                 |          |             |                  |                 |
| 7750.781                    | atmos.                      | 0.0322 |                 |          |             |                  |                 |
| 7794.201                    | atmos.                      | 0.0223 |                 |          |             |                  |                 |
| 7821.623                    | atmos.                      | 0.0517 |                 |          |             |                  |                 |
| 7851.066                    | UN                          | 0.1470 |                 |          |             |                  |                 |
| 7853.381                    | atmos.                      | 0.0263 |                 |          |             |                  |                 |
| 7854.82                     | UN                          | 0.0248 |                 |          |             |                  |                 |
| 7878.902 7877.054           | Mg II (8)                   | 0.2393 | 0.390           | 9.99−11.57 | 1.848        | +55.15          |
| 7898.179 7896.367           | Mg II (8)                   | 0.3963 | 0.650           | 10.00−11.57 | 1.812        | +53.61          |
| 7913.766                    | atmos.                      | 0.0636 |                 |          |             |                  |                 |
| 7921.164                    | atmos.                      | 0.0420 |                 |          |             |                  |                 |
| 7964.76                     | atmos.                      | 0.0554 |                 |          |             |                  |                 |
| 7993.434                    | atmos.                      | 0.0468 |                 |          |             |                  |                 |
| 8001.991 8000.12            | [Cr II] (1F)                | 0.0441 |                 |          |             | 1.871           | +54.93          |
| 8025.808                    | atmos.                      | 0.0350 |                 |          |             |                  |                 |
| 8062.346                    | atmos.                      | 0.0199 |                 |          |             |                  |                 |
| 8215.857                    | UN                          | 0.0891 |                 |          |             |                  |                 |
| 8236.683                    | UN                          | 0.2139 |                 |          |             |                  |                 |
Table 2c. Lines with P-Cygni profiles in IRAS13266-5551 (CPD-55 5588). Equivalent widths of the absorption and emission components of the P-Cygni profiles are given. Wind velocities are estimated from the blue absorption edges of the P-Cygni profiles.

| \( \lambda_{\text{lab}} \) (Å) | Ident. | \( W_\lambda \) (absorption) (Å) | \( W_\lambda \) (emission) (Å) | \( \log (g_f) \) | \( \chi \) (eV) | Wind Velocity (km s\(^{-1}\)) |
|----------------|-------|-------------------------------|-------------------------------|------------|----------|---------------------|
| 5875.618       | He I (11) | 0.079                          | 0.484                         | 0.410      | 20.97–23.08       |
| +5875.650      | He I (11) |                                | −0.140                        | 20.97–23.08 |
| +5875.989      | He I (11) |                                | −0.210                        | 20.97–23.08 |
| 6562.817       | H\(\alpha\) | 6.902                          | 0.710                         | 10.15–12.04 |
| 6582.882\(^\dagger\) | C II (2) | 0.031                          | −0.180                        | 14.45–16.33 |
| 6678.149       | He I (46) | 0.212                          | 0.076                         | 0.330      | 21.22–23.08–101.34|

Owing to the broad wings of the H\(\alpha\) emission component, the absorption component of the P-Cygni profile lies above the normalised continuum (see Fig. 3).\(^\dagger\): the emission component of C II(2) 6582.882 Å P-Cygni profile is blended with [N II](1F) 6583.6 Å

Table 2d. Absorption (a) and emission (e) components of Na I D\(_2\) (5889.953 Å) and Na I D\(_1\) (5895.923 Å) lines in the spectrum of IRAS13266-5551 (CPD-55 5588). \( W_\lambda \) are the equivalent widths of the components and \( V_r \) are the respective heliocentric radial velocities.

| Component | IRAS13266-5551 |
|-----------|---------------|
|           | Na I D\(_2\)  | Na I D\(_1\)  |
| \( \lambda_{\text{obs}} \) (Å) | \( W_\lambda \) (Å) | \( V_r \) (km s\(^{-1}\)) | \( \lambda_{\text{lab}} \) (Å) | \( W_\lambda \) (Å) | \( V_r \) (km s\(^{-1}\)) |
| 1.        | a 5889.54 | 0.168 | −36.28 | 5895.432 | 0.062 | −40.22 |
| 2.        | a 5890.003 | 0.551 | −12.69 | 5896.002 | 0.415 | −11.22 |
| 3.        | a 5890.366 | 0.292 | +5.80 | 5896.38 | 0.203 | +8.01 |
| 4.        | a 5890.938 | 0.021 | +34.92 | 5896.913 | 0.029 | +35.13 |
| 5.        | e 5891.324 | 1.371 | +54.59 | 5897.373 | 0.007 | +58.54 |
Table 3a. Absorption lines in IRAS17311-4924 (Hen3-1428)

| $\lambda_{\text{obs}}$ (Å) | $\lambda_{\text{lab}}$ (Å) | Ident. | $W_\lambda$ (Å) | log (gf) | $\chi$ (eV) | $\Delta \lambda$ (Å) | $V_r$ (km s$^{-1}$) |
|---------------------------|--------------------------|--------|----------------|----------|----------|----------------|-------------------|
| 5045.576                  | 5044.8                   | C II (35) | 0.0976         |          | 24.27–26.71 |                  |                   |
| +5045.099                 |                          | N II (4) | −0.330         | 18.48–20.94 |          |                  |                   |
| 5047.665                  | 5047.2                   | C II (35) | 0.0686         | −1.00    | 24.27–26.71 | 0.465           | +25.17           |
| +5043.281                 |                          | C II (16)| −0.200         | 20.70–23.12 |          |                  |                   |
| 5133.486                  | 5132.947                 | C II (16) | 0.0643         | −0.240   | 20.70–23.12 | 0.515           | +27.57           |
| +5133.281                 |                          | C II (16) | −0.200         | 20.70–23.12 |          |                  |                   |
| 5144.009                  | 5143.494                 | C II (16)| 0.0436         | −0.240   | 20.70–23.12 | 0.515           | +27.57           |
| +5145.165                 |                          | C II (16)| 0.160          | 20.70–23.12 |          |                  |                   |
| 5151.433                  | 5151.085                 | C II (16)| 0.0294         | −0.200   | 20.71–23.12 | 0.348           | +17.8            |
| +5160.026                 |                          | O II (32)| 0.0584         | −0.660   | 26.55–28.96 | blend           |                  |
| 5207.288                  | 5206.715                 | O II (32)| 0.0137         | −0.860   | 26.56–28.94 | 0.573           | +30.54           |
| 5496.109                  | 5495.655                 | N II (29) | 0.0215         | −0.170   | 21.16–23.42 | 0.454           | +22.31           |
| 5667.181                  | 5666.629                 | N II (3) | 0.1652         | 0.010    | 18.46–20.65 | 0.552           | +26.75           |
| 5676.614                  | 5676.017                 | N II (3) | 0.1386         | −0.340   | 18.46–20.65 | 0.597           | +29.08           |
| 5680.022                  | 5679.558                 | N II (3) | 0.2475         | 0.280    | 18.48–20.67 | 0.464           | +22.04           |
| 5686.792                  | 5686.213                 | N II (3) | 0.1017         | −0.470   | 18.47–20.65 | 0.579           | +28.08           |
| 5697.17                   | 5696.603                 | AI III (2)| 0.1941        | 0.230   | 15.64–17.82 | 0.567           | +27.39           |
| 5711.247                  | 5710.766                 | N II (3) | 0.0758         | −0.470   | 18.48–20.65 | 0.481           | +22.80           |
| 5723.368                  | 5722.730                 | AI III (2)| 0.1158        | −0.070  | 15.64–17.81 | 0.638           | +30.97           |
| 5740.416                  | 5739.734                 | Si III (4)| 0.1923        | −0.160  | 19.72–21.88 | 0.682           | +33.18           |
| 5780.096                  | 5780.410                 | DIB     | 0.1099         |          | −0.314     | −18.77          |                  |
| 6143.323                  | 6143.063                 | Ne I (1) | 0.1289         | −0.350   | 16.62–18.64 | 0.26            | +10.23           |
| 6163.944                  | 6163.594                 | Ne I (5) | 0.0460         | −0.590   | 16.72–18.73 | 0.35            | +14.56           |
| 6286.823                  | 6266.495                 | Ne I (5) | 0.0351         | −0.530   | 16.72–18.69 | 0.328           | +13.23           |
| 6334.755                  | 6334.428                 | Ne I (1) | 0.0709         | −0.310   | 16.62–18.58 | 0.327           | +13.02           |
| 6380.267                  | 6379.617                 | N II (2) | 0.0216         | −0.920   | 18.47–20.41 | 0.65            | +28.10           |
| 6383.238                  | 6382.991                 | Ne I (3) | 0.0587         | −0.260   | 16.67–18.61 | 0.247           | +9.14            |
| 6402.463                  | 6402.246                 | Ne I (1) | 0.2416         | 0.360    | 16.62–18.56 | 0.217           | +7.7             |
| 6482.705                  | 6482.049                 | N II (8) | 0.1270         | −0.160   | 18.50–20.41 | 0.656           | +27.89           |
| 6506.754                  | 6506.528                 | Ne I (3) | 0.0441         | 0.030    | 16.67–18.58 | 0.226           | +7.95            |
| 6641.812                  | 6640.994                 | O II (4) | 0.0738         | −0.890   | 23.42–25.29 | 0.818           | +34.48           |
| 6722.179                  | 6721.358                 | O II (4) | 0.1031         | −0.590   | 23.44–25.29 | 0.821           | +34.17           |
| 7032.735                  | 7032.413                 | Ne I (1) | 0.1089         | −0.250   | 16.62–18.38 | 0.322           | +11.27           |
| 7772.134                  | 7771.944                 | O I (1)  | 0.743           | 0.320  | 9.14–10.74 | blend           |                  |
| 7774.474                  | 7774.166                 | O I (1)  | 0.530           | 0.170   | 9.14–10.74 | blend           |                  |
| 7775.758                  | 7775.388                 | O I (1)  | 0.206           | −0.050  | 9.14–10.74 | blend           |                  |

\[1\]: O II (32) 5160.026 Å absorption line is blended with [Fe II] (19F) 5158.81 Å.

![Image of Table 3a: Absorption lines in IRAS17311-4924 (Hen3-1428)](image-url)
Table 3b. Emission lines in IRAS17311-4924 (Hen3-1428)

| \( \lambda_{\text{obs}} \) (Å) | \( \lambda_{\text{lab}} \) (Å) | Ident. | \( W_1 \) (Å) | \( \log \chi \) (gf) | \( \chi \) (eV) | \( \Delta I \) (Å) | \( V_r \) (km s\(^{-1}\)) |
|-----------------|-----------------|--------|--------------|-----------------|-----------------|-----------------|-----------------|
| 5041.596        | 5041.024        | Si II (5) | 0.0952       | 0.290           | 10.07–12.53     | 0.572           | +31.57          |
| 5056.559        | 5055.984        | Si II (5) | 0.1625       | 0.590           | 10.07–12.53     | 0.575           | +31.65          |
| 5122.428        | 5121.69         | C II (12) | 0.0712       |                 | 20.06–23.47     | 0.738           | +40.76          |
| 5159.448        | 5158.81         | [Fe II] (19F) | 0.049 | \[Fe II\] (18F) | 0.0186 | 8.66–11.04 | 0.658 | +35.54 |
| 5194.567        | 5193.909        | Fe III (5) | 0.0186       | −2.852          | 18.27–20.63     | 0.703           | +37.75          |
| 5198.512        | 5197.929        | Fe I (1091) | 0.0546       | −0.977          | 4.28–6.66       | 0.583           | +31.18          |
| 5200.874        |                 | UN | 0.0217 | |                 | | | |
| 5244.099        | 5243.306        | Fe III (113) | 0.0512 | 0.405           | 18.27–20.63     | 0.703           | +37.75          |
| 5262.238        | 5261.61         | [Fe II] (19F) | 0.0375 | \[Fe II\] (18F) | 0.0182 | 2.19–4.42 | 0.627 | +31.50 |
| 5273.955        | 5273.38         | Fe III (113) | 0.0350 | 0.108           | 18.27–20.61     | 0.649           | +34.39          |
| 5282.946        | 5282.297        | Fe III (113) | 0.0350 | 0.108           | 18.27–20.61     | 0.649           | +34.39          |
| 5299.612        | 5299.045        | O I (26) | 0.0501 | −2.140          | 10.99–13.33     | 0.567           | +29.63          |
| 5343.07         |                 | UN | 0.0698 | |                 | | | |
| 5516.076        | 5515.335        | V I (1) | 0.0805 | −3.570          | 0.00–2.24       | 0.741           | +37.84          |
| 5535.998        | 5535.346        | V I (1) | 0.0293 | −4.043          | 0.02–2.25       | 0.652           | +32.86          |
| 5538.387        | 5537.760        | Mn I (4) | 0.0314 | −2.017          | 2.19–4.42       | 0.627           | +31.50          |
| 5555.575        | 5554.94         | O I (24) | 0.0327 |                 | 10.94–13.16     | 0.635           | +31.82          |
| 5577.325        | 5576.61         | Si II (9) | 0.0332 |                 |                 | 0.715           | +35.99          |
| 5577.832        | 5577.35         | [O I] (3F) | 0.0529 |                 |                 | 0.482           | +23.46          |
| 5892.228        | 5891.598        | C II (5) | 0.1504 | −0.470          | 18.04–20.15     | 0.63            | +29.61          |
| 5920.922        | 5920.124        | Fe III (115) | 0.0634 | −0.034          | 18.79–20.88     | 0.798           | +37.97          |
| 5954.287        | 5953.613        | Fe III (115) | 0.0384 | 0.186           | 18.79–20.87     | 0.674           | +31.49          |
| 5958.201        | 5957.559        | Si II (4) | 0.1694 | −0.300          | 10.07–12.15     | 0.642           | +29.86          |
| 5959.277        | 5958.46         | O I (23) | 0.0285 |                 | 10.94–13.01     |                 | +31.82          |
|                 | +5958.63        | O I (23) | 10.94–13.01 |                 | | | | |
| 5979.620        | 5978.930        | Si II (4) | 0.3998 | 0.000           | 10.07–12.15     | 0.69            | +32.15          |
| 6000.211        | 5999.543        | Fe III (117) | 0.0563 | 0.355           | 18.82–20.88     | 0.668           | +30.93          |
| 6033.247        | 6032.604        | Fe III (117) | 0.0830 | 0.497           | 18.82–20.87     | 0.643           | +29.51          |
| 6047.098        | 6046.46         | O I (22) | 0.0835 |                 | 10.94–12.98     | 0.638           | +29.18          |
| 6095.944        | 6095.37         | C II (24) | 0.0490 |                 | 22.47–24.50     | 0.574           | +25.78          |
| 6099.236        | 6098.62         | C II (24) | 0.0837 |                 | 22.47–24.50     | 0.616           | +27.83          |
| 6152.043        |                 | UN | 0.1118 | |                 | | | |
| 6244.028        | 6243.355        | Al II (10) | 0.0428 | 0.670           | 13.08–15.06     | 0.673           | +29.87          |
| 6257.864        |                 | UN | 0.0164 | |                 | | | |
| 6260.221        |                 | UN | 0.0242 | |                 | | | |
| 6300.877        | 6300.304        | [O I] (1F) | 0.6924 | | | | +24.81 |
| 6347.803        | 6347.109        | Si II (2) | 0.3636 | 0.300           | 8.12–10.07      | 0.694           | +30.33          |
| 6364.348        | 6363.776        | [O I] (1F) | 0.2262 | | | | +24.94 |
| 6372.111        | 6371.371        | Si II (2) | 0.1646 | 0.000           | 8.12–10.07      | 0.74            | +32.37          |
| 6462.585        |                 | UN | 0.1393 | | | | |
Table 3b. contd...

| $\lambda_{\text{obs}}$ (Å) | $\lambda_{\text{lab}}$ (Å) | Ident. | $W_{\lambda}$ (Å) | log (gf) | $\chi$ (eV) | $\Delta \lambda$ (Å) | $V_{\text{r}}$ (km s$^{-1}$) |
|-----------------------------|-----------------------------|--------|------------------|----------|------------|----------------------|--------------------------|
| 6546.69                     | 6545.80                     | Mg II (23) | 0.0218           | 11.58–13.47 | 0.89       | +38.32               |
| 6548.82                     | 6548.1                      | [N II] (1F) | 0.1552           |          | 0.72       | +30.52               |
| 6583.6$^\dagger$            |                             | [N II] (1F) |                  |          |            |                      |
| 6611.462                    | 6610.562                    | N II (31) | 0.0364           | 0.430    | 21.60–23.48 | 0.9                  | +38.37                  |
| 6667.584                    | 6666.938                    | O II (85) | 0.0253           | −1.030   | 28.94–30.80 | 0.646                | +26.60                  |
| 6731.683                    | 6730.79                     | C II (21) | 0.0412           |          | 22.43–24.27 | 0.893                | +37.33                  |
| 6751.248                    | 6750.22                     | C II (21) | 0.0191           |          | 22.44–24.27 | 1.028                | +43.22                  |
| 6794.664                    |                             | UN      | 0.0641           |          |            |                      |
| 6852.518                    |                             | UN      | 0.0321           |          |            |                      |
| 7002.964                    | 7001.93                     | O I (21) | 0.0958           |          | 10.94–12.70 |                    |
| +7002.22                    |                             | O I (21) |                   |          | 10.94–12.70 |                    |
| 7042.823                    | 7042.048                    | Al II (3) | 0.0695           | 0.350    | 11.32–13.08 | 0.775                | +30.55                  |
| 7053.906                    | 7052.9                      | C II (26) | 0.0323           |          | 22.80–24.55 | 1.006                | +40.32                  |
| 7057.413                    | 7056.612                    | Al II (3) | 0.0512           | 0.130    | 11.32–13.07 | 0.801                | +31.58                  |
| 7156.014                    | 7155.14                     | [Fe II] (14F) | 0.0320 |          | 0.874                | +34.17                  |
| 7232.065                    | 7231.332                    | C II (3) | 0.801            | 0.070    | 16.33–18.04 | 0.733                | +27.94                  |
| 7237.489                    | 7236.421                    | C II (3) | 1.072            | 0.330    | 16.33–18.04 |                    |
| +7236.91                    |                             | S II (18) |                   |          | 14.09–15.80 |                    |
| 7255.214                    | 7254.448                    | O I (20) | 0.119            | −1.100   | 10.99–12.70 | 0.766                | +29.21                  |
| 7378.794                    |                             | UN      | 0.1842           |          |            |                      |
| 7412.59                     |                             | atmos. | 0.0637           |          |            |                      |
| 7443.104                    | 7442.298                    | N I (3) | 0.0369           | −0.450   | 10.33–11.99 | 0.806                | +30.02                  |
| 7469.175                    | 7468.312                    | N I (3) | 0.0555           | −0.270   | 10.33–11.99 | 0.863                | +32.20                  |
| 7750.613                    |                             | atmos. | 0.0195           |          |            |                      |
| 7877.897                    | 7877.054                    | Mg II (8) | 0.1891           | 0.390    | 10.00–11.57 | 0.843                | +29.64                  |
| 7897.18                     | 7896.367                    | Mg II (8) | 0.3615           | 0.650    | 10.00–11.57 | 0.813                | +28.42                  |
| 8000.947                    | 8000.12                     | [Cr II] (1F) | 0.0765 |          | 0.827                | +28.54                  |
| 8126.292                    | 8125.50                     | [Cr II] (1F) | 0.0501 |          | 0.792                | +26.77                  |
| 8188.652 $^\dagger$         | 8187.95 $^\ast$             | N I (2) | 0.0384           |          | 10.28–11.79 |                    |
| 8214.932                    |                             | UN      | 0.0631           |          |            |                      |
| 8217.301                    | 8216.28                     | N I (2) | 0.0582           |          | 10.29–11.79 | 1.021                | +34.81                  |
| 8224.161                    | 8223.07                     | N I (2) | 0.0979           |          | 10.29–11.79 | 1.091                | +37.33                  |

$^\dagger$: [N II](1F) 6583.6 Å is blended with the emission component of C II(2) 6582.882 Å P-Cygni profile. $^\ast$: N I

(2) 8187.95 emission line is affected by atmospheric absorption lines in the region.
Table 3c. Lines with P-Cygni profiles in IRAS17311-4924 (Hen3-1428). Equivalent widths of the absorption and emission components of the P-Cygni profiles are given. Wind velocities are estimated from the blue absorption edges of the P-Cygni profiles.

| $\lambda_{\text{lab}}$ (Å) | Ident. | $W_{\lambda}$ (absorption) (Å) | $W_{\lambda}$ (emission) (Å) | log (gf) | $\chi$ (eV) | Wind Velocity km s$^{-1}$ |
|-----------------------------|--------|-------------------------------|-------------------------------|-----------|-------------|--------------------------|
| 5015.675                    | He I (4) | 0.183                         | 0.319                         | −0.820    | 20.62−23.09 | −146                     |
| 5073.78                     | Fe III (5) | 0.015                         | 0.009                         | −2.557    | 8.65−11.09  | −81.36                   |
| 5086.69                     | Fe III (5) | 0.010                         | 0.018                         | −2.590    | 8.66−11.09  | −81.33                   |
| 5127.463                    | Fe III (5) | 0.070                         | 0.025                         | −2.218    | 8.65−11.07  | −81.34                   |
| 5156.00                     | Fe III (5) | 0.037                         | 0.035                         | −2.018    | 8.64−11.04  | −78.20                   |
| 5875.618                    | He I (11) | 0.992                         | 0.410                         | 20.97−23.08 |             |                          |
| +5875.650                   | He I (11) | 0.014                         | 0.140                         | 20.97−23.08 |             |                          |
| +5875.989                   | He I (11) | 0.020                         | 0.210                         | 20.97−23.08 |             |                          |
| 6562.817                    | H$_\alpha$ | 9.872                         | 0.710                         | 10.15−12.04 |             |                          |
| 6578.03                     | C II (2) | 0.327                         | 0.082                         | 14.45−16.33 | −114.20     |                          |
| 6582.85                     | C II (2) | 0.269                         | 0.120                         | 14.45−16.33 |             |                          |
| 6678.149                    | He I (46) | 0.417                         | 0.412                         | 21.22−23.08 | −145.77     |                          |
| 7065.188                    | He I (10) | 0.137                         | 1.062                         | 20.96−22.72 |             |                          |
| +7065.719                   | He I (10) | 0.116                         | 1.160                         | 20.96−22.72 |             |                          |
| 7281.349                    | He I (45) | 0.151                         | 0.229                         | 21.22−22.92 |             |                          |

Two blended absorption components are visible in the P-Cygni profile of He I(11). The emission peak of the H$_\alpha$ P-Cygni profile is asymmetric indicating two emission components blended together. Owing to the broad wings of the emission component in H$_\alpha$, the absorption component of the P-Cygni profile lies above the normalised continuum (see Fig. 3). $^*$: the emission component of C II(2) 6582.85 Å P-Cygni profile is blended with [N II](1F) 6583.6 Å

Table 3d. Absorption (a) and emission (e) components of Na I D$_2$ (5889.953 Å) and Na I D$_1$ (5895.923 Å) lines in the spectrum of IRAS17311-4924 (Hen3-1428). $W_{\lambda}$ are the equivalent widths of the components and $V_t$ are the respective heliocentric radial velocities.

| Component | IRAS17311-4924 |
|-----------|----------------|
|           | Na I D$_2$     | Na I D$_1$     |
|           | $\lambda_{\text{abs}}$ (Å) | $W_{\lambda}$ (Å) | $V_t$ (km s$^{-1}$) | $\lambda_{\text{lab}}$ (Å) | $W_{\lambda}$ (Å) | $V_t$ (km s$^{-1}$) |
| 1. a      | 5889.886       | 0.552          | −5.87          | 5895.875       | 0.479          | −4.90          |
| 2. a      | 5890.334       | 0.121          | +16.94         | 5896.331       | 0.121          | +18.30         |
| 3. e      | 5890.677       | 0.096          | +34.41         | 5896.695       | 0.020          | +36.82         |
Table 4. Expansion velocities

|          | IRAS13266-5551 |          | IRAS17311-4924 |
|----------|----------------|----------|----------------|
| Ident.   | \( \lambda_{\text{lab}} \) | FWHM | \( V_{\text{exp}} \) | Ident. | \( \lambda_{\text{lab}} \) | FWHM | \( V_{\text{exp}} \) |
| [N II](1F) | 6548.1          | 0.845   | 19.36          | [O I](3F) | 5577.35 | 0.418 | 11.24 |
|          |                 |         |                | [O I](1F)    | 6300.304  | 0.527 | 12.55 |
|          |                 |         |                | [O I](1F)    | 6363.776  | 0.517 | 12.19 |
|          |                 |         |                | [N II](1F)   | 6548.1    | 1.024 | 23.46 |

From CO observations Loup et al. (1990) and Nyman et al. (1992) estimated expansion velocities of 11 km s\(^{-1}\) and 14.1 km s\(^{-1}\) respectively in IRAS17311-4924. Absorption component 2 of the Na I profile in IRAS17311-4924 has radial velocity (= 18.30 km s\(^{-1}\)) comparable with the expansion velocity of the star.

Table 5a. Derived chemical composition of IRAS13266-5551. The abundances are for \( \log \epsilon(\text{H}) = 12.0 \). Solar abundances \( \log \epsilon(\text{X})_{\odot} \) are from Grevesse & Sauval (1998) and Allende Prieto et al. (2001, 2002). \( n \) refers to the number of lines of each species used for the abundance determination. \( \sigma \) is the standard deviation. For comparison we have listed the average abundances of main sequence B-stars from the Ori OB1 association (Kilian, 1992)

| X       | n  | log \( \epsilon(\text{X}) \) | \( \sigma \) | \( [\text{X/Fe}] \) | log \( \epsilon(\text{X})_{\odot} \) | log \( \epsilon(\text{X}) \) |
|---------|----|-----------------------------|----------------|-------------------|-----------------------------|-------------------|
| He I    | 1  | 11.26\(^{\dagger}\)         | +0.33           | +0.50             | 10.93                       | 11.04             |
| C II    | 4  | 8.67                        | 0.27            | +0.28             | +0.45                       | 8.39              | 8.23             |
| N II    | 6  | 8.23                        | 0.29            | +0.31             | +0.48                       | 7.92              | 7.72             |
| O II    | 4  | 8.78                        | 0.28            | +0.09             | +0.26                       | 8.69              | 8.60             |
| Ne I    | 4  | 9.16\(^{\dagger}\)          | 0.32            | +1.08             | +1.25                       | 8.08              |                  |
| S II    | 4  | 7.96\(^{\dagger}\)          | +0.63           | +0.80             | 7.33                        |                  |
| Fe III  | 4  | 7.33                        | 0.32            | −0.17             | 7.50                        |                  |

The abundances were derived using Kurucz’s WIDTH9 program (modified for Unix machines by John Lester at the University of Toronto, Canada). \( \dagger \): these values were derived from spectrum synthesis analysis using the SYNSPEC code. \( \dagger \): Ne abundances derived using Kurucz’s WIDTH9 program appear to be in error. The observed Ne I lines are much stronger than the corresponding lines synthesised with the SYNSPEC code using the derived atmospheric parameters of the star and the Ne abundance in Table 5a. NLTE effects may be significant for these lines (see Sec. 3.8.5).
Table 5b. Uncertainties in the abundances, $\Delta \log \epsilon(X)$ due to uncertainties in the model atmospheric parameters

| Element | $\Delta T_{\text{eff}}$ $+\ 1000$ K | $\Delta \log g$ $+\ 0.5$ | $\Delta \xi_t$ $+\ 1$ km s$^{-1}$ | $\sigma_m$ |
|---------|-----------------------------------|-------------------------|----------------------------------|---------|
| C       | + 0.12                            | − 0.18                  | − 0.02                           | 0.22    |
| N       | + 0.12                            | − 0.04                  | − 0.02                           | 0.13    |
| O       | − 0.03                            | + 0.21                  | − 0.02                           | 0.21    |
| Ne      | + 0.16                            | − 0.20                  | − 0.02                           | 0.26    |
| Fe      | + 0.14                            | + 0.05                  | − 0.02                           | 0.15    |
Appendix A: High resolution optical spectrum of IRAS 13266-5551 (CPD-55 5588)

Fig. A. Optical spectrum of IRAS13266-5551
Fig. A. Optical spectrum of IRAS13266-5551 contd...
Fig. A. Optical spectrum of IRAS13266-5551 contd...
Fig. A. Optical spectrum of IRAS13266-5551 contd...
Fig. A. Optical spectrum of IRAS13266-5551 contd...
Appendix B: High resolution optical spectrum of IRAS17311-4924 (Hen3-1428)

Fig. B. Optical spectrum of IRAS17311-4924
Fig. B. Optical spectrum of IRAS17311-4924 contd...
Fig. B. Optical spectrum of IRAS17311-4924 contd...
Fig. B. Optical spectrum of IRAS17311-4924 contd...
Fig. B. Optical spectrum of IRAS17311-4924 contd...
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